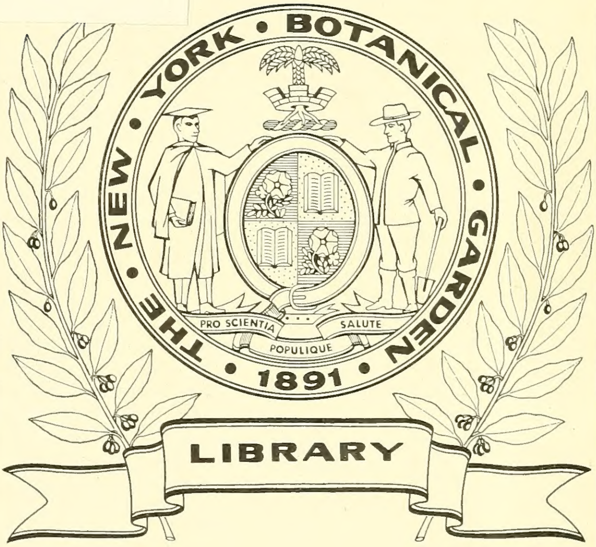
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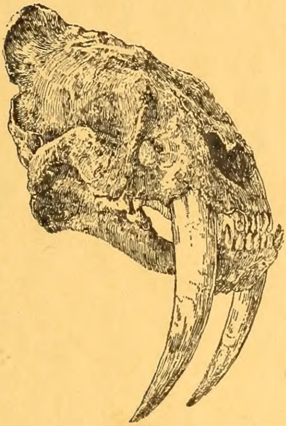

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EXPERIMENTAL STUDIES ON FACTORS INVOLVED IN CARE-GIVING BEHAVIOR IN THREE SPECIES OF THE CETACEAN FAMILY DELPHINIDAE[1]

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Los Angeles County Museum
and
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INTRODUCTION

In a recent literature survey we have shown that a type of succorant behavior, evidenced in its fullest extent by one or more animals lifting a distressed animal to the surface, exists in several, if not all, species of the marine mammal order Cetacea. Such behavior showed no phylogenetic correlation (Caldwell and Caldwell, *In press*).

It has been theorized that wounded or dead animals or even inanimate objects elicit this lifting behavior (Slijper, 1958: 231). It is true that many of the small odontocete cetaceans, particularly, play with objects, lifting them on their snouts and carrying them on their flippers (*e.g.*, Kellogg, 1961: 23).

The purpose of the following experiments was to subject a species of cetacean, in which highly-developed succorant behavior is known to exist, to various stimuli to see if such lifting behavior could be elicited. Supporting behavior has been observed in *Tursiops truncatus*, the Atlantic bottlenose dolphin, at least 18 times (Caldwell & Caldwell, *In press*). Fourteen of the occasions occurred in captivity where close observations could be made. The behavior on nine of the 18 occasions was directed toward young of the species. *T. truncatus* consequently was chosen as the animal most likely to show supporting behavior, and a dead young and a model of a dead young

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[1] Partial support for this study was received through grants from the National Institute of Mental Health (MH-07509-01) and the National Science Foundation (GB-1189).

were used in attempting to elicit the behavior. Other, less likely, stimuli also were used.

As, with one exception, only adult female *Tursiops* have shown supporting behavior, animals of this sex and age were used in most of the observations. Immediately following the beginning of the experiments, two of these animals were transferred away and work was continued on the remaining two.

MATERIALS AND METHODS

Subjects:

Atlantic bottlenose dolphin *Tursiops truncatus* (Montagu).

Group I. Four mature females, designated A, B, C and D. The age of A was estimated to be 20 years, and that of B as 8 to 10 years by David H. Brown, Curator of Mammals at Marineland of the Pacific. The estimates were based on size at capture and duration of captivity. Estimates of the ages of C and D were not available. It is not known whether any had delivered young in the wild before captivity, but none had delivered young since capture. All four animals were retired from training and work in public shows. Figures on the exact duration of captivity were not available. After our experiments were completed, one of these animals directed aiding behavior toward another when the latter was in mortal distress.

Group II. Three large juveniles, two females and one male. This group had been in captivity for less than two months at the time of the experiments. They had adjusted well to captivity, were feeding from the trainer's hand and training had begun.

Group III. Three large juveniles, two females and one male. These animals had also been in captivity for less than two months, were well adjusted and were feeding from the trainer's hand. Training procedures with this group had not been started.

Pacific pilot whale, *Globicephala scammoni* (Cope).

Group IV. Two mature animals, one male and one female, both adapted to cativity for several years.

Pacific striped dolphin, *Lagenorhynchus obliquidens* (Gill).

Group V. Three mature animals, one male and two females. All were adjusted to captivity, but figures on the lengths of time in captivity were not available.

Stimuli:

Tursiops truncatus were exposed to different stimuli and comparisons of the reactions to each were noted. The stimuli used ranged progressively from inanimate bearing no relation to living objects to a dead young *Stenella* sp. The stimuli used were:

1. Wooden log (20 inches long and six inches in diameter). The log floated low in the water.

2. Crude inflatable red plastic model of an infant dolphin, approximately life size. The model floated high in the water.

Figure 1. Plastic model of infant dolphin used in experiments described herein.

3. Life-like model of infant dolphin (Fig. 1). The outside skin was of vinyl plastic, the interior of polyurethane foam. There were two dorsal and three ventral ballast chambers constructed of fiber-glass. The chambers, when filled with water or lead shot, could be manipulated so as to cause the model to list in several positions, or float or sink as desired. The model was cast from a dead infant *Stenella* sp. and the coloration, cast into the vinyl coating, duplicated that of a young *T. truncatus*. To the human eye, visually and texturally the reproduction was excellent. On several occasions, experienced personnel confused the model and the real dead infant. No acoustical tests were conducted on the sonar characteristics of the model, and chances are very good that it may have given a different echo to an echoranging dolphin than would an actual young. Such textural differences are likely apparent to *T. truncatus* since humans that have practiced are able to discriminate textural differences by echolocation (Kellogg, 1962: 404). This model was the only one of the stimuli to which the *Globicephala* and *Lagenorhynchus* were subjected.

4. Dead infant *Stenella* sp. which was kept frozen but thawed when used in the tests.

5. Fine nylon string.

Experimental Area:

Studies were conducted at Marineland of the Pacific oceanarium near Los Angeles, California, where the Cetacea that were used were maintained in three types of tanks.

Initially, four adult female *T. truncatus* (Group I) were maintained in what is termed the Seal Pool which is here designated as Tank A. This enclosure is teardrop in shape, roughly 50 feet long and 39 feet wide at the widest point. Six harbor seals (*Phoca vitulina* Linnaeus) were concurrently maintained there. Underwater observations were not possible, but the water depth was only about a maximum of five feet, and as the pool was completely below ground level, an observer could look down into it from the top with ease.

The six juvenile *T. truncatus* (Groups II and III) were maintained in two smaller training pools designated as Tanks B and C, respectively. Underwater observations were not possible in these pools either, and although the water depth was only about four feet, viewing from above was not as easily accomplished as it had been in Tank A as these training pools were partially above ground. However, by standing on a platform, the same effect could be accomplished.

The specimens of *Globicephala scammoni* and *Lagenorhynchus obliquidens* were maintained in a large observation tank (80 feet in diameter by 22 feet in depth). This tank is here designated as Tank D. Observation windows at three levels afforded good vision of underwater behavior, and in addition the animals could be viewed from above the surface.

Methods:

In addition to the experimental procedures, about 150 hours were spent in normative behavior studies. Thirty of these hours were continuous for a comparison of diurnal and nocturnal activity. Most of the normative studies were conducted on the juveniles as the tanks in which they were housed were not available to the public. Observations were made in part from atop an adjacent building, using binoculars, and out of sight by the dolphins.

Vocalizations were monitored intermittently over a period of about 50 hours, with special attention paid to the vocalizations when the stimuli were introduced. This acoustical equipment was described elsewhere (Caldwell, Haugen and Caldwell, 1962).

As observer interpretation may heavily influence observations, particularly of the kind under study here, two observers were present at all critical observations.

The period of observations extended from February 26, 1962, through June 20, 1962.

EXPERIMENTAL RESULTS

Tursiops truncatus. Atlantic bottlenose dolphin

Experiment 1A. Reactions to dead young; first exposure:

Experimental animals: Four mature females (Group I). All were naive to all of the test stimuli.

Experimental conditions: February 26, 1962. The animals were housed in Tank A (Seal Pool). No hydrophones were present in the tank.

Stimulus: Dead young *Stenella* sp. (Stimulus 4).

Results: When the dead dolphin was introduced into the tank, it floated, doubtless due to gasses of internal decomposition. The *Tursiops* immediately schooled and fled to the opposite side of the pool. Schooling was the most constant component of the following sequence, and at all times the animals acted as a unit.

As the dead animal drifted across the pool, it drifted into the center of the deep end. Previous observations had established that this was the area where the dolphins spent most of their time. The entrance of the carcass into this "preferred" area elicited excited responses by the *Tursiops*. They began swimming violently in a single file around the carcass until it drifted off to the side of the pool. The dolphins then withdrew to the far side of the pool, again schooling.

The dead infant was pushed across the pool and across the "preferred" area thirteen times. Forceful tail-slapping was performed four times, at least twice by the same animal. When circling, the four dolphins exhaled visibly and loudly more frequently than normal. These frequent loud exhalations were noted only under unusual conditions such as these.

Each time the dead young drifted away from the center of the pool, the animals schooled on the side away from the carcass.

The six harbor seals maintained in the tank exhibited no fear or excited behavior toward the dead dolphin. They frequently attempted to bite the dead animal's flukes. When this occurred, the *Tursiops* showed no protective behavior to the dead young.

When the carcass was twice pushed to the bottom of the pool and held there with a dipnet, the *Tursiops* remained schooled and motionless on the far side of the pool.

The reactions of the *Tursiops* during this sequence can only be interpreted as fear and excitement. At no time did they approach the carcass except to circle it rapidly and they usually remained schooled and as far away as possible.

Experiment 1B. Reactions to dead young; second exposure:

Experimental animals: Two mature females, A and B of Group I. Animals C and D had been shipped away. A and B were experienced with dead young.

Experimental conditions: March 28, 1962. The animals were still housed in Tank A (Seal Pool). Hydrophones were present in the tank.

Stimulus: Dead young *Stenella* sp. (Stimulus 4).

Results: The dead young was introduced after an initial period of adjustment by the dolphins to the hydrophones. No flight behavior was noted, nor was spontaneous approach behavior elicited. No significant vocalizations were noted. When dead food fish were thrown into the immediate area of the carcass, the dolphins, which had not been fed for several hours, approached and took the fish without hesitation.

The reaction by these two dolphins was in marked contrast to the behavior noted by the four used on the first exposure. Although some habituation to the carcass may have occurred on the first exposure, it also seems possible that one of the two animals that had been shipped away was responsible for initiating the previous excited responses. Social organization and social facilitation in dolphins are so highly developed that this could occur. Individual differences in temperament of dolphins were also found to be marked.

Experiment 1C. Reactions to dead young; third exposure:

Experimental animals: Two mature females, A and B of Group I, and experienced with dead young.

Experimental conditions: April 9, 1962. Animals housed in Tank A (Seal Pool). Hydrophones present in tank.

Stimulus: Dead young *Stenella* sp. (Stimulus 4).

Results: No approach, avoidance, or significant vocalizations were noted. As no further significant behavior was being elicited and as some danger of bacterial contamination existed from the dead animal used in this procedure, the dead young was not used again.

Experiment 2A. Reactions to log:

Experimental animals: Two mature females, A and B of Group I, experienced with the dead young (Stimulus 4) only.

Experimental conditions: March 12, 1962. Animals housed in Tank A (Seal Pool).

Stimulus: Log (Stimulus 1).

Results: When the stimulus was first introduced, some avoidance occurred. Within 10 minutes, however, one of the animals touched the log with its snout and withdrew. Within 20 minutes, the log had drifted between the two animals, but was ignored. The log was allowed to remain in the tank for two hours and no further avoidance or approach was noted.

Experiment 2B. Reactions to log:

Experimental animals: Three juveniles (Group II). All were recently captured and naive to the test stimuli.

Experimental conditions: April 9, 1962. The animals were housed in a small training pool (Tank C). Hydrophones were present in the tank.

Stimulus: Log (Stimulus 1).

Results: The animals showed no tendency to either avoid or to approach the stimulus. No significant vocalizations were noted until the log was removed after 17 minutes. Then an unfamiliar chirping sound occurred. This same chirping occurred when the life-like model was removed after being left floating in the tank for 43 minutes.

Experiment 2C. Reactions to log:

Experimental animals: Three juveniles (Group III). All were recently captured and naive to the test stimuli.

Experimental conditions: April 9, 1962. The animals were housed in a small training tank (Tank B). Hydrophones were present in the tank.

Stimulus: Log (Stimulus 1).

Results: The animals showed no tendency to either avoid or approach the stimulus. Strange high vocalizations, however, not whistles, were made during the exposure.

Experiment 3. Reactions to crude model young dolphin:

Experimental animals: Two mature females, A and B of Group I. The animals were experienced with the log (Stimulus 1), the life-like model (Stimulus 3), the dead young *Stenella* sp. (Stimulus 4) and the string (Stimulus 5).

Experimental conditions: March 19, 1962. Animals housed in Tank A (Seal Pool). No hydrophones present in the tank.

Stimulus: Crude model of young dolphin (Stimulus 2).

Results: Upon introduction of the stimulus, the dolphins withdrew for a short distance but evidenced no excitement. No approach behavior was observed over a period of 30 minutes.

Experiment 4A. Reactions to life-like model of young dolphin:

Experimental animals: Two mature females, A and B of Group I. The animals were experienced with the log (Stimulus 1) and the dead young *Stenella* sp. (Stimulus 4).

Experimental conditions: March 19, 1962. Animals housed in Tank A (Seal Pool). No hydrophones present in the tank.

Stimulus: Life-like model of young dolphin (Stimulus 3).

Results: In this first exposure to this stimulus, the dolphins fled to the far side of the pool when the model was introduced. Whenever the model was pushed or floated toward the dolphins, they left the area.

After 30 minutes of exposure, the model was weighted and sunk in the dolphins' "preferred" area. The dolphins again fled the area. The seals evidenced no fear of the model, approached it and nibbled at its flukes and snout as they had done with the dead young (Stimulus 4). The dolphins remained schooled at the far end of the tank.

After the model was left motionless in the same area for ten to 15 minutes, the dolphins sometimes darted in, swam rapidly around the model, and then swam off violently together. Such scouting runs by *Tursiops gilli* in the wild have been described (Evans and Dreher, 1962; Eberhardt and Evans, 1962).

Rapid and loud exhalations, evidence of excitement, were frequent during this sequence. The only change in behavior noted over a three-hour period of observation was a diminution of the exhalations.

Experiment 4B. Reactions to life-like model of young dolphin:

Experimental animals: Two mature females, A and B of Group I. The animals were experienced with the log (Stimulus 1), the crude model (Stimulus 2), the life-like model (Stimulus 3) and the dead young *Stenella* sp. (Stimulus 4). They were also experienced with the string (Stimulus 5), which had been attached to Stimulus 3.

Experimental conditions: March 28, 1962. Animals housed in Tank A (Seal Pool). Hydrophones were present in the tank.

Stimulus: Life-like model of young dolphin (Stimulus 3).

Results: After the animals were adjusted to the hydrophones, the model was introduced and sunk in the "preferred" area. The dolphins fled as in the previous observation. When the model was allowed to remain in the area without disturbance, the two *Tursiops* sometimes made a scouting run on the model, circled it rapidly, and swam quickly away. The older female always initiated this behavior and at times the younger female began an approach with the other, then fell back leaving the other to continue alone. At such times, a scouting run by one animal, uncomplicated by the vocalizations of another animal, could be seen and audited.

At other times the two dolphins began scouting runs and then both turned back together and swam quickly away to the far end of the pool.

The model remained in the pool for 45 minutes. Although the completed scouting runs increased somewhat with time, they were still infrequent after 45 minutes.

It was during this sequence that the vocalizations previously described as "cracks" (Caldwell, Haugen and Caldwell, 1962) were first noted. When the model was first introduced, one "crack" was elicited. These "cracks" apparently are associated with alarm.

After the initial "crack," there was a complete lack of vocalization for 1½ minutes, then another "crack." In the next 3½ minutes, there occurred a double "crack," triple "crack," and quadruple "crack." The sound was intense and startling over the earphones. It could not be detected out of water. It is not known whether one or both animals were involved in the sound production, nor how the sound is produced. The four observers present were not able to detect any jaw-clapping or tail-slapping as a possible source during the sound production.

Three echolocation runs or scouting runs by a single individual and directed toward the model were performed in a ten-minute period. The patterns of sound produced in each case were similar. A loud, rapid echolocation burst was first produced as the animal approached the model, and a prolonged high whistle followed immediately as the dolphin swam past the model.

The model initially appeared to inhibit routine vocalizations, such as whistles, but these appeared later during the 45-minute observation period.

Experiment 4C. Reactions to life-like model of young dolphin:

Experimental animals: Three juveniles (Group II). Previously exposed only to the log (Stimulus 1).

Experimental conditions: May 10-11, 1962. Animals housed in Tank C. Hydrophones present in the tank. The experimental animals were exposed to the model for a 28-hour observation period. The model was floated in the tank for an 18-hour familiarization period, including both daylight and dark, and then was sunk (during daylight) and behavior observed at that time.

Stimulus: Life-like model of young dolphin (Stimulus 3).

Results: When the model was first introduced, floating, the animals schooled and avoided it. After 90 minutes, they had ceased avoiding the model, and swam close to it without evidence of fear. At 91 minutes, one of the juveniles performed the first of many tail-slaps directed at the model. These were performed by breaking away from the school, swimming toward the model, diving under, and swerving and slapping the water with the flukes close to the model. During one 30-minute period, six tail-slaps at the model, two at another dolphin, and one at an observer were recorded. They were of moderate intensity and the significance is not known.

After six hours exposure, the dolphins were well-enough familiarized to the floating model to play with a plastic ring that floated nearby, but no approach to the model was performed, other than the tail-slapping noted above.

After the familiarization period, the model was sunk. The dolphins schooled and swam close by but did not touch it. After the model had been sunk for two hours, the three dolphins were playing with bits of algae in the pool, and in the following seven hours exhibited neither positive nor negative behavior toward the model.

Experiments 4D and 4E. Reactions to life-like model of young dolphin:

Experimental animals: Three juveniles (Group III). Previously exposed only to the log (Stimulus 1).

Experimental conditions: 4D, June 1-4, 1962. 4E, June 11-20, 1962. Animals housed in Tank B. No hydrophones present in the tank.

Stimulus: Life-like model of young dolphin (Stimulus 3).

Results: The model was weighted and sunk in the pool and allowed to remain there undisturbed for periods of four and ten days.

None of the dolphins was ever observed to approach, play with or lift the model.

In both of these experiments (3 and 4), conducted in circular tanks with a noticeable current, the dolphins swam almost steadily against the current, indicating a positive rheotaxis. Kellogg and Kohler (1952: 251) also reported *T. truncatus* constantly swimming against a current.

Experiment 5. Reactions to string:

Experimental animals: Two mature females, A and B of Group I, experienced with log (Stimulus 1), life-like model (Stimulus 3) and dead young *Stenella* sp. (Stimulus 4).

Experimental conditions: March 28, 1962. Animals housed in Tank A (Seal Pool). Hydrophones present in the tank.

Stimulus: Nylon string (Stimulus 5).

Results: The dolphins exhibited extreme avoidance of the string for the 20-minute period that it was presented. The animals could be manipulated in the tank by dragging the string toward them, as they always fled from it.

Vocalizations were limited during the session to four brief bursts of echolocation clicks. Whether the dolphins can echolocate an object as fine as a string is speculative, although it is known that they can perceive a smell-meshed net hung in the water, but not one of large mesh (McBride, 1956). Scanning movements of the head (Kellogg, 1960: 26) during the bursts appeared directed toward the string rather than the attached metal weight. When being dragged, the weight made a rasping sound on the concrete bottom of the pool, but avoidance of the string at rest was as great as it was when it was in motion.

Globicephala scammoni. Pacific pilot whale

Experiment 6. Reactions to life-like model of young dolphin:

Experimental animals: Two adults, one male and one female (Group IV). Male had twice previously carried dead animals for several hours.

Experimental conditions: June 1, 1962. Animals housed in large observation tank containing underwater viewing ports (Tank D). No hydrophones present in tank.

Stimulus: Life-like model of young dolphin (Stimulus 3).

Results: The model was first allowed to float for 20 minutes. The two pilot whales schooled when the model was first introduced, and began surfacing to breathe or descending in the tank in unison. Although the male did not leave his "preferred" area when the model was floated into it, he remained submerged and surfaced only when it drifted away.

The model was next weighted and sunk into the male's "preferred" area. He jaw-clapped aggressively once as the model was descending. In dolphins, the jaw-clap is a form of intimidation by a dominant animal toward a subordinate (Wood, 1953: 122). Several times his eyes opened wider than normal and then relaxed to normal size. For the 30 minutes that the model remained sunk, however, neither pilot whale approached it.

The male in this experiment was the same animal that had on earlier occasions evidenced strong reactions to a dead *Lagenorhynchus* female and dead of its own species (see Caldwell, Brown and Caldwell, 1963).

Lagenorhynchus obliquidens. Pacific striped dolphin

Experiment 7. Reactions to life-like model of young dolphin:

Experimental animals: Three mature individuals, two females and one made (Group V).

Experimental conditions: June 1, 1962. Animals housed in large observation tank with viewing ports (Tank D). No hydrophones present in the tank.

Stimulus: Life-like model of young dolphin (Stimulus 3).

Results: When the model was introduced, these animals avoided it but not to the same high degree as had the *Tursiops truncatus*. The *Lagenorhynchus* also schooled and followed the model as it sank. The same behavior was repeated when the model was withdrawn.

SOCIAL FACILITATION

A frequently-cited (*e.g.*, Andrews, 1911: 439) aspect of cetacean behavior is the degree to which they sometimes synchronize their movements. This is so pronounced that it has given rise to a nonexistent species, a double-finned cetacean (Beddard, 1900: 415). As experienced a cetologist as Andrews was temporarily led into believing that he had finally seen a double-finned cetacean, but ultimately realized that he was observing two humpback whales swimming in perfect unison (Andrews, 1928: 61).

Crook (1961: 135) used the term *social facilitation* operationally to indicate "that phenomenon observed when the performance of an activity by an individual stimulates the immediate performance of the same activity by its neighbors." Particular attention was paid to this prominent aspect of cetacean behavior as there was a possibility that it might lead to *standing by* in Cetacea.

Social facilitation was observed in three *Lagenorhynchus obliquidens*, one male and two females. Two of the animals had experienced a long period of association in captivity, the third had been introduced recently to their tank. The animals were observed intermittently over a continuous 30-hour period.

Quantitative evaluations were not attempted as the animals were continuously subjected to disturbing stimuli, but qualitative examination of the behavior revealed certain suggestive facts.

During daylight hours, several minutes of each hour were spent by two of the three animals in a precise swimming formation. They swam up or down together, turned at precisely the same moment, surfaced together, and rested together. This synchronous swimming lasted for varying periods from a few seconds to several minutes.

A low-intensity movement of the tail flukes by the lead animal appeared to serve as an intention movement (Tinbergen, 1953: 54). However, this did not necessarily induce the second animal to begin swimming. Frequently there was no apparent reason for the cessation of the behavior.

The third animal, recently introduced, never participated during the day, but pursued its independent activities.

Social facilitation increased during the night. The animals were not observed to sleep, although observations were made at least once an hour. The two dolphins which swam together frequently during the day swam together almost continuously during the night. The third animal, which was never seen to swim with the other two during daylight hours, spent much time swimming synchronously with the other two that same night. The following day the third animal resumed its independent swimming.

There is a tendency among animals to come together at night. The details of how this operates are not known (Allee, 1951: 28). Gunther (1949: 124) noted that wild fin whale groups numbered from two to five or six in the day, but increased to upwards of 20 towards evening. Pilot whales at least tend to aggregate before darkness sets in (Kenneth S. Norris, personal conversation). A reduction in aggression due to drowsiness may be invoked to explain this in animals that sleep at night, but the dolphins were not observed to sleep. Consequently, increased fear is postulated as leading to the observed increase in social cohesion. Schools of whales also come together in hurricanes (Uda and Nasu, 1956). Crook (1961: 144) observed that during fright, bird flocks also draw together in dense little bunches in which no aggressive behavior was ever observed.

Plasticity rather than rigidity in social facilitation in dolphins was indicated by the observations that an intention movement did not necessarily precipitate it, it was terminated by minor stimuli or for no apparent reason, it was noted more extensively in animals with greater experience with each other, and it increased at night. It is felt, therefore, that such plastic behavior could not fully account for cetacean *standing by* under conditions of stress.

Schneirla (1946: 398) divided social facilitation into two types: "biosocial" as in insects and "psychosocial" as in humans; both with their origins in trophallaxis and learning. Social facilitation in dolphins more nearly approximates the "psychosocial" type.

SUMMARY AND DISCUSSION OF EXPERIMENTS

In three species of Cetacea, no epimeletic behavior was elicited towards a sunken or listing model of a young dolphin. The three species investigated were *Tursiops truncatus*, *Globicephala scammoni* and *Lagenorhynchus obliquidens*. In addition, no epimeletic behavior was directed by *Tursiops truncatus* towards a dead young.

Four similar-sized foreign objects presented to *T. truncatus* initially caused fear responses. The objects were a log, a crude plastic model dolphin, a life-like model of a young dolphin and a dead young dolphin. The more closely the object resembled an animate object, the more intense and durable were the withdrawal tendencies.

The only reactions observed in these species when presented with the model that was life-like were fear and excitement, and lack of interest. Fear predominated. Scouting runs were observed and described.

The same two *T. truncatus* that had ceased to withdraw from a log in ten minutes continued to show extreme fear of the life-like model after a continuous exposure of three hours. The work of the European ethologists has pointed out there is no difference in social and non-social stimuli in insects, birds and fish. Jacobs and Smith (1960) have indicated that this also applies to albino rats, the importance of the stimuli being related to two factors: (1) the amount of stimulus movement and (2) the number of activated sense modalities. McBride and Hebb (1948: 121) contended, however, that dogs, cats, primates and dolphins show a greater responsiveness than rats to the intrinsic characteristics of an object as well as to its place or movement.

Observer impression throughout the above work was that the dead young and the model, even though motionless, were initially reacted to as social objects. The jaw-clap of *Globicephala* to the model, the high-intensity tail-slapping by adult *Tursiops* toward the dead young and the low-intensity tail-slaps by juvenile *Tursiops* toward the model, all appeared to have social significance.

It should be emphasized that there is probably at least one element of a distressful situation that has not been incorporated into the experimental work. Recordings of the suspected distress cry (Lilly, 1963) were not made available to us and the difficulties in obtaining such a cry are obvious. If such a vocalization is shown to exist as a context specific sound, tapes should be played back to Cetacea in conjunction with an exposure to the life-like model. However, in any case it should be noted that two instances of supporting behavior, reported by Siebenaler and Caldwell (1956: 127) and Norris and Prescott (1961: 293), clearly show that such a distress call is not always necessary in eliciting aiding (supporting) behavior.

No hormonal preparations were administered as the animals were too valuable for this to be permitted.

The effect that captivity has had on the subjects in this work is not known. Zuckerman's (1932) studies of captive primates and later investigations in the field (*e.g.*, Carpenter, 1934, 1935, 1940; Kortlandt, 1962; Collias and Southwick, 1952) reveal pronounced behavioral differences in confinement. Confinement is also listed as one of the four known factors that elicit aggressive behavior in the grasshopper mouse (Clark, 1962: 182). Twice, however, in the period of the experimental work, dolphins that directed primarily fear behavior toward the model, directed succorant or related behavior toward dead or distressed animals with whom they had had long periods of association.

There were indications that *Globicephala* and *Tursiops* set up microterritories in the oceanaria. The introduction of both the life-like model and the dead young into these microterritories elicited aggressive reactions that were reduced if the intruding objects were moved to a different part of the tank. New arrivals also precipitate attack from established *Tursiops truncatus*, both male and female (McBride, 1940: 23, 25). *Tursiops* aggressive behavior seems more typical of the male, however (Brown and Norris, 1956: 317). Mr. J. B. Siebenaler also stated (personal communication, 1962) that of five established captive *T. truncatus* in his care, only the three males attacked a newly-introduced male. Attacks by male *T. truncatus* also include attacks on new-born infants (McBride and Kritzler, 1951: 258) but females usually protect new-born, either their own or those of another female of the colony. A female's male consort may sometimes aid her in protecting a new-born (Essapian, 1962: 216).

The conclusion was reached here that the model and the dead young were initially perceptually received by the dolphins as a threat, and most probably as a social threat.

The theory is also proposed that succorant behavior in cetaceans is strongly influenced by the sexes of both individuals.

There is a persistent myth among sailors that dolphins and porpoises may save them from drowning in shipwrecks (Alpers, 1961: 109). There is also a much-discussed report of a drowning woman's being aided to shore by a "tremendous shove" from a dolphin (Anonymous, 1949). The usual explanation of such incidents is that it is play behavior (Goodwin, 1947). The experimental work on the cetaceans with the like-like model and the dead young, taken in conjunction with McBride and Hebb's (1948:117) observation of *Tursiops truncatus*' 24- to 48-hour period of fear of a strange object, virtually eliminates the possibility or succorant or play behavior toward a strange object. Of these two explanations, the play behavior would be less likely.

Another explanation suggested from the experiments is that the woman's experience may have been the result of a form of aggressive behavior. This would account for the wording of a "tremendous shove" used in the report cited above. Although it has been stated that the small delphinids do not attack man (Lilly, 1961: 111), a sick captive female *T. truncatus* recently rammed with its snout and hospitalized a woman familiar to it who persisted in trying to feed it when it was sick (Ruth M. Haugen, the victim, personal conversation). The animal had been captive for several years. There is no reason to expect that an aggressive animal would not attack any intruder in its territory unless it had been previously conditioned to accept the intruder, or was prevented by fear.

However, it is true that after weeks of intensive work on the part of the trainer, certain of the dolphins do become cooperative animals to work with in captivity. They have even been referred to as "man-oriented" (Kellogg, 1961: 22). A convincing theory of how this may operate between man and dog has been offered by Scott (1950: 1019), *i.e.*, the behavior patterns of the two species are so similar in many respects that man can readily recognize their meaning in dogs. This is equally true of the dolphins and is particularly applicable to play behavior. The juvenile dolphins at Marineland of the Pacific had a game that they played with fronds of sea lettuce. They tussled over the larger pieces. The possessor, with the alga in its mouth, would approach another juvenile with the mouth open exposing the alga, then quickly would turn and swim away. Almost always this invitation led to a chase and a tussle over the alga. This readily recognizable play invitation was extended to us on one occasion after we had been present at the side of the tank all day. Our inability to participate resulted in a drenching as the dolphin turned and gave a decisive tail-slap in our direction.

Summary and Conclusions

In our experimental work, no succorant behavior toward a model and other stimuli could be elicited from adults of three species of cetaceans: *Tursiops truncatus*, *Lagenorhynchus obliquidens* or *Globicephala scammoni*. Fear usually was evoked. *T. truncatus* directed only fear, excited behavior or lack of response to an unfamiliar dead young dolphin. These responses are discussed individually for each group.

Social facilitation as a possible component of *standing by* was observed briefly. The conclusion was reached that this is psychosocial in cetaceans, and, although possibly a component of *standing by*, could not be the complete explanation for succorant behavior.

While there seemed to be positive correlation between the amount of aid given a distressed individual and the time those rendering aid had been associated with it (see Caldwell and Caldwell, *In press*), and although a simple reduction of fear toward a known individual may account for such correlation, there is at least one report (see Caldwell and Caldwell, *In Press*) in which the aiding individual apparently had had no prior association with the distressed animal.

In conclusion then, and on the basis of our earlier historical review and present observations and experiments, it appears that there is a tendency for succorant behavior to be extended on an individual basis in which both the sexes of the participants and the length of time they have been associated are the more important factors. These factors seem to be even more important that the species of each participant being the same.

While these remarks primarily are based on findings for captive animals, we believe that they generally hold true for wild individuals as well, because of their evident close social organization. On the other hand, we wish to emphasize that succorant behavior does not always occur with captive animals, even under circumstances where it should be expected, and that therefore it should not always be expected in wild groups of cetaceans.

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CONTRIBUTIONS FROM THE LOS ANGELES MUSEUM–CHANNEL ISLANDS BIOLOGICAL SURVEY 38. DIPTERA FROM SAN NICOLAS ISLAND AND POINT MUGU, CALIFORNIA

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During a faunal survey of San Nicolas Island and the Point Mugu lagoon, a collection of insects was made from the intertidal zone. Most of the specimens were obtained near floating or drying mats of *Macrocystis* along the open shore, and the green alga *Enteromorpha intestinalis* within the lagoon. The active diurnal species were taken by hand and net. Light traps and bait attractants were not used. On San Nicolas Island collections were made near the sea lion rookery on the western point of the island, Corral Harbor and the anchorage area at the eastern point of the island.

This study is part of a detailed survey of the marine organisms of the area under the direction of Professors G. E. and N. MacGinitie. The period of study was from June through September 1962.

The Point Mugu locality is probably the last major lagoon preserve in southern California. It is to be hoped that the native fauna and flora will be maintained during naval research programs on the Channel Islands and within the lagoon.

The primary interest was devoted to Diptera; insects of the other orders have been deposited in the Los Angeles County Museum. Those specimens collected only at one locality are noted.

The determinations made by specialists are indicated by initials in brackets. This list includes: R. H. Foote, [RF], C. W. Sabrosky, [CS], G. Steyskal, [GS], A. Stone, [AS], and W. W. Wirth [WW], all of the United States Department of Agriculture, and C. L. Hogue, [CH], of the Los Angeles County Museum.

Determined specimens are to be distributed among the Naval Center reference collection, the United States National Museum, the Los Angeles County Museum, and the University of California, Los Angeles.

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A list of the species follows:

Anthomyiidae: *Fucellia costalis* Stein, 1910. [GS] San Nicolas Island.

F. pacifica Malloch, 1923. [GS]. San Nicolas Island. Found along brackish lagoon near anchorage area.

F. sp. near *fucorum* Fallen, 1819. [GS], Point Mugu. One specimen, female.

F. rufitibia Stein, 1910. [GS]. First described from Pacific Grove, California. It is the most common and numerous of the kelp flies. Prefers open sandy beach amid piles of *Macrocystis* and other Phaeophytes.

F. thinobia (Thomson, 1863)–*Scatophaga*) [GS]. San Nicolas Island. Associated with the sea lion rookery at western-most point of island. This species remains under rocks and in crevices during daylight.

Asilidae: *Stichopogon coquilletti* (Bezzi, 1910–*Neopogon*) Wilcox, 1936. Point Mugu. Active from water edge to beach strand. Listed by Cole (1912) and Essig (1922) from Laguna Beach, California. The endemic species, *Cophura hennei* Wilcox, 1945, was not recollected from San Nicolas Island.

Coelopidae: *Coelopina anomala* Cole, 1923. [GS]. A new record heretofore known only from the Las Animas Bay on the east coast of Baja California. Larvae burrow in *Enteromorpha.*

Coelopa vanduzeei Cresson, 1914. A few adults were found on rocks and pier pilings adjacent to the Mugu lagoon.

Dolichopodidae: *Hydrophorous praecox* Lehman, 1822. [GS]. Larvae and adults found on *Enteromorpha* mats. They are the principal predators of *Lamproscatella quadrisetosa* and *Coelopina anomala.*

Canaceidae: *Canaceoides nudata* Cresson, 1934. [WW]. San Nicolas Island.

Ceratopogonidae: *Leptoconops kerteszi* Kieffer, 1908. [WW]. Point Mugu.

Culicidae: *Culex tarsalis* Coquillett, 1896. [CH]. Point Mugu. Few individuals present.

Empididae: *Drapetis* sp. [GS]. Point Mugu.

Ephydridae: *Atissa pygmea* (Haliday, 1833–*Ephydra*) Haliday, 1839. [WW]. Point Mugu.

Discocerina turgidula Cresson, 1940. [WW]. Point Mugu.

Ephydra riparia, Fallen, 1813. The most cosmopolitan of the ephydrids.

Glenanthe litorea Cresson, 1925. [WW]. Point Mugu.

Ilythea spilota Curtis, 1832. [WW]. San Nicolas Island.

Lamproscatella quadrisetosa (Becker, 1896–*Scatella*) Lindner, 1926. [WW]. Point Mugu.

Lipochaeta slossonae Coquillett, 1896. [WW]. Point Mugu. Numerous but restricted to the seaward side of the Mugu lagoon. Feeds on diatoms from the intertidal sandy mud flats and migrates at night to the adjoining sand dunes. Immature stages are unknown. Principal predators of this species include the flies, *Hydrophorus praecox*, *Stichopogon coquilletti*, and a tiger beetle *Cicindela trifasciata sigmoideus*, Le Conte, 1851.

Mosillus (Gymnopa) tibialis Cresson, 1916. Taken on San Nicolas Island in 1939 and on Point Mugu in 1962. A cosmopolitan species.

Parascatella sp. [WW]. San Nicolas Island.

Scatella paludum (Meigen, 1830–*Ephydra*) Haliday, 1839. [WW]. San Nicolas Island. Abundant near springs by the sea lion rookery.

Heleidae: *Culicoides variipennis occidentalis* Wirth and Jones, 1957. Point Mugu. Presently a small population compared to that found by Wirth (1957) in this area in 1948.

Muscidae: *Fannia femoralis* (Stein, 1897–*Homalomyia*) Malloch, 1913. [GS]. Point Mugu.

Phyllogaster inermis Stein, 1920. [GS]. Point Mugu.

Schoenomyza dorsalis sulfuriceps Malloch, 1918. [GS]. San Nicolas Island.

Phoridae: Megaselia sp. [WW]. Point Mugu.

Piophilidae: *Piophila casei* Linn., 1758. [GS]. San Nicolas Island.

Sarcophagidae: *Sarcophaga californica* Parker, 1918. [CS].

Sphaeroceridae: *Leptocera hirtula* Rondani, 1880. [CS]. Point Mugu.

Leptocera sp. near *fuscipennis*, Haliday. [CS]. Point Mugu.

Leptocera johnsoni Spuler, 1925. [CS]. The most common of the smaller kelp flies. The species is characterized by long bristles on the costa.

Leptocera sp. [CS]. San Nicolas Island.

Syrphidae: *Tubifera tenax* (Linn., 1758–*Eristalis*) Meigen, 1800. Point Mugu.

Tachinidae: *Ptilodexia* sp. [CS]. Point Mugu.

Tendipedidae: *Paraclunio alaskensis* (Coquillett, 1900–*Telmatogeton*) Malloch, 1915. [CH]. Common on the rocky points at both locations and on pier pilings near Mugu entrance.

Tephritidae: *Valentibulla californica* (Coquillett, 1894–*Trypeta*) [RH]. Point Mugu. Common in the salt marsh glasswort (*Salicornia*).

Tethinidae: *Pelomyiella melanderi* (Sturtevant, 1913–*Pelomyia*) Hendel, 1934. [CS]. Point Mugu. A small (1.5 mm) marine halophile found from British Columbia to Baja California, and from the Gulf of California into southern Arizona by way of the Sonoyta River.

Tipulidae: *Gonomyia* sp. [AS]. San Nicolas Island. Found near fresh water springs at the western point of the island.

Limonia venusta Bergroth, 1888. [AS]. San Nicolas Island as above.

Discussion

The Channel Island surveys, under the sponsorship of the Los Angeles County Museum, have covered the period from 1939 to the present. Some of the entomological material collected during this time remains undetermined in the Museum, and additional smaller series are scattered among other institutions.

In 1939 five out of six flies (asilids) were found to be endemic to the various islands; these were described by Wilcox (1945). Later collections have not included these species, and those taken recently are quite cosmopolitan. Studies of longer duration will be necessary to determine if some of the original species still exist on the islands. Future work may help in solving what admixtures have been produced by the postwar inter-island traffic. The continuing interpretation of species lists will add to the knowledge of southern California zoogeography. Systematic and biological studies are enhanced by the use of an isolated site. The Channel Islands provide a series of favorable locations for such observations.

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The opinions and assertions contained herein are those of the writer and do not necessarily reflect those of the Navy Department.

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THE SOUTHERN YELLOW BAT IN JOSHUA TREE NATIONAL MONUMENT, CALIFORNIA

Early in the morning of August 2, 1962 (approximately 12:30 A.M.) an adult male Southern Yellow Bat, *Lasiurus ega xanthinus* (Thomas), was found in a mist net at Cottonwood Spring, elevation 2975 feet, Joshua Tree National Monument, Riverside County, California. The mist net was set near a shallow pool of water fed by a small spring. Fan Palms, *Washingtonia filifera* (Linden) and Cottonwoods, *Populus Fremontii* Torr., were growing in the immediate vicinity. This oasis is in the Sonoran Desert. Two *Pipistrellus hesperus* (H. Allen) and two *Myotis californicus* (Audubon and Bachman) were taken earlier in the same net.

This specimen (no. 3894 in the mammal collection of Long Beach State College) was obtained by the authors and Gary Bateman and it was prepared as a skin and skull (original number SVH 2091) by South Van Hoose. Measurements in mm are: total length, 118; tail, 47; hind foot, 10; and ear, 13.

This represents the second record of occurrence from California, the first being from Palm Springs (Constantine, Bull. So. Calif. Acad. Sci., 45: 107, 1946), which is approximately 40 miles west of Cottonwood Spring. Other records from the United States are based on two specimens from Tucson, Arizona (Cockrum, J. Mamm., 42: 97, 1961) and eight examples from Guadalupe Canyon, Hidalgo County, New Mexico (Mumford and Zimmerman, J. Mamm., 44: 147, 1963). The known range of the subspecies is southern California, southern Arizona, southwestern New Mexico, northern Coahuila, southward through Mexico to southern Costa Rica (Hall and Jones, Univ. Kansas Publs. Mus. Nat. Hist., 14: 91, 1961).

Acknowledgment is made to Superintendent William R. Supernaugh of Joshua Tree National Monument for permission to obtain specimens. This investigation was supported by Public Health Service Research Grant, AI-3407, from the National Institute of Allergy and Infectious Diseases, to Long Beach State College.—Richard B. Loomis, *Department of Biology, Long Beach State College, Long Beach, California*, and Robert C. Stephens, *El Camino College, California.*

A FOSSIL OWL FROM SANTA ROSA ISLAND, CALIFORNIA

With Comments on the Eared Owls of Rancho La Brea

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Los Angeles County Museum

Among the fossil bird bones collected many years ago on Santa Rosa Island, by the California Institute of Technology, is an owl tibiotarsus that was never recorded. The locality number on the bone reads "106." Field notes for this locality state, "Pleistocene sediments and alluvium, northerly face of westerly part of Santa Rosa Island, Santa Barbara County, Calif. In sea cliffs and banks of stream cuttings tributary to Santa Barbara channel." A label with the specimen reads, "Arlington Canyon, E. of canyon mouth." The exact date of collecting is not noted, but presumably it was between 1928 and 1931 as these dates are found on previous and subsequent locality notations. In a previous paper (Howard, 1962:228) it was noted that according to Phil C. Orr of the Santa Barbara Museum of Natural History, all of the deposits in Arlington Canyon are of the Tecolote member of the Santa Rosa Island Formation, and are, therefore, of Wisconsin age.

Study of the specimen in comparison with tibiotarsi of existing owls indicates allocation to the Strigidae rather than to the Tytonidae on the basis of lesser posterior protrusion of the distal condyles and longer, more smoothly contoured internal cnemial crest. Within the Strigidae the combination of shallow, rounded depression posteriorly above the distal condyles, relatively short external cnemial crest, narrow shaft and relatively long fibular crest place the species represented in the genus *Asio*. Detailed characters distinguish it from existing American species of the genus.

ACKNOWLEDGMENTS

This report is part of a series of studies on avian fossils of western United States being conducted under a John Simon Guggenheim Foundation research fellowship; my appreciation is extended to that Foundation. I wish also to thank the University of California Museum of Vertebrate Zoology for the loan of skeletons of *Asio flammeus galapagoensis* and *Asio stygius*.

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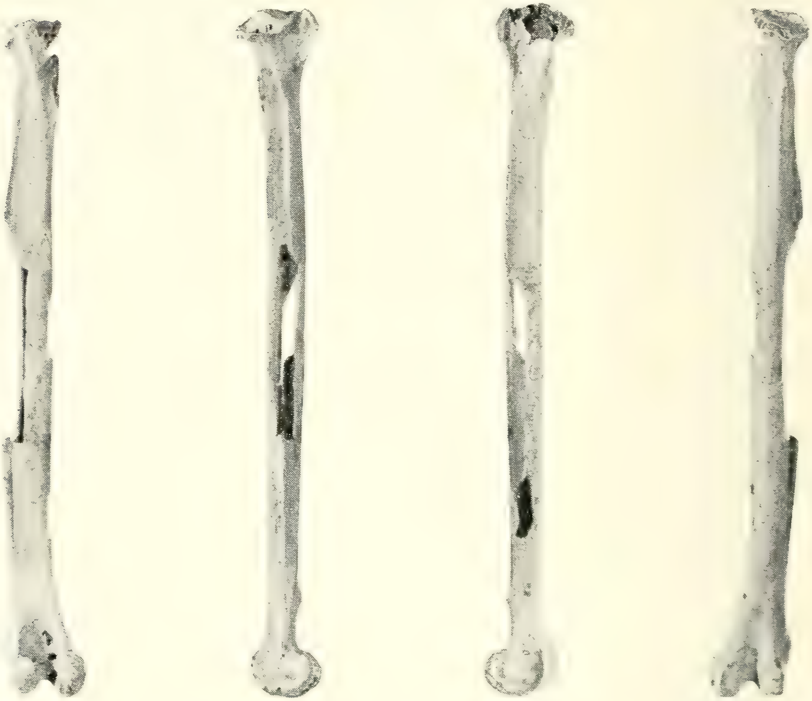

Figure 1. Type tibiotarsus of *Asio priscus.* Left to right, anterior, external, internal, and posterior views. Natural size.

Photographs of the type specimen were taken by George Brauer, retouched by Mary Butler.

Asio priscus,[2] new species

Type: Right tibiotarsus, lacking small portions of proximal end and shaft; Los Angeles County Museum No. 4712. Collected by Calif. Instit. Tech. party 1929-1930 (?).

[2] Latin, *priscus,* belonging to former times.

Locality, age and formation.—L.A. Co. Mus. (C.I.T.) locality No. 106; Arlington Canyon, Santa Rosa Island, California; late Pleistocene Tecolote member, Santa Rosa Island Formation.

Diagnosis: Similar to *Asio flammeus* and *Asio otus* in general contours of the tibiotarsus, and deep excavation of shaft anteriorly above distal condyles, but differing as follows: fibular crest flared externally, with broad longitudinal depression medial to its edge anteriorly, contrasting with broadly convex contour of anterior face of shaft in the existing species; intermuscular line above fibular crest slanting more abruptly posteriorly from crest, as viewed from external side; external cnemial crest less excavated at its postero-external edge; muscle papilla on internal side of distal end prominent; internal condyle 5 to 13 per cent deeper antero-posteriorly relative to its depth than in Recent species; length of bone measured to articular surfaces, 6.0 mm. greater than maximum of available Recent specimens of *A. flammeus* from California, and 1 mm. longer than female specimen of that species (Univ. Calif. Mus. Vert. Zool. No. 140967) from the Galapagos Islands.

TABLE 1

Measurements of Owl Tibiotarsi, Genus *Asio*

	A. *priscus* LACM no. 4712	A. *flam. flammeus* LACM no. Bi 892	A. *flam. galapagoensis* UCMVZ no. 140967	A. *otus* wilsonianus LACM no. Bi 910	A. *stygius* UCMVZ no. 93789
Length to articular surfaces	90.4 mm.	84.4 mm.	89.4 mm.	80.4 mm.	95.5 mm.
Breadth distal end	10.1	9.5	10.1	8.6	10.6
Depth external condyle	8.5	7.5	8.25	7.4	9.3
Depth internal condyle	8.3	7.3	8.2	7.3	9.1
Height, internal condyle, posteriorly	7.2	5.9	6.7	5.35	7.1
Greatest breadth across fibular crest	6.45	5.6	5.85	5.0	6.1
Depth internal side of shaft at level of distal edge of fibular crest	5.1	4.2	4.5	3.7	4.7
Ratio height (posteriorly) to depth of internal condyle[3]	86.7%	80.7%	81.7%	73.3%	78.1%

[3] Range of this ratio is approximately 73-82% in both *A. otus* and *A. flammeus.*

Discussion: Diagnostic features of *Asio priscus* as described above also separate the fossil from *Asio stygius* of Mexico and south. In addition, the tibiotarsus of *A. stygius* is more deeply indented posteriorly above the condyles, and the muscle attachment above and posterior to the fibular crest is not delimited by a ridgelike line as in *A. priscus* and the two existing North American species.

The occurrence of this fossil owl in the Santa Rosa Island Pleistocene prompted a reexamination of the *Asio* bones found at Rancho La Brea. Both *Asio otus* and *Asio flammeus* were originally thought to occur at this locality, but only the larger species *(A. flammeus)* is now recorded (Wetmore, 1956: 19). In a series of 125 complete tibiotarsi from Rancho La Brea, none equals the island specimen in length, or resembles it in the diagnostic characters described above. The maximum length in the series (88.2 mm.) lacks 1.2 mm. of equalling the tibiotarsal length of the female specimen of *A. flammeus galapagoensis*, and .6 mm. of a male specimen (U.C.M.V.Z. No. 140966). Fourteen La Brea tibiotarsi exceed the maximum of the two available Recent specimens of *A. flammeus flammeus* by 1 to 4 mm. At the other extreme (with a minimum of 72.2 mm.) there are five bones that are 1 to 3.5 mm. shorter than the minimum measurement of four available tibiotarsi of *A. otus wilsonianus*. As size alone distinguishes the limb elements of the two existing North American species, the size range of tibiotarsi suggests that both species were present at Rancho La Brea. This is borne out by measurements of the other leg elements, as well as the humerus and carpometacarpus. The minimum length of the Rancho La Brea series of ulnae, however, is larger by 3 mm. than the maximum of the Recent specimens of *A. o. wilsonianus*. Pit by pit study of each element of the Rancho La Brea eared owls would be of value, and might result in some significant observations concerning the relative proportions of wing to leg lengths in fossil and Recent owls. In this regard it should be noted that although the female specimen of *A. flammeus galapagoensis* notably exceeds *A. f. flammeus* in length of tibiotarsus, tarsometatarsus and ulna, its humerus and carpometacarpus are the same size as the maximum of *A. f. flammeus*, and the femur slightly less than the maximum. I am inclined to believe that both *Asio otus* and *Asio flammeus* occurred at Rancho La Brea, but that racially one or both may not fully have attained the skeletal proportions found in the existing California populations. In those elements in which *A. f. galapagoensis* exceeds *A. f. flammeus*, Rancho La Brea specimens do not attain the size of the Galapagos race, although they may exceed the maximum of *A. f. flammeus.*

The island fossil, *Asio priscus*, adds a third species to the California Pleistocene record of eared owls. Both in size and qualitative characters, *A. priscus* is distinct from the mainland forms.

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THE NORTHERN YELLOW BAT IN SINALOA, MEXICO

On the afternoon of June 30, 1962, Alan R. Hardy shot a northern yellow bat, *Lasiurus intermedius intermedius* H. Allen, from a coco palm tree in a trailer court, three miles north of Mazatlan, in the Mexican state of Sinaloa. This specimen (no. 3895 in the mammal collection of Long Beach State College), an adult female that carried two embryos measuring 25mm in crown-rump length, provides the first record of the species from Sinaloa and the northernmost record in western Mexico.

Lasiurus intermedius, which is known to occur in eastern North America from Virginia and Florida south to Honduras, first was reported from western Mexico in 1962—by Winkelmann (J. Mamm., 43:108) from Guerrero and by Gardner (*ibid.* 103) from Colima and Nayarit. Our Sinaloan specimen extends the known range of the species approximately 145 miles northwestward from the previous northernmost record in western Mexico, eight miles east of San Blas, Nayarit.

Field work that resulted in the collection of the aforementioned bat was supported by Public Health Service Research Grant AI-3407 from the National Institute of Allergy and Infectious Diseases to Long Beach State College.—Richard B. Loomis, *Department of Biology, Long Beach State College, Long Beach, California*, and J. Knox Jones, Jr., *Museum of Natural History, The University of Kansas, Lawrence.*

DESCRIPTION OF A NEW GENUS FOR *OMMATOPTERYX VIRESCENS* (HULST) (LEPIDOPTERA: PYRAUSTIDAE, GLAPHYRIINAE)

Hahn W. Capps[1]

The purpose of this paper is to provide a genus for the species *Ommatopteryx virescens* (Hulst), and to note its transfer from the Crambidae to the subfamily Glaphyriinae of the Pyraustidae.

When describing *Eromene virescens*, Hulst stated that it was not exactly congeneric with *Eromene*, the labial palpi being much shorter and the wing of a different shape. In addition to the differences Hulst noted, species of *Euchromius Guenée* (= *Eromene* Hübner and *Ommatopteryx* Kirby) differ from *virescens* as follows: Frons conical; the origin of vein 11 of the forewing is closer to the outer angle of the cell than to the middle of the cell and vein 1a terminates anterior to the inner margin; the origin of vein 2 of the hindwing is closer to the middle of the cell than to the lower angle; vein 4 is stalked with 5 and the cell open. In the male genitalia, the gnathos is much more strongly developed, extending well beyond the uncus and with a modified receptacle for the tip of the uncus, and the armature of the harpe is of a different type. In the female genitalia, the apophyses are nondilated; the anterior apophyses are very short, less than one-fourth as long as the posterior ones; the ductus bursae is much longer and the bursa copulatrix membranous, nonsclerotized and nonpigmented, except for the signum. The larval stage of the only species known, *E. ocelleus* (Haw.), is subterranean in habitat and feeds on the roots of Gramineae.

The venation, genitalia, and larvae (in both structure and feeding habit) of *virescens* are very similar to those of species of the pyraustid genus *Dicymolomia* Zeller of the Glaphyriinae. The short, concealed third joint of the labial palpus of the adult of *virescens* and the fruit-feeding habit of its larvae are also aberrant for a crambid, but normal for a pyraustid. The character of the labial palpus, in combination with the larval fruit-feeding habit and similarity to *Dicymolomia*, as noted, indicates that *virescens* is definitely not a

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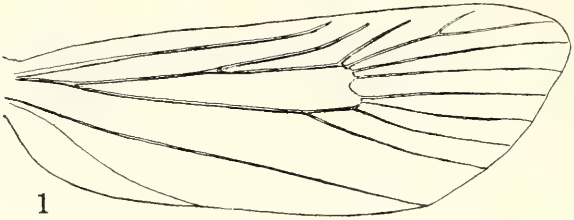
[1] Entomology Research Division, Agric. Res. Serv., U.S. Department of Agriculture, Washington, D.C.



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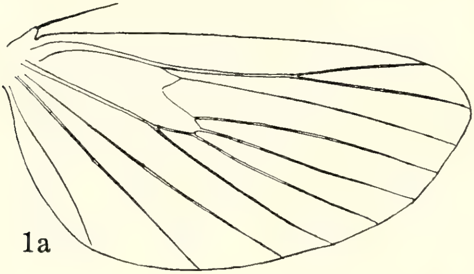

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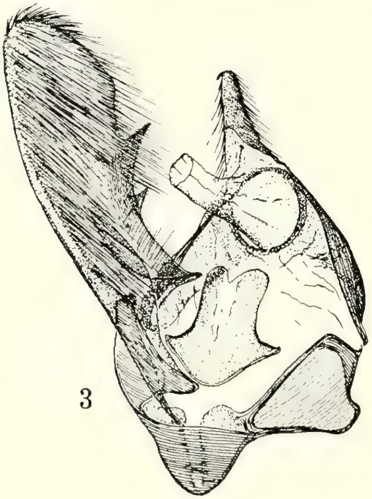

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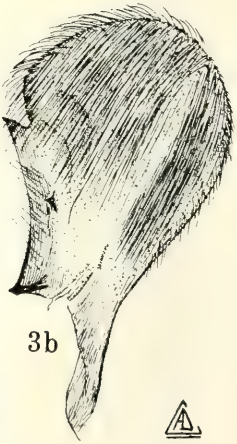

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crambid and that its true affinity is with the pyraustids. Subfamily placement, however, is somewhat moot and is complicated by its having characters of both the Glaphyriinae and the Pyraustinae. Although the palpi and frons are those of a pyraustine, I believe, with the presence of fringe on the lower median vein on the upper surface of the hindwing and the similarity of venation, genitalia, and larval stage to species of *Dicymolomia*, the larvae of which also feed in the fruits of cactus, *virescens* is best placed in the Glaphyriinae.

Upiga, new genus
Figures 1-4

Type: Eromene virescens Hulst.

Frons smooth, oblique but not conically produced. Ocelli present. Antennae simple, slightly thicker in male than female. Labial palpus porrect or but slightly upturned; length two times width of head or slightly less; third joint short, concealed by scales. Maxillary palpus well developed, triangulate distally. Forewing (Fig. 1) with 12 veins, 8 and 9 stalked, remainder with origin from the cell and free. Vein 1a free and terminating on inner margin, near middle. Hindwing (Fig. 1a) with 8 veins; 2, 3, 4 and 5 with origin from the cell and free; 2 from near outer angle; 3 and 4 from outer angle; 5 approximate to 4; 6 from slightly below upper angle; 7 and 8 long stalked. Cell closed. Termination of vein 1a of the forewing and discocellular veins of the hindwing may require denuding or clearing for discernibility.

Genitalia: Male (Fig. 3, 3b) with uncus well developed, tubular, distal termination a short, sharp, down-curved spine. Gnathos moderately developed, arms narrow, straplike, sclerotization weaker distally. Anellus broad basally, median area membranous, strongly sclerotized laterally. Harpe broad, flaplike. Aedeagus (Fig. 3a) with cornuti. Female (Fig. 4) with anterior portion of bursae copulatrix sclerotized, termination of bursa copulatrix bulbous, membranous and nonpigmented. Posterior apophyses shorter than anterior apoph-

Figures 1-4. Upiga virescens (Hulst). 1, 1a. Venation of fore- and hindwing. 2. Adult, male. 3. Male genitalia with harpe and aedeagus removed, three-quarter ventral view. 3a. Aedeagus, lateral view. 3b. Inner surface of removed harpe. 4. Female genitalia, ventral view. Delineations of venation and genitalia prepared by Mr. A. D. Cushman, Scientific Illustrator, U.S. Department of Agriculture; not drawn to scale. Photograph of adult is twice natural size.

yses; posterior apophyses with conspicuous dilation between middle and the ovipositor.

Remarks: Dicymolomia differs from *Upiga* in venation, genitalia, frons, and labial palpus as follows: In *Dicymolomia*, the origin of vein 11 of the forewing is approximate to the outer angle of the cell and vein 1a terminates anterior to the inner margin; in the male genitalia, the lateral arms of the anellus are much narrower and there is no spurlike projection between the base and distal end of the sclerotized part of costa of the harpe; in the female genitalia, the dilation of the posterior apophyses is weaker and at or near the middle, and the bursa copulatrix is nonconstricted and nonbulbous below the ductus seminalis; the frons is round and the third joint of the labial palpus is unconcealed, and well developed.

Upiga virescens (Hulst), new combination
Figures 1-4

Eromene virescens Hulst, 1900, J. N.Y. Ent. Soc., vol. 8, p. 225.

Ommatopteryx virescens (Hulst). Dyar, 1903, U.S. Nat. Mus. Bull no. 52, p. 410, no. 4619.—Barnes and McDunnough, 1917, Check list Lepid. Boreal Am., p. 140, no. 5418.—McDunnough, 1939, Mem. So. Calif. Acad. Sci., vol. 2, no. 1, p. 24, no. 5953.

Adult (Fig. 2). Alar expanse 17-18 mm. Genitalia: male (Figs. 3, 3a, 3b); female Fig. 4).

Mature larva 15-17 mm. long; cylindrical, rather robust and conspicuously tapered posteriorly (ninth abdominal and anal segments greatly reduced in size). Head, prothoracic, and anal shield pale amber, without conspicuous markings. Body color sordid white; skin scobinate (scobination distinct in cleared specimens); body setae weak, pinacula small, concolorous with adjacent body area. Prolegs on abdominal segments 3 to 6 and on anal segment; the prolegs rather short, little, if any, longer than wide. Crochets on abdominal prolegs uniordinal, arrangement a complete ring or slightly interrupted outwardly; on anal legs, uniordinal and in a transverse bandlike series.

Type: Male, in collection of U.S. National Museum. USNM Type No. 5186.

Type locality: Arizona.

Distribution: United States: Arizona. Mexico: Libertad, Sonora.

Food plant: Lophocereus schottii Engelm. (in fruits).

Remarks: The short, concealed, third joint of the labial palpus in combination with the conspicuous white frons and patagia, and the two rather broad, whitish, longitudinal lines on the forewing, one medial and the other along the inner margin, distinguish *virescens* from all other American Lepidoptera.

A difference in the crochets of the abdominal prolegs will distinguish the larvae of *virescens* from those of *Dicymolomia* species; they are uniordinal in the former and biordinal or irregularly triordinal in the latter.

Specimens of *virescens* are very rare in collections. Since *L. schottii*, in the United States, is restricted to a small area between Ajo, Arizona and the Mexican border, it appears likely *virescens* may be specific in respect to food plant.

I am indebted to members of the staff of the Division of Foreign Plant Quarantines at Nogales, Arizona, for rearing this species and supplying biological information.

OBSERVATIONS OF THE MATING PROCESS OF THE SPIDER CRAB *PUGETTIA PRODUCTA* (MAJIDAE, CRUSTACEA)

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General Remarks

There have been few descriptions of courtship and mating in the Brachyura. Some families within the Brachyura seem to be much more well-known than others in their breeding activities, possibly because the individuals are larger and more conspicuous in their activities. However, accounts of copulation in the family Majidae appear to be absent in the literature. With the exception of one account concerning the reproductive and copulatory activity of *Pugettia gracilis* (see Knudsen. *In press*) nothing is known of this aspect of spider crab behavior.

Fundamentally all of the Brachyura must achieve the transfer of sperm in essentially the same manner. That is, sperm must be transferred by means of the intromittent organs to the vulvae of the female crab. There it is stored in spermatheca and is used for fertilization during the time of egg deposition. However, the process of copulation may be extremely different between different families of crabs, depending on a number of circumstances. For example, the literature (Williamson, 1903: 101; Hay, 1904: 405; Churchill, 1918: 105) suggests that the cancroid crabs have elaborate courtship behavior prior to the molting of the female, and that they copulate while the female is in the soft shell condition. These references and others (Knudsen, 1960: 3-17, reporting on several species of xanthid crabs) suggest that the typical copulatory pattern is that of the male-over-female position. Hiatt (1948: 199) reported on the mating process of the grapsoid crab *Pachygrapsus crassipes* and gave the first account for this family. The remarkable point in his discussion (and Knudsen, *In press*) is that this species copulates in the female-over-male position, contrary to the heretofore norm.

With Hiatt's observations on *Pachygrapsus crassipes* and Knudsen's account of *Hemigrapsus nudus*. *Hemigrapsus oregonensis* and *Pugettia gracilis*, it would now appear that the female-over-male position is more common than originally suspected and that this

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position is typically used by the Grapsidae and the Majidae. The present discussion concerning *Pugettia producta* tends to strengthen this supposition.

FIELD OBSERVATIONS

During a very intensive two-year study of the more common crabs in the Puget Sound area, *Pugettia producta* and other species were kept under constant surveillance on bi-monthly field trips and in the laboratory. On several occasions it appeared as if courting pairs were attempting to initiate copulation. However, the receding low tide interrupted the only observations that at first seemed favorable in producing field data of the mating process. It was assumed then that pairs of this species probably mated while clinging to pilings, as is the case for *Pugettia gracilis*, but no concrete evidence of this could be presented. Recently, on May 14, 1963, I had the occasion to collect in Quartermaster Harbor, Vashon Island, near Tacoma, Washington, and to observe *Pugettia producta* in the process of copulation. Although one observation under most circumstances would be considered inadequate for the basis of a descriptive publication, I feel that due to my long-term study of this and other species and my many observations and publications concerning the mating process of the Brachyura, that this observation is justifiably of significant value to warrant the description herein.

The habitat in Quartermaster Harbor is essentially that of a sandy beach which gradually slopes out into the depths of the bay. Considerable algae is carried into this area by the tidal current. Although higher up on the beach much of the seaweed present (such as *Ulva*) is attached to a gravel substrate, the weed in the lower intertidal and subtidal zone is for the most part unattached and permitted to drift around very slowly. During the spring and summer large numbers of *Pugettia producta* migrate into this kind of a habitat in order to feed among the drifting algae. A wide assortment of the more common species of green, brown, and red algae is present permitting almost any species of weed desired by this crab in its normal diet. A large number of male and female crabs was encountered in Quartermaster Harbor and in each case the females were examined in order to ascertain if they had eggs attached to the pleopods and to determine the approximate age of the eggs. None of the females possessed extremely new eggs (of a bright orange color) but about 50 per cent of those examined possessed eggs of an intermediate age (deep red in color) or of a pre-hatch state of development showing the semi-pigmented embryo with the eyes in evidence. In this latter state of development the eggs appear brownish-gray, and under the microscope the gross anatomy, eyes, mouth parts, and the beating of the hearts of the larvae can be observed.

One pair of copulating *Pugettia producta* was observed in shallow water among some drift algae. A few moments were devoted to observing the gross position of the two animals after which they were retrieved from the water for closer examination. My technique in the latter operation is to reach down behind the copulating animals and to simultaneously clamp my fingers around the carapace of both the male and female and thus completely restrict separation or any alteration of position. A careful examination was then made of the crabs without interrupting their copulatory position. Upon being set free the two animals quickly separated and hid among the drift seaweed.

The gross position was of interest in that the male was postured beneath the female as is true of *Pugettia gracilis* and several species of the grapsoid crabs. The actual means of posturing the female for copulation is, of course, unknown but may well be similar to that of the grapsoid crabs which work on a level substrate. This involves the male's lifting of the female by her chelipeds and then the simple procedure of rolling backwards, thus positioning the female over the male. The male *Pugettia producta* held onto the female by the use of his chelipeds, which were folded over her carapace. His walking legs were also interlaced between her walking legs and folded over her carapace. It appeared as if most of the ambulatory legs of the female were used for supporting the pair and for locomotion. When undisturbed the pair tended to move along the substrate with the drift algae and thus remain partially hidden.

As is true of other species of Brachyura the abdomen of the male was open posteriorly beneath that of the female. This essentially forces the female abdomen into an open position and exposes the vulvae. Both of the intromittent organs were inserted into the vulvae suggesting the transfer of sperm. Field equipment was lacking for the dissection and microscopic study of spermatheca and thus it was impossible to see if fresh sperm were present. Both animals seemed extremely passive and showed none of the typical bluff responses that often greet a would-be predator or intruder. This passive behavior of copulating crabs toward an intruder is typical of many other species of crabs in the family Xanthidae and Grapsidae.

Perhaps the most unique feature of this observation is that the female in the copulatory pair possessed eggs attached to the pleopods. These were in the pre-hatch condition and probably would hatch during the month of May or June. This would permit the deposition of new eggs well within the time range of from April through August which is one of the two periods of egg deposition for this species (Knudsen, *In press*). It would be conjecture to suggest that this species habitually copulates prior to the hatching of the current brood of eggs. However, it does strongly open the possibility that this may be a practice, in part at least, and that this species may elect to copulate either before or shortly after the hatching process has occurred. To the writer's knowledge there are no other data available for the Brachyura suggesting copulation while eggs are still attached to the pleopods. Possibly when more field observations are made, this, like the male-under-female position, may become a more common event than it now seems.

More observations are surely needed concerning the natural history of the Brachyura. In many instances, such as the actual process of copulation, the collector is more lucky, than anything else, in obtaining field data. The spider crabs seem to be especially secretive in their activities both in the field and in the laboratory and thus are more difficult to detect. Should field collectors encounter copulating pairs of the Brachyura, it would be of great value to have careful observations made as to the time, position, and behavior of the animals involved.

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FIRST RECORD OF THE EXTINCT SHARK, *SQUALICORAX FALCATUS*, FROM CALIFORNIA

The upper Cretaceous shark fauna in California has received little attention. Jordan and Hannibal (Bull. So. Calif. Acad. Sci., 22, 1923) listed and discussed four questionable species, based on fragmentary teeth, from the upper Cretaceous Chico formation, near Martinez, California. Camp (Mem. Univ. Calif., 13, 1942) mentioned small sharks' teeth from the Garzas sand member of the Moreno formation.

Professor William J. Morris, of Occidental College, recently gave the Los Angeles County Museum a single sharks' tooth (LACM 6459). This specimen (Fig. 1) was collected at LACM locality 1895, near the town of Silverado, California, in the Santa Ana Mountains. The tooth is imbedded in a grey fossiliferous siltstone, with a pelecypod (*Isocardia* sp.), other shell fragments, and bits of altered wood. The rock containing the tooth was taken from the Holz silt member of the Ladd formation; which is of Senonian age (Popenoe, Calif. Div. Min. Bull. 170, 1954).

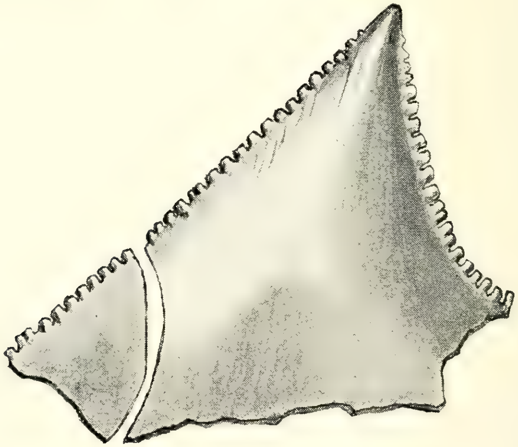

Figure 1. Squalicorax falcatus from the Holz silt member of the Ladd formation, upper Cretaceous, southern California. Eight times natural size.

Only the crown of the tooth is present, yet the shape and serrations are clear enough to identify it as a lateral tooth of *Squalicorax* *falcatus* (Agassiz). The genus *Squalicorax* long has been placed in the family Cetorhinidae and is thought by White (Bull. Amer. Mus. Nat. Hist., 74, 1937) to lie between the family Isuridae and the genus *Cetorhinus*, the basking shark.

Squalicorax is a common upper Cretaceous genus of sharks and is known to extend from the Cenomanian to the Danian. McGrew (Contrib. Geo. Univ. Wyo., 2, 1963) illustrated an excellent example of this genus from the Paleocene of Wyoming. The species *S. falcatus* is confined to the upper Cretaceous, and previously has been reported from southern India, Madagascar, Northern Europe, England, Africa, New Jersey, Maryland, Mississippi, Georgia, Texas, Kansas, Wyoming, New Mexico, and now southern California.—Shelton P. Applegate, *Los Angeles County Museum, Los Angeles, Calif.*

NOTES ON THE BIOLOGY OF *BLEPHAROCERA MICHENERI* AND *PHILORUS YOSEMITE* (DIPTERA: BLEPHAROCERIDAE) IN SOUTHERN CALIFORNIA

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During the spring of 1962 I was fortunate to discover thriving populations of two blepharocerid species, *Blepharocera micheneri* Alexander, 1959, and *Philorus yosemite* (Osten-Sacken, 1877) in the San Gabriel Mountains of southern California. I took the opportunity to record numerous observations on their biology which I summarize here. The data add to the very little existing published information on the North American species of this family. This deals mainly with one eastern species, *Blepharocera tenuipes*, (Comstock & Comstock, 1907; Kellogg, 1900; Johannsen, 1903). Only brief notes by one author (Kellogg, 1903a, b) are recorded for the following 5 western species: *Agathon elegantulus*, *comstocki*, *doani*, *Blepharocera jordani* and *Philorus* n. sp.[1] (as *yosemite*).

The exact locality where the observations were made is in Big Tujunga Canyon, Angeles National Forest, Los Angeles County, primarily in the tributary stream that drains Trail Canyon, a small side canyon in the Big Tujunga complex. During the rainy season (January to April) this stream is very turbulent, with many small falls and rapids. During the dry summer it dries to a few pools. Three pools at approximately 2000, 2450 and 3000 feet elevation were studied. *B. micheneri* larvae and pupae were first collected on April 8, *P. yosemite* on April 22. The latest date when larvae, pupae and adults could be found was July 16.

The two species were distinguished in the field by the characteristics described in Table 1.

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[1] The contiguous nature of the pupal gills mentioned by Kellogg in the latter paper (1903b) indicates that the species with which he was dealing was not *yosemite* (gills not contiguous) but another species which Dr. C. L. Hogue of the Los Angeles County Museum presently is describing as new from Kellogg's and other material.

Blepharocera micheneri

LARVAL HABITATS

1. *Above the water surface on rocks wet by spray.* Larvae were not common in this habitat. When they occurred they were found often as much as a foot above the water line. Frequently larvae of *P. yosemite* were found here too.

2. *Submerged rocks in rapid water.* Frequently dense aggregations were found here. Rocks in the swiftly moving water at the lip of small waterfalls usually yielded the largest numbers, smaller concentrations being found on rocks in rapids. No larvae were found on the intervening gravel between rocks in rapids.

3. *Shallowly submerged shelves of rock.* Entire shelves had large populations in which each individual was usually within a few inches of others.

4. *Rocks pounded by waterfalls.* Larvae were common on these, in the most turbulent area of the stream. Simuliid larvae shared the same habitat and far outnumbered the blepharocerid larvae.

Always, larvae in submerged habitats were found near the surface, none at a greater depth than about two inches and the majority within the top inch of water.

LOCOMOTION OF LARVAE

Two types of locomotion were noted: 1. *Caterpillar-like.* This was the motion of the undisturbed, feeding and wandering larva. The ventral suckers act as false feet like the prolegs of caterpillars. Undulating waves pass along the length of the body and as each wave passes a sucker it is released, moved forward and reattached. 2. *Lateral progression.* When a larva was disturbed (as when touched with a finger or instrument or when the rock to which it was attached was removed from the water), it often exhibited a progression sideways. Similar movements were noted for another species by Kellogg (1903a:212). First the larva releases all except the anterior or the posterior sucker and swings the opposite end out to the side, pivoting around the attached sucker. The free end is reattached and the former pivot sucker is released. The newly released end is then swung to the side, pivoting around the newly attached sucker and reattached. Then the motion is repeated. By this series of movements larvae progress laterally in an alternating, stepwise manner. Lateral progression is much more rapid than caterpillar-like progression.

Larval Aggregations

Larvae were seldom found singly. Usually they were in small to large aggregations of various sizes and instars. The aggregations were particularly dense on submerged shelves of rock and at the lips of waterfalls. Larvae never were in contact although in some particularly concentrated groups they were within ½ inch of each other.

Behavior of Prepupal Larvae

When ready to pupate, larvae usually congregate at spots that already had several to many pupae, *i.e.* there seemed to be preferred pupation sites. Young larvae were usually not found in these sites.

The orientation of larvae settling down for pupation appeared to be related to current velocity. In very swift water all individuals align themselves with the current, facing downstream. In slower currents only a few were noted so aligned, most being at an angle to the flow. Even an occasional individual was found oriented nearly at right angles to the current. None were ever found facing upstream.

Pupal Habitats

Pupae were most often found on submerged rocks in rapid water as is the case with larvae. However, they were generally in shallower areas, usually less than ½ inch from the surface. Rocks at the lips of waterfalls harbored the largest numbers, smaller groups being found on rocks in rapids. Pupae were also found in dense, localized groups on rocks pounded by a waterfall.

Resting Places of Adults

Moist, overhanging rocks and damp, deep recesses formed by exposed roots of large trees were preferred resting places. Phalangids and the psychodid, *Maruina lanceolata*, were often found resting in the same spots.

Adults seemed to be inactive most of the day. They hang from the underside of their perches in a peculiar posture. All claws grasp the perch within ¼ inch of each other and the long legs bend outward to form a shape like a Japanese lantern. The abdomen hangs almost vertically with the wings folded under it. The position was the same whether the adult was hanging from a flat rock or small twig.

DAILY MIGRATION OF ADULTS

Adults exhibited a daily migration that appeared to be related to general humidity fluctuations. In the morning and during moist, foggy days, adults were abundant in bushes up to 25 feet from the stream. On sunny days after mid-morning, and on foggy days when the sun emerged around noon, adults began to appear near the stream. They were found at the stream until at least mid-afternoon. At the height of the season during late May, swarms were only found near the stream during these hours.

No observations were made from mid-afternoon to about an hour before sunset. From the latter time until it was too dark to work, the adults were not found concentrated in one area. Instead, sweeping yielded only a few from rocks and roots that had been frequented earlier and a few from bushes up to 25 feet from the stream. No adults were collected at night when lights were placed in the area although nocturnal insects were abundant.

There was one observed exception to the daily migration. This involved a mossy bank that was ten feet from the stream and was overgrown with small ferns. Here, during most of the season, sweeping at any time of the day always yielded a few adults. When the bank dried near the end of the season, the adults deserted it during the noon hours just as they deserted bushes at this time.

FLIGHT HABITS OF ADULTS

Adults usually flew like tipulids, bobbing up and down both in normal flight and when approaching a perch. Generally, flight was slow and infrequent. During flight, the hind legs trailed while the other pairs were sometimes folded or extended. When approaching a perch all legs were spread and the forelegs extended towards the landing spot. The insect held this position in flight whether or not it actually landed.

APPARENT FEEDING BEHAVIOR OF ADULTS

On June 27, around mid-morning, adults were unusually active. Those resting on twigs would suddenly dart out a foot or more, hover for an instant, and then return to their perch. It was a warm, sunny day and many small insects were flying. The many individuals exhibiting these actions seemed, like robber flies, to be in the act of capturing prey. However, none were actually seen to do so even though one adult was watched for over five minutes while it made many darting flights before finally flying away. Either their actions were not predatory or their prey was too small for me to see. This behavior was observed only on this one occasion.

APPARENT OVIPOSITING OF FEMALES

During three field trips a total of eight females were observed apparently in the act of ovipositing. These observations were on June 16, 27 and 12. No observations were made on the first day until about noon when the morning fog lifted. The remaining days were sunny and warm and observations were made from mid-morning until afternoon. On the first date two females, on the second date five and on the third date one, were observed. The first female was captured for identification. The others were observed until they flew away.

The places where the oviposition occurred had the following characteristics in common: 1. moving water varying from the turbulence of a waterfall basin to nearly calm pools, 2. earlier presence of larvae, 3. shade provided by white alders.

The females behaved in the following manner. After hovering above the water generally facing upstream, they dropped to the surface and bobbed like tipulids, still facing upstream. At each dip, the tip of the abdomen touched the water. Insufficient light and the timidity of the females made it impossible for me to see if they landed on the water at the instant their abdomens touched the surface. After bobbing this way for about 10 seconds they usually flew away. On one occasion a female flew to the bank vegetation and rested for about 5 minutes before returning to continue the activity. In other cases they either flew out of sight or landed among a group of adults in some recess.

Philorus yosemite

LARVAL HABITATS

1. *Rocks wet by spray*. In this situation, which was also frequented by *B. micheneri* larvae, *P. yosemite* was the dominant species. The larvae were often very difficult to find because their color blended with the dark rocks. Often they could be located only by touch.

2. *Emergent rocks wet by capillarity*. Larvae frequently were

common on the moist patches of such rocks. This habitat was frequented mainly in the narrow rocky courses of the stream where the water trickled over the rocks.

3. *Submerged rocks.* Only occasional larvae were found below the stream's surface, near the waterline. In all cases the larvae were in very turbulent water.

Locomotion of Larvae

The same remarks for *B. micheneri* above apply here.

Behavior of Prepupal Larvae

This was about the same as for *B. micheneri*. There also seemed to be preferred pupation sites not frequented by young larvae and the pupae were found in groups, each generally facing downstream.

Pupal Habitats

Rocks wet by spray were the most frequent sites for pupae. They usually were found in groups located close to the stream's surface, often on rocks that were frequently splashed or alternately submerged and exposed as the turbulence fluctuated. Particularly large groups of over 25 individuals were common at waterfalls where there was great turbulence.

Pupae also were found on emergent rocks wet by capillarity, the site of many larvae also. The larvae were either close to the stream's surface or in damp recesses. In a few cases pupae were found on moist rocks that were fully exposed to the sun during parts of the day.

A few pupae were found, barely submerged on rocks in turbulent water. These were either isolated individuals or groups of less than five.

Resting Position and Habits of Adults

Adults were found clinging to the sides and undersides of cliffs and overhanging rocks located up to about 100 feet from the stream. The greatest numbers were found on cliffs within about 20 to 40 feet from the stream. Many were found closer than 20 feet but only a few near the 100 maximum range. Some were encountered up to about 100 feet above the stream on cliffs.

Resting flies clung with their bodies pressed against the surface with their legs radiating from the thorax. A similar attitude was noted for *Agathon elegantula* by Kellogg (1903a:216). The wings also were extended and pressed against the rocks. They always faced upward except when resting on the horizontal underside of an overhanging rock.

Adults generally rested in groups, often in full sunlight, in contrast to the habit of *B. micheneri* which seems to require more humid surroundings.

FLIGHT HABITS OF ADULTS

P. yosemite has a less hesitant flight than *B. micheneri*. When disturbed, they fly directly to a new perch with little or no tipulid-like bobbing. On warm days the adults were noted to be very alert and easily disturbed. On cold days, unlike *B. micheneri*, they could be captured by hand.

THE EMERGENCE OF AN ADULT

The following observations were taken in the morning on a pupa which was just above the water surface on a large rock in a rapid. As the turbulent water fluctuated every few seconds, the pupa was alternately exposed and submerged.

10:45—Discovered pupa emerging. Adult emerging slowly and is frequently splashed by the swift current. It is cream colored.

10:47—Adult now ⅔ emerged. The halteres are standing out from the thorax. The eyes are darker than the rest and the thorax is swollen. The wings resemble long black straps along either side.

10:55—Emergence nearly complete. The appendages are still held close to the body. Turbulent water frequently submerges and splashes the fly but does not dislodge it.

10:58—Wings are suddenly pulled free from the pupal case. They are flicked and immediately unfold. They are smoky colored. At this point the other appendages are also pulled loose and the fly grasps the rock. It twists around so that it faces upward and struggles to pull its hind legs free also. While glancing at my notes the fly disappeared. I immediately looked for it in a fairly calm pool a few feet down stream but did not find it. Apparently it had flown away.

COMPARISONS OF THE TWO SPECIES

HABITATS

Larval habitats of the two species overlap. Both were found at the first and second pools, although only *P. yosemite* occurred at the third pool. *B. micheneri* was the most abundant in the lower courses of the stream while the opposite was true of *P. yosemite*. Both species as larvae could live on either submerged or emergent rocks, although in general, *B. micheneri* preferred the former, *P. yosemite* the latter.

SEASONAL CHANGES IN RANGE AND ABUNDANCE

Larvae. At mid May, a few weeks after their first appearance, *P. yosemite* larvae were found from the first to the third pool. The greatest numbers were in the area of the second to third pools. As the season progressed, larvae of *P. yosemite* became scarce at the first pool, although they did not vanish from this area for many weeks. While this species became scarce, remaining abundant only at the higher elevations, *B micheneri* grew more abundant. In late May, at the time that *P. yosemite* had become scarce, *B. micheneri* larvae reached their greatest numbers and extended from the first pool to an area between the second and third pools.

Near the end of June, *P. yosemite* larvae, after weeks of decreasing in number, finally vanished. *B. micheneri* also gradually declined until mid July. At this time only a few undersized larvae were observed and some mature specimens collected. At the end of the season, *B. micheneri* larvae were found only near the first pool.

Adults. From mid to late May, a few weeks after they had first appeared, *P. yosemite* reached peak abundance. Some were found in the area of the first pool but the greatest concentration was around the second to third pools. At this time *B. micheneri* adults were very scarce, only a few being taken near the first pool. After late May, *P. yosemite* adults went through a slow decline in numbers that ended with their disappearance around mid June.

While adult *P. yosemite* numbers diminished, *B. micheneri* became slowly more abundant, reaching their peak in late June. At peak they were far more abundant than had been *P. yosemite*. Only a few hundred of the latter were observed while *B. micheneri* occurred in swarms of thousands. After maintaining a population peak for about a week, *B. micheneri* suddenly declined and had vanished by mid July.

ACKNOWLEDGMENTS

I would like to thank C. P. Alexander, Amherst, Massachusetts for identifying the flies, C. L. Hogue, Los Angeles County Museum, Los Angeles, California, for his advice and assistance in preparing this paper for publication and Peter Spoecker, who helped me with some of the observations.

Considerable material was preserved of both species, most of which I have deposited in the entomological collection of the Los Angeles County Museum. The remainder is at San Fernando Valley State College, Northridge, California. From this material, C. L. Hogue is presently preparing descriptions of all stages to be published in a future paper.

TABLE 1
Field Characters of *B. micheneri* and
P. yosemite

	B. micheneri	*P. yosemite*
Larvae	Skin smooth, generally brown with black stripes on head.	Black with conspicuous spines.
Pupae	All black with upright, close lamellate gills.	Black with bright metallic green sheen in strong light with spreading, grey rippled gills.
Adults	Small (range in length in male: 4-5mm; in female: 6-8mm. General color light brown, both sexes with clear wings.	Large (range in length in male: 5-7mm; in female: 8-10mm. General color light grey, male with infuscated wings.

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NOTES ON *ATRACTOCERUS BRASILIENSIS* LEPELTIER & SERVILLE (COLEOPTERA: TELEGUSIDAE) IN WESTERN MEXICO

Recent faunal studies in western Mexico by field parties from Long Beach State College have resulted in the collection of several examples of *Atractocerus brasiliensis* Lepeltier & Serville. They have been compared with named material from Brazil belonging to that species.

This species has been previously recorded by Vaurie (Coleopterists Bull. 10(6):86, 1957) and previous workers from Chile and Argentina northward to Puerto Rico, Cuba and San Luis Potosi in Mexico.

The following abbreviations are used: (LBSC) for Entomological Collections, California State College at Long Beach, (LACM) for Entomological Collections, Los Angeles County Museum.

Records not previously published: BRAZIL: *Sao Paulo*, Sao Jose dos Campos, X-24/25-60, D.L. Tiemann Collr. (LACM). PANAMA: *Canal Zone*, Summit Radio Facility, VII-13-46, W. C. Scott Collr. (LBSC). MEXICO: *Oaxaca*, Tehuantepec, VI-15-62, 330′, at neon sign, G. R. Swenson Collr. (LBSC); VII-19-63, at light, Eric Fisher (LACM); Zanatepec, VI-17-62, 920′, at white light, G. R. Swenson Collr. (LBSC); *Jalisco*, Tizapan, VII-22-62, 4500′, at car lights, T. R. Wilson Collr. (LBSC). *Nayarit*, 6 mi. N Compostela, VIII-14-63, 3400′, at blacklight, E. L. Sleeper Collr. (LBSC). *Sinaloa*, 17 mi. NE San Blas, IV-7-63, at coleman lantern, A. R. Hardy & W. J. Wrenn Collrs. (LBSC). *Sonora*, 40.7 mi. SE Navojoa, XII-23-62, 100′, at white light, A. R. Hardy & G. R. Noonan Collrs. (LBSC); La Aduana, 1600′, VIII-5-63, at coleman lantern, R. B. Loomis, R. M. Davis & W. J. Wrenn Collrs. (LBSC); 26 mi. SW Tezopaco, VIII-25-63, at blacklight and under bark *Cassia emarginata* L., E. L. Sleeper Collr. (LBSC). This latter location (109° 12′, 27° 51′) represents the northernmost record for this species. It is 22 airline miles northeast of Ciudad Obregon and only 265 airline miles from the nearest similar habitat in the United States.

With the exception of the material from near Tezopaco, Sonora, and Tizapan, Jalisco, the material from Mexico has been taken in the Tropical Evergreen Forest, Tropical Deciduous Forest or the Tropical Thorn Forest Vegetation Zones of Starker Leopold. The Tizapan, Jalisco area is Pine-Oak Forest typical of the Sierra Madre Occidental. The Tezopaco, Sonora collecting area shows the influence of several vegetation zones. The most obvious were the Tropical Deciduous Forest and the Mesquite-Grassland Vegetation Zones. This area is much like the latter vegetation zone in Arizona. The dominant plants of the Tezopaco site were *Lysiloma divaricata* (Jacq.), *Lysiloma watsoni* Rose, *Acacia constricta* Benth., *Acacia cymbispina* Sprauge & Riley, *Acacia occidentalis* Rose, *Acacia farnesiana* L., *Prosopis* spp., *Cassia emarginata* L., *Cercidium* spp., *Jatropha spathulata* Ortega and *Franseria ambrosiodes* Cav. and several species of grasses.

The area 6 mi. N Compostela, Nayarit was also somewhat a marginal area in that while it was predominantly Tropical Deciduous Forest there were numerous oaks present. On the higher slopes and ridges there were other influences of the Pine-Oak Vegetation Zone.

The author gratefully acknowledges the assistance of Drs. Fred Truxal and Charles L. Hogue of the Los Angeles County Museum for determined specimens; Messrs. S. W. Agnew, R. M. Davis, A. R. Hardy, G. R. Noonan, P. Sullivan, and W. J. Wrenn for assistance in the field studies. The travel funds for field studies were supplied in part by Public Health Service Research Grant AI-3407 from the National Institute of Allergy and Infectious Diseases (R. B. Loomis, Principal Investigator).—Elbert L. Sleeper, Entomology, California State College at Long Beach, Long Beach, California. Biological Sciences Contribution No. 11.

NOTES ON *EUPHORIA FASCIFERA* (LECONTE) (COLEOPTERA: SCARABAEIDAE) IN CALIFORNIA

In the course of studies of the insects of Joshua Tree National Monument and other localities in Southern California, specimens of *Euphoria fascifera* (LeConte) were taken. These seemingly are the first records of this insect from California. This species has been taken previously in southeastern Arizona and in Baja California Sur (type locality).

Five specimens are at hand. Four bear the following data in common: California, Riverside Co., Joshua Tree National Monument. Other data: Jumbo Rocks Stn. #1, IX-28-1962, E. L. Sleeper Collr. (1 specimen) (Long Beach State College Collection); 1.8 mi. NW Old Dale Junction, X-13-1962, E. L. Sleeper Collr. (3 specimens) (Long Beach State College and A. R. Hardy Collections). The fifth specimen was taken in San Bernardino Co., California, Mountain Pass, Mescal Range, VII-29-1961, D. S. Verity Collr. (Verity collection).

The specimens from Joshua Tree National Monument were taken in gallon bait cans containing a mixture of 236 ml. (1 cup) of glycerine, 2 ml. proprionic acid, and filled with a solution of molasses and water in proportions of 1 part molasses to 9 parts water. The glycerine was used to prevent the dessication of the mixture, while the proprionic acid acted as a preservative to prevent rotting or molding of the material, and to slow down fermentation. This type of bait can has been extremely successful in the drier regions of California and Arizona. The specimen taken by Mr. Verity was collected sitting on *Larrea divaricata* Cav.

The two locations in Joshua Tree National Monument are very different in vegetational composition. At Jumbo Rocks Stn. #1, El. 4400′, the vegetation consists primarily of scrub oak (*Quercus turbinella* Greene), catclaw (*Acacia greggi* Gray), desert almond (*Prunus fasciculata* Torr.), hollyleaf buckthorn (*Rhamnus crocea illicifolia* (Kell.)), desert squaw-bush (*Rhus trilobata* Nutt.), joint fir (*Ephedra viridis* Coville), cottonhorn (*Tetradymia spinosa* H. & A.), peach-thorn (*Lycium cooperi* Gray), Anderson thornbush (*Lycium andersoni* Gray), Joshua Tree (*Yucca brevifolia* Englm.), Mojave yucca (*Yucca schidigera* Sarg.) and California juniper (*Juniperus californica* Carr.). Approximately one-tenth of a mile west are numerous desert willows (*Chilopsis linearis* (Cav.)). About the same distance to the east are creosote bushes (*Larrea divaricata* Cav.). At 1.8 mi. NW Old Dale Junction (Porcupine Wash), El. 2375′, the dominant vegetation consists of desert ironwood (*Olneya tesota* Gray), smoke tree (*Dalea spinosa* Gray), indigobush (*Dalea schotti* Torr.), Mojave yucca (*Yucca schidigera* Sarg.), goatnut (*Simondsia chinensis* (Link)), holycross cholla (*Opuntia ramosissima* Englm.), creosote bush (*Larrea divaricata* Cav.), desert willow (*Chilopsis linearis* (Cav.)), and burrobush (*Franseria dumosa* Gray).

The authors wish to acknowledge the aid and assistance of Drs. Charles Hogue and Fred Truxal of the Los Angeles County Museum, and Dr. M. Cazier of Arizona State University who have made determined material available, Mr. W. R. Supernaugh, Superintendent, and Mr. J. R. Youse, Naturalist, of Joshua Tree National Monument for valuable assistance in research projects within the monument. Travel funds for the field work at Joshua Tree National Monument were supplied in part by the United States National Park Service.—E. L. Sleeper and Alan R. Hardy, Entomology, California State College at Long Beach. Biological Science Contribution No. 12.

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OCCURRENCE OF THE INSECTIVORE GENUS *MICROPTERNODUS* IN THE JOHN DAY FORMATION OF CENTRAL OREGON

R. A. Stirton
and
John M. Rensberger
University of California, Berkeley[1]

Introduction

A rostrum and part of a left mandible of a small insectivore, still held in occlusal position by the matrix, was found in an exposure of the John Day formation during the summer of 1956 by Anthony Morgan of Monument, Oregon. The boy's father, Milton Morgan, who had collected fossils in the valleys of the John Day River for a number of years, immediately recognized the specimen as different from the others he had seen. He presented the specimen to the Museum of Paleontology with the request that it be described by the senior author.

The junior author has undertaken a study of the vertebrate sequence in the John Day beds. This research is being done in conjunction with the stratigraphic studies of the formation by Richard V. Fisher of Santa Barbara and Richard L. Hay of Berkeley, both at the University of California. It will be some time before these studies are completed; consequently, because of Mr. Morgan's request, the description of the insectivore is presented at this time.

The first information on the genus *Micropternodus*, to which the John Day specimen belongs, appeared when W. D. Matthew (1903) described *M. borealis* from a mandible which was found near Pipestone Springs, Montana. Then in 1954, T. E. White published on *Kentrogomphios strophensis*, based upon the anterior part of a cranium and a referred right mandibular fragment which were found about one mile north of Canyon Ferry, Montana. Two other man-

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[1] Museum of Paleontology.

dibular fragments from Pipestone Springs were referred to *Micropternodus* by Jean Hough (1956). One of these (Fig. 17) was subsequently identified as *Geolabis* by McKenna (1960). McKenna also observed that Hough's Fig. 16 is not referable to the same genus as Fig. 17, but did not confirm its reference to *Micropternodus*. Additional specimens, including the rostrum of a cranium and ten mandibular fragments found at Pipestone Springs by J. LeRoy Kay, were studied by Dale A. Russell (1960). Russell concluded that *K. strophensis* White was a synonym of *M. borealis* Matthew. He reviewed all of the publications and statements about the genus as well as the discussions and opinions on its broader relationships in the order Insectivora. Reed (1956) has suggested that the humeri from Pipestone Springs, which he described (1954) as *Cryptoryctes kayi*, may belong to *Kentrogomphios* (= *Micropternodus*). Unfortunately no limb bones have been found in association with any specimen to support this plausible conclusion.

The only other genus clearly referable to the Micropternodidae is *Clinopternodus* Clark, 1937, from an upper member of the Chadron formation in South Dakota.

The association of the upper and lower teeth in the John Day *Micropternodus* confirms the reference of these teeth in the types and referred specimens from Pipestone Springs and Canyon Ferry. It also extends the vertical range of the genus from early Oligocene (Chadronian) to the early Miocene (Arikareean).

ACKNOWLEDGEMENTS

We wish to commend Mr. Milton Morgan for his appreciation of the true value of the specimen found by his son. He not only recognized the fossil as representing a mammal not previously discovered in the John Day formation, but felt that its importance could be fully realized only if it were described by a professional paleontologist. This attitude by amateur paleontologists and "rock hounds" is becoming progressively more important as thousands of these people swarm over the countryside in search of fossils and rocks to satisfy their curiosity.

We are grateful to Dr. Craig Black of the Carnegie Museum for the loan of the type of *Micropternodus borealis*, and to Dr. C. L. Gazin of the U. S. National Museum for permission to study the type of *Micropternodus strophensis*. The illustrations were done by Owen J. Poe. All measurements are in millimeters.

ABBREVIATIONS

AMNH	American Museum of Natural History
CM	Carnegie Museum
UCMP	University of California Museum of Paleontology
USNM	United States National Museum

Order—INSECTIVORA
Superfamily—*ERINACEOIDEA*
Family—MICROPTERNODIDAE

Family Diagnosis.—About the size of moles; probably fossorial (see Reed, 1954; 1956). Rostrum long, moderately wide and deep (*Micropternodus borealis*), or short, wide and deep (*M. strophensis* and *M. morgani* sp. new.); sutures tend to fuse early; infraorbital foramen short and large; no lacrimal tubercle.

Upper cheek teeth hypsobrachiodont; ectolophs slant strongly lingually; three upper incisors, I^1 greatly enlarged in *M. borealis*, not known in other species. Canines with one root. P^1 not present. Diminutive alveolus for P^2 in *M. borealis* and *M. strophensis*, one root; P^2 not present in *M. morgani*. P^3 nearly triangular; main cusp an oblique sectorial blade with steeply inclined posterior edge; no anterior basal cusp; protocone extremely reduced. P^4 submolariform; small hooklike cusp behind and above metastyle at posterior end of sectorial blade of ectoloph; paracone high, somewhat trenchant, anterior in position; protocone almost directly linguad of paracone, sharp triangular outline, half as high as paracone; inner part of tooth wide; hypocone separated from protocone by V-shaped emargination of lingual border of tooth; talonid shelf as in molars, wide, with shallow basin between hypocone and ectoloph, labial end separated from metastyle by deep anterior emargination.

M^1 and M^2 with slight labial basal cingula; parastyles and metastyles at ends of long thin winglike crests from paracones and metacones, with thin hooklike cusps anterior to parastyles and posterior to metastyles, especially on M^2; ridge on labial surface anterolabiad of metacone usually present (near position of mesostyle of some mammals), but fades out before it reaches basal cingulum, evidently originates from metacone not from cingulum; wide emargination of ectoloph between stylar cusps; paracones and metacones distinct but not widely separated; protocones with relatively narrow V-shaped angles formed by protolophs and metalophs; talon wide anteroposteriorly and even more extended transversely than in P^4, but with emargination of posterior outline between labial ends of talons and metastyles; no anterior basal cingula.

Lower cheek teeth hypsobrachiodont. Alveolus for I_2 larger than those for I_1 and I_3. Canine alveolus apparently for one root. P_3 much larger than P_2, somewhat submolariform. P_4 and lower molars with very high and anteroposteriorly narrow trigonids, with upper half of crowns curving posteriorly; talonids equal to or narrower than trigonids and about half as high or higher; anterior spur of hypoconid connecting on posterior surface of protolophid at midline of tooth on lower molars.

Generic diagnosis:

Micropternodus: smaller than *Clinopternodus;* lower canine, crowns of P_3, P_4, M_1 not as procumbent nor lingually curved, tips of crowns more recumbent than in *Clinopternodus;* P_2 present although small; P_3 higher crowned than in *Clinopternodus;* M_1 talonid almost equal to height of trigonid.

Clinopternodus: larger; lower canine, crowns of P_3, P_4, M_1, quite procumbent, lingually curved; tips of crowns not recumbent; P_2 absent; P_3 lower crowned than in *Micropternodus;* M_1 talonid equal to two-thirds height of trigonid.

Micropternodus morgani NEW SPECIES

Figures 1 and 2

Holotype.—Rostrum with premaxillae broken off back of I^1, palate and most of dorsal part of rostrum preserved; right and left I^2 broken off; right I^3 broken off, left I^3 preserved; tips of canines broken off; no alveoli for first or second premolars; P^3 and P^4 present on both sides; all molars present except left M^3; posterior part of cranium missing as far as anterior ends of orbits. Part of right mandible with P_3 to M_3 in place. UCMP 60801.

Type Locality.—Surface of white tuffaceous claystone, about 130 feet below welded tuff, a few feet below brownish nodular tuff; NW ¼ SE ¼, Sec. 14, T. 10 S., R. 27 E., Courtrock quadrangle, Grant County, Oregon, Univ. Calif. Loc. V5950.

Formation.—Middle beds of John Day.

Age.—Earliest Arikareean; early Miocene.

Specific Diagnosis.—Proportions and shape of cranium much more like that in *M. strophensis* than *M. borealis;* deeper than in either of those species; rostrum wider than in *M. strophensis*, much more so than in *M. borealis;* forehead more steeply inclined; depressions on

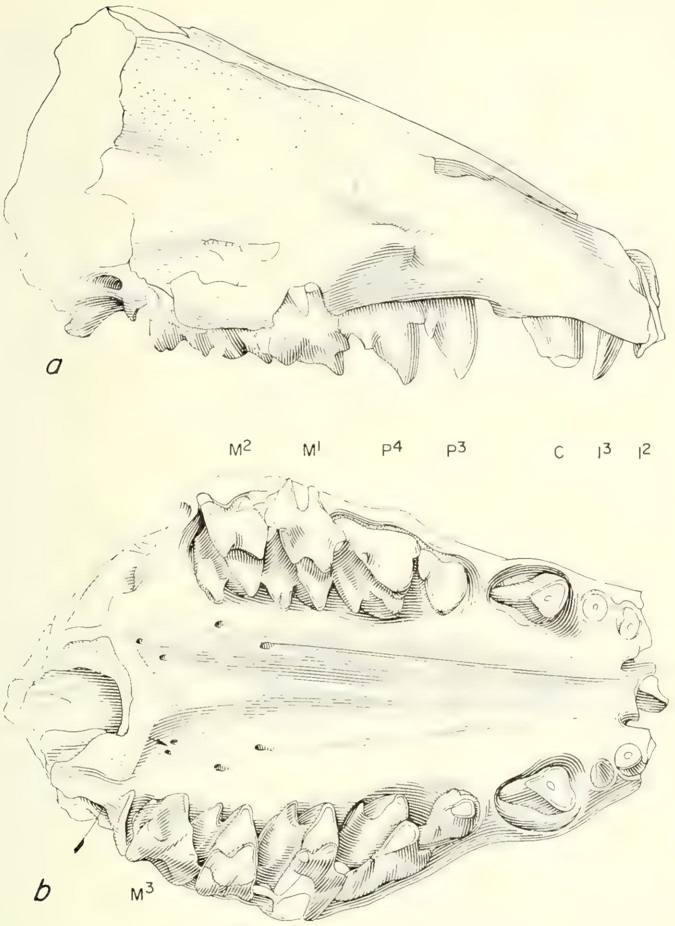

Figure 1. *Micropternodus morgani*, n. sp., UCMP 60801, middle John Day fm., Oregon. *a*, rostrum, right lateral view; *b*, rostrum, palatal view.

maxilla in front and behind canine even shallower than in *M. strophensis.*

Upper canine twice as large as in Oligocene species. Cheek teeth higher crowned, crowns and even roots with more procumbent orientation than in other species. No indication of tiny alveolus for P^2. P^3 larger, higher crowned, main cusp with greater posterior curvature than in *M. strophensis*, and with tiny labial cusp posterior to metastyle at end of sectorial blade; partly overlapped by P^4; greater tendency to develop posterolingual shelf on P^3 than in *M. strophensis;* other teeth not significantly increased in size.

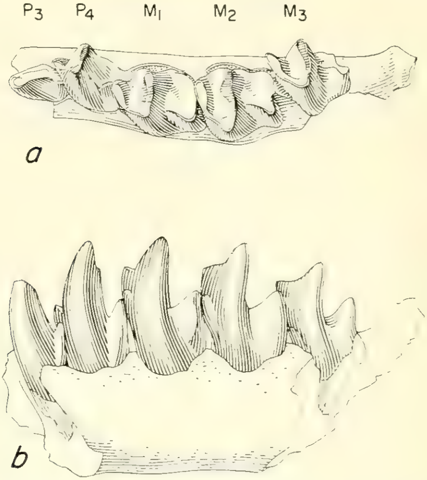

Figure 2. *Micropternodus morgani*, n. sp., UCMP 60801, middle John Day fm., Oregon. *a*, left mandible, occlusal view; *b*, same, left lateral view.

Paracone on P^4 not demarcated from paraconal blade; parastyle anterolabiad to sectorial blade; protocone markedly procumbent; hypoconal shelf with conspicuous labial expansion and with less abrupt descent to protocone and sectorial blade than in *M. strophensis;* parastyle not as prominent as in Oligocene species.

Slight indication of anterior bulge on protoloph at anterolingual base of paracone in upper molars, absent on M^1; only faint trace of protoloph at anterolabial base of paracone connecting through to parastyle; parastyle, paracone and protocone less distinct from intervening parts of protoloph than in other species; paracone and metacone closer together than in the other species, and parastyle and metastyle less pronounced than in Oligocene species; anterior (protoloph) and posterior (metaloph) wings of protocone close narrow basin between paracone, metacone and protocone; protocone more procumbent than in *M. borealis* or *M. strophensis;* no "mesostyle" on M^1, slightly developed on M^2; labial cingulum flattened; small posterior crest of hypoconal shelf connected to hypocone; hypoconal shelf with greater labial expansion than in Oligocene species, and more restricted emargination of posterobasal outline.

M^3 longer than in *M. strophensis;* protoloph at anterior edge of tooth; protocone and paracone not crescentic; protocone, paracone and parastyle of almost equal height and not as distinct on protoloph as in *M. strophensis;* crest from paracone to anterolabial end of tooth not as elongate and parastyle not as bulbous as in *M. strophensis;* small talon with tiny hypocone.

Mandible more robust than in Oligocene species and with M_1 and M_2 larger; P_3 less molariform and smaller than in *M. borealis;* less suggestion of trigonid pattern; markedly curved posteriorly, nearly oval in outline except at base; talonid more reduced than in *M. borealis*, with single cusp on posterolabial corner and labiad of paraconid of P_4; paraconid and hypoconid of about equal height: paraconid of *M. borealis* is much higher; anterior cingulum as nubbinlike process; strong posterior curvature; talonid more transversely reduced than in *M. borealis*, with single cusp on posterolabial corner; hypoconid extends backward with tip resting under paraconid of M_1; no shelflike union of labial base of talonid with trigonid as in *M. borealis;* no diastema between P_4 and M_1.

Lower molars high crowned, somewhat procumbent in lower half of crown, and curved posteriorly in upper third; paraconids not as high in relation to heights of metaconids and not located as far lingually as in *M. strophensis;* trenches (metaflexids) between paraconids and metaconids longer transversely and deeper than in *M. strophensis* or *M. borealis;* nubbinlike process replaces anterior cingulum; hypoconids much higher and more distinct than in *M. strophensis;* hypoconulids thin and transversely elongate; entoconids do not stand out as distinct cusps on hypolophids; talonids wider than in *M. strophensis;* no labial shelflike connection from base of hypoconid to base of protoconid.

DESCRIPTION

CRANIUM:—The rostrum, palate, most of the frontal, and part of the orbital areas of the cranium are preserved. In some respects it is more completely preserved than the Canyon Ferry specimen but in others it is not. Although the John Day specimen represents a young animal the sutures are fused beyond recognition. Most of the area of the nasals is broken away as far back as the end of the canine root. This exposes the turbinals. Much of the anterodorsal surface of the cranium is preserved. The part remaining reaches a point 4.5 back of M^3. This is probably opposite the anterior end of the orbit.

Only the medial wall and floor of the infraorbital canal are preserved. Its transverse diameter appears to have been 1.4. Both sides of the rostrum are in excellent condition. The palate is nearly perfect as far forward as the posterior parts of the incisive foramina. The anterior extremities of the premaxillaries are broken off, consequently their anterior extension and shape cannot be determined. They evidently are broken off back of the alveolar border of I^1, therefore there is no evidence of the size or position of that tooth. The tooth rows are represented from I^2-M^3 on the left side, and I^2-M^2 on the right. Both P^1 and P^2 were never present in the John Day specimen.

The rostrum is 7.9 wide behind the canine and 4.4 deep above the alveolus of P^4. It also appears to have been relatively short. This is partly reflected in the absence of P^2 and in the absence of a diastem between the canine and P^3. The anterior part of the rostrum seems to be longer in *M. borealis*, although the length of the molar series is about the same in both species. On the lateral surface the bone is not bulbously expanded over the root of the canine, although the canine root extends posteriorly to a position above the anterior end of P^4. There are only slight, nearly vertical expansions of the bone above P^3, but a prominent one occurs above P^4. The swelling above P^4 forms the anterior end of a diminishing ridge which covers the shorter labial roots of the molars and forms the floor of the infraorbital canal. There is also a sulcus above the labial root of P^4. Its depth is accentuated by the ridge. Another sulcus occurs above the infraorbital canal. Three longitudinally aligned nutritive foramina are present just mediad of each canine root on the dorsal part of the rostrum. Another foramen is ventral to the left P^3 root protuberance, but is absent on the right side. There are no foramina above or between the roots of P^4 and M^1.

The palatine grooves are long and distinct. They extend from the anterior palatine foramina to the incisive foramina. These grooves form the lateral margins of an elongate median surface that is more depressed than the areas on both sides of the palate. A low but sharp crest is present along the midline. The anterior palatine foramina lie opposite the posterior border of M^1. There are four smaller foramina near the posterior end of the palate. Of these, two (the left, not visible in Fig. 1b, is indicated by the short arrow) lie just in front of, and pierce, the palatal torus. A large postpalatine foramen (fig. 1b, long arrow) is back of M^3. *M. strophensis* clearly displays all these foramina. However, an additional pair a short distance anterior to the palatal torus were not observed in the Canyon Ferry specimen.

Upper teeth:—The dental formula differs from that in *M. borealis* and *M. strophensis* in the absence of any indication of P^2. This reduction is not surprising in *M. morgani*, because the alveoli in the

Oligocene specimens are already conspicuously reduced. All of the other upper teeth are represented in *M. morgani* except the right M^3 and the front incisors, which were lost when the supporting bones were eroded away.

Crowns of both of the second upper incisors, I^2, were destroyed, but the root with most of the basal enamel surface is preserved. The transverse diameter is 0.7. It is rather widely oval in cross-section and was probably a caniniform tooth. The root extends 2.3 upward and backward where it appears to terminate near and possibly above the end of the root of I^3. The crown evidently was less vertical than in I^3. A very short diastem (.4) separates I^2 and I^3 on the right side, but on the left side the teeth are in contact.

I^3 is caniniform, also oval in cross-section and with a transverse diameter of 0.9. Its crown is vertical. A carina on the posterolabial side forms the edge of a worn surface. The tooth is apparently larger than in *M. borealis* as determined from the relative sizes of the alveoli. A pit for the reception of the lower canine is present between the alveolus of I^3 and the canine, as in *M. borealis*. The anterior end of the pit in *M. morgani* is so close to the alveolus of the canine, however, that the rim between the pit and the alveolus is almost nonexistent.

The tips of both canines are missing but the basal cross-sections are triangular in outline. The long axis of the triangle is anteroposterior. In the basal half of the crown the anterior surface is slightly concave but the right canine shows the anterior border becoming convex toward the tip. The enamel is thickest on the anterior surface of the canines and diminishes to almost nothing at the posterior edge. Although the alveolus is larger than that of *M. borealis*, the two are similar in outline. The canine does not completely fill the alveolus, evidently because it is a young specimen. The parts preserved indicate a length of crown much less than that visualized by White (1954, fig. 43) for *M. strophensis*. Nevertheless, it extended below the level of the apices of P^3 and P^4.

P^2 has been lost. The rostrum has been so foreshortened that the diastema between C and P^3 is only a thin lamina of bone not more than 0.2 in thickness. If the canine were fully erupted the diastema would not be apparent.

P^3 is nearly triangular. The paracone is extremely high and curved posteriorly at its apex. A long, steeply inclined, posterior, sectorial blade is less oblique in orientation than in *M. strophensis* and the labial surface is more concave anteroposteriorly. This concavity is emphasized by a prominent labial paraconal ridge and by the distinctness of the short metastyle near the upper posterior corner. The metastyle emerges on the labial side of the posterior paraconal blade just anterior to a tiny stylar cusp on the extreme posterolabial corner of the tooth. A talon is not apparent. The small protocone appears to be closer to the anterior end of the tooth than in *M. strophensis*. The anterior basal outline of the tooth is convex transversely, and there is no anterolabial basal cusp. The height of the paracone is 2.5, whereas the metastyle is 1.2. The roots cannot be seen, but there are probably three as in *M. borealis*. On the whole P^3 is little more molariform than in the Oligocene species.

P^4 is submolariform and, of course, larger than P^3. It is more molariform than in *M. strophensis* and much more so than in *M. borealis*, especially in the orientation of the sectorial blade. The sectorial blade is less oblique than in *M. strophensis*, which is less so than in *M. borealis*. Furthermore the labial surface appears to be less concave anteroposteriorly than in either of the Oligocene species. The concavity, however, appears to be relatively wider in *M. morgani* than in *M. strophensis*. In *M. borealis* the concavity is narrower and deeper than in *M. strophensis*. *M. morgani* differs from both of the other species in the presence of an extremely flattened cingulum-like structure that extends backward and upward from the parastyle to the metastyle. A small stylar cusp (metastylule of White [1954]), occurs on the posterolabial corner as in *M. borealis*, but it is more widely separated from the metastyle than in that species. The small posterior stylar cusp is overlapped by the parastyle of M^1. The small stylar cusp is the "hooklike" cusp referred to by Russell (1960); it is, however, not hooklike in *M. morgani*, and is more reduced than in *M. borealis*. The paracone (parametacone of White, 1954) is approximately twice as high as the protocone, and the protocone about twice as high as the hypocone. The talon is wide, slants dorsolabially, and is basined between the hypocone and paracone. The protocone is broader anteroposteriorly and labially flatter than in *M. borealis*. There is no cingulum posterior to the hypocone as in *M. borealis*. The talon in *M. morgani* is much wider transversely than in *M. borealis* and *M. strophensis*, consequently the emargination of the posterior basal outline between the outer end of the talon and the metastylar area is greatly reduced in *M. morgani*. The depressed talon shelf slopes upward to the emargination. The depression is overshadowed by the anterolabial corner of the tooth behind and does not show in the illustration. The height of crown of the tooth as measured from the bifurcation of the roots is 3.7, whereas it is estimated to have been 2.2 in *M. borealis.*

M^1 and M^2 are grossly alike but differ in certain details. M^1 is slightly larger, has no labial ridge ("mesostyle") slightly anterolabiad to the metacone on the upper part of the crown as in M^2. The "mesostylar" ridge tends to fade out toward the base of the crown on M^2. This ridge has been called a "mesostyle" but its homology with that structure is doubtful because it does not connect to a basal cingulum and there is no mesostyle in the early erinaceoids from which this genus probably evolved.

On M^1 and M^2 the protoloph passes to the anterolingual base of the paracone where it forms a slight indication of an anterior bulge on M^2 which is absent on M^1. From that point there is only a faint trace of the protoloph connecting across the paracone to the parastyle. In *M. borealis* the protoloph forms a prominent bulge on M^1 and a less conspicuous one on M^2, and in both teeth the connection to the parastyle is incomplete. This is one of the characters that *M. borealis* shares with *M. morgani.* The protoloph of *M. strophensis* has slightly formed bulges on both M^1 and M^2; but whereas on M^1 it passes along the anterior surface of the tooth to the parastyle, on M^2 the connection is incomplete. The protolophs are higher than the metalophs. Protoconules and metaconules are not apparent. The parastyles on M^1 are somewhat less prominent in *M. morgani* than in *M. strophensis*, and much less so than in *M. borealis.* The M^2 parastyles and metastyles of *M. morgani* are destroyed. The parastyle, paracone and protocone are less distinct from the intervening parts of the protoloph than in the other species. The paracone and metacone are highest in M^1, and become progressively more widely separated from M^1 to M^3. Nevertheless the proximity of the paracones and the metacones are conspicuous features in *Micropternodus.* They are closer together in *M. morgani* than in the other species. The anterior (protoloph) and the posterior (metaloph) wings of the protocone close the narrow basin between the paracone, metacone and protocone. In this respect *M. strophensis* more closely approaches *M. morgani* than *M. borealis.* The sectorial ectolophs slant inward, and with wear the thickened enamel on the lingual sides of the paracones, metacones, and protocones accentuates this attitude. The metastyles on M^1 are less pronounced in both *M. morgani* and *M. strophensis* than in *M. borealis.* The labial cingulum is flattened in the upper third of the distance between the bases and the notch between the paracone and metacone. The protocones are nearly as high as the paracones and metacones. The hypocone is prominent and is separated from the protocone lingually by a deep vertical cleft. Farther labially, however, the hypoconal crest connects to the base of the metaloph. There is no small crest at the posterior edge of hypoconal shelf as in Oligocene species. The dorsolateral hypoconal shelf has a greater labial expansion than in Oligocene species. As in P^4 the posterior basal outlines of the molars have a reduced emargination between the labial ends of the talons and the metastylar areas.

M^3 has an elongate, rather narrow, triangular outline. The protoloph lies at the anterior edge of the tooth, whereas in *M. strophensis* the loph is located well back of the anterior edge. The protoloph is a straight, obliquely transverse blade. The contained protocone, paracone, and parastyle are of almost equal height and much less distinct from intervening parts of the protoloph than in *M. strophensis*. The parastyle is sharply crested and not as prominently extended anterolabially, nor as bulbous as in *M. strophensis*. Beyond the parastyle on the anterolabial corner of the tooth is a small hooklike cusp (parastylule of White, 1954), but this little cusp is only slightly developed. On the labial surface the parastyle is separated from the "mesostyle" by a deep vertical depression. The "mesostyle" is larger than on M^2, forms the middle angle of the W-pattern, and appears to have been derived from the anterolabial corner of the metacone. The metacone is partly broken off; the metaloph is absent, leaving a rather wide vault opening posterolingually between the protoloph and the metacone. The metastyle is absent and leaves the W-pattern incomplete on M^3. A small talon and hypocone are present, whereas in *M. strophensis* the talon is even smaller and there is no hypocone.

MANDIBLE:— Only the part of the left mandible with P_3 to M_3 is preserved but the horizontal ramus is uniform in depth (3.4) at least between P_4 and M_3. It is more robust than in *M. borealis* and *M. strophensis*.

There has been some uncertainty about the presence of the first two lower premolars of *M. borealis*. This area is not preserved in our specimen but it is important in the generic diagnosis. In his original description Matthew (1903) states: "Molars and especially premolars are short, high, and recurved; P_4 submolariform, with small anterior and internal trigonid cusps and strong basal heel. P_3 much smaller and simpler, with small heel and no accessory cusps. P_2 is small and one rooted. . . . No diastemata except a slight one behind

P_2." In 1909, p. 543, in reference to the type, he states, however, that there are four premolars. Evidently sometime after his first paper appeared the specimen was carefully prepared revealing a tiny alveolus in the diastema mentioned above. This is clearly revealed in his photograph of plate 51, fig. 1. Evidently Schlaikjer (1933) did not see Matthew's 1909 statement and figure. He wrote: "I have examined the specimen, and it is very obvious that the slight diastema behind P_2 of which Matthew spoke, presents a small but distinct alveolus. P_2 therefore is two-rooted and was probably as large as P_3." McDowell (1958, p. 175) agreed with Matthew that these alveoli represented P_1 and P_2. Russell (1960, p. 945) believed that Schlaikjer was correct.

Although we have not seen the type specimen, Matthew's 1909 figure seems to be perfectly clear. The alveolus in front is much larger than the one behind it and it seems more likely that a premolar with two roots would have the larger one behind. Furthermore, as seen in the lateral view of Matthew's figure the bone behind the first alveolus is elevated as it is between the other teeth, and the bone is relatively thick between the alveoli. We therefore believe there were four premolars in *M. borealis*.

P_3 and P_4 are somewhat procumbent in the lower half of the crowns in *M. morgani*, but the upper parts curve posteriorly. P_3 is high crowned. Wear on the posterior surface of the protoconid makes it difficult to determine its exact height but it appears to have been as high or nearly as high as the metaconid on P_4. In this young specimen the crown extends at least 3.0 above the edge of the alveolus and about 1.0 below. It is 1.0 wide and nearly oval in outline except at its base. A minute cusp (?paraconid) is present on the anterolingual side of the tooth; this cusp is less prominent than in *M. borealis*. There is less suggestion of a trigonid than in *M. borealis*. The talonid is reduced to a single cusp on the posterolabial corner of the tooth. This cusp is directly labiad of the paraconid of P_4, whereas in *M. borealis* the talonid is wider, the cusp is anterior to the paraconid of P_4 and there is a wide, sloping surface on its labial side. P_3 appears to have had a short and slightly bifurcate root, most of which is exposed on the labial side. Unfortunately, after this tooth was illustrated and described the crown was accidentally broken and lost.

P_4 has a well-developed but anteroposteriorly constricted trigonid and a single-cusped talonid. The protoconid is the highest cusp but is only about 0.7 higher than the metaconid. As viewed from the front it curves lingually, and this is more accentuated toward the apex. When the inner edges of the alveoli of the cheek teeth are held in a horizontal position, it is seen that the tip of the protoconid of P_4 is about equal in height to that cusp on M_1, and is, therefore, one of the highest cusps in the lower cheek teeth. The height of the protoconid, as measured from the edge of the alveolus on the labial side, is 3.6. Its labial surface is markedly convex anteroposteriorly, but the lingual surface is much less so. The metaconid, on the other hand, is shorter than that cusp on M_1 and M_2, but appears to be slightly higher than the metaconid on M_3. The paraconid is about the same height as the hypoconid, whereas in *M. borealis* the paraconid is much higher. The paraconid is a rounded cusp and is well separated from the protoconid by a distinct metaflexid. It also projects forward and in lateral view has a markedly curved anterior edge. The prominent anterior cingulum descending from the paraconid to the anterolabial base of the protoconid in *M. borealis* is nubbinlike in *M. morgani*. The cusp of the talonid is on the posterolabial corner of the tooth and extends backward so that its tip rests under the paraconid of M_1. In *M. borealis* the cusp is centrally located, and the talonid is wider. A vertical groove separates this cusp from the posterior slope of the protoconid, and there is no low horizontal shelf between the labial base of the talonid and the trigonid, as in *M. borealis*.

In lateral view the spaces between the bases of P_4 and M_1 and between the molars is less in *M. morgani* than in *M. strophensis* and much less than in *M. borealis*. M_1 is longer than M_2 because the paralophid is more flared anteriorly. The trigonids are wider than the talonids on all of the molars, and they become progressively narrower from M_1 to M_3. The molars are somewhat procumbent in the lower half of the crowns, and the trigonids are well developed. As with the protoconids on the premolars, the protoconids and metaconids in the upper half of the molar crowns curve backward, more so than in *M. strophensis*, and much more than in *M. borealis*. The protoconids are the highest cusps but the metaconids and paraconids are much higher than those cusps on P_4. The paralophid descends anterolingually from the protoconid then turns rather abruptly more lingually to the paracone. The juncture of the two parts of the paralophid are more distinct on M_1 than on the other molars. The paralophids stand out as projections from the protoconids and abut against the inner edges of talonids of the teeth in front. There are, therefore, spaces between the bases of the molars and between P_4 and M_1. As on P_4 there is no prominent anterior cingulum descending from the paraconid to the anterolabial base of the protoconid in *M. morgani*. This feature is well developed in *M. borealis* but only partly so in *M. strophensis*. There is, however, a remnant of this cingulum on the anterior surface of each molar; on M_2 and M_3 this forms a rounded nubbinlike process on the anterolabial surface. It is a mere vestige on M_1 and is well separated from contact with the talonid of P_4. The crests of the talonid are triangular on M_1 and M_2. The hypolophid of M_1 forms a transverse crest, the lingual side of which flares back to rest against the tooth behind, whereas the labial side of the hypolophid does not flare back because it rests against the remnant of the anterior cingulum of the tooth behind. On M_2, however, the nubbinlike anterior cingulum of M_3 fits into a median notch of the hypolophid; consequently the labial extremity of the lophid also flares back. M_3 is slightly displaced lingually in the John Day specimen.

The height of the talonid is equal to more than half the height of the trigonid in *M. morgani* and only less so in *M. strophensis*, whereas in *M. borealis* it is about half, especially on M_1 and M_2. The anterior spur of the hypoconid connects high on the posterior surface of the protolophid at the midline of the tooth on all three molars. The middle of the hypolophid is only slightly lower than it is at each end; consequently the hypoconulid at the inner end of the crest is nearly as high as the hypoconid and not as distinct as in *M. strophensis*. The entoconid does not stand out as a distinct cusp on the hypolophid. A low crest on M_1 and M_2 extends from the hypoconid diagonally down to the middle of the base of the protolophid. This helps define the wide, sloping, talonid basin that opens lingually. Labially there is a rather wide, nearly vertical, groove between the basal half of the protoconid and the hypoconid. In *M. morgani* and *M. strophensis* there is no labial shelf connecting the base of the hypoconid to the base of the protoconid as in *M. borealis*. The labial surfaces of the hypoconids on all of the molars curve lingually. This is more clearly shown on M_3 than on the other molars, evidently because it is not as worn. The hypoconids are about half as high as the metaconids. The posterior surface of each molar is vertical. As viewed from above, the outline of the molar series is crescentic with the convexity on the labial side. M_2 is approximately equal to M_1 in size. M_3 is much smaller. The talonid of M_3 is relatively wider than in *M. strophensis* and there was probably no entoconid, although the lingual part of the hypolophid is destroyed.

SPECIFIC RELATIONSHIPS AND EVOLUTIONARY TRENDS

Our observations indicate that *M. borealis* Matthew and *M. strophensis* (White), as classified by Russell (1960), are referable to one genus. We feel, however, that *M. borealis* and *M. strophensis,* as well as *M. morgani,* are specifically distinct.

M. morgani is the most advanced species of the genus. Most of its measurements exceed those of the Oligocene species. Its teeth have higher crowns, show a fusion of roots in the premolars, and have undergone a reduction in number. The skull is the widest and deepest of the three genera.

Of the Oligocene species, *M. strophensis* is the more closely related to *M. morgani.* This is evidenced not only by its incipient development of the skull proportions of *M. morgani,* but also in the details of its dental characters. These include the increased molariformity of P^4 and the modification of cusps and crests into more effective sectorial blades. In not all characters, however, does *M. strophensis* more closely approach *M. morgani* than *M. borealis.* Some features in the teeth of *M. borealis,* such as the discontinuation of the protoloph connection to the parastyle on the upper molars, are seen in *M. morgani* but not in *M. strophensis.* Several primitive characters are exclusively shared by *M. borealis* and *M. strophensis.* Among others, these include the presence of a "mesostyle" on M^1, and the separation of the small crest at the posterior edge of the hypoconal shelf from the hypocone; these characters are altered or lost in *M. morgani.*

On the basis of this knowledge, *M. strophensis* could be ancestral to *M. morgani.* If this is true, the progressive molariformity of P^4, the alteration in rostrum proportions to one relatively shorter and wider, the modification of cusps and crests into blades, and the deepening of the rostrum in prelude to higher crowned teeth, are evolutionary trends initiated by *M. strophensis.* If *M. morgani* and *M. strophensis* descended from an earlier common ancestor with *M. borealis,* which seems likely, the evolutionary trend toward *M. morgani* shows a reduction in the kind of submolariformity of P_3 inherited by *M. borealis.* This tooth, and possibly P_1 in the *M. morgani* lineage, became somewhat more caniniform with reduction of the paralophid and the talonid.

COMPARISON OF *Clinopternodus*

The second genus classified in the Micropternodidae is *Clinopternodus.* The only known specimen, *C. gracilis* (Clark), 1936, (in

Scott and Jepson, "The mammalian fauna of the White River Oligocene—Part I,"; also Clark, 1937), is part of a left mandible with the canine, P_1, P_3, P_4 and M_1 found in an upper member of the Chadron formation.

Clark (1937) states that it is about a third larger than *M. borealis* although it is not much younger than Matthew's species. The size difference between *C. gracilis* and *M. morgani* is much less, but the Oregon species is much younger. This and other features indicate that *Clinopternodus* is more advanced than the contemporary species of *Micropternodus* and evidently represents another lineage in the family.

The lower canine appears to have been slightly larger than in *M. borealis*. The tooth is not known in the other species of *Micropternodus*. The crown of P_1, although broken off, evidently had one root as in *M. borealis*, but is more rounded and more linguad in position than in the Pipestone Springs species. A foreshortening in the mandible possibly resulted in the loss of P_2 in *Clinopternodus*, although Clark says the specimen is fractured in that area and the evidence for the absence of a tiny alveolus is not conclusive. In *M. borealis* a small alveolus indicates the presence of a reduced P_2 with one root. This area is not known in the mandibles of *M. strophensis* and *M. morgani* but the maxillae in those species indicate that reduction of this interval had taken place. The crowns of P_3, P_4 and M_1 are more conspicuously procumbent, the upper parts of the crowns more curved lingually, and the tips of the crowns less recumbent than in any species of *Micropternodus*. Insofar as we can see now, these features alone are valid generic distinctions. P_3 is relatively lower crowned than in *M. borealis* and still lower than in *M. morgani*. There is a small anteromedian basal cusp which in *M. borealis* is linguad in position; in *M. morgani* the cusp assumes the same position as in *M. borealis* but is vestigial. There is one cusp on the talonid. P_3 and P_4 are not unlike those teeth in *M. morgani* except for their height, direction and orientation. The talonid equals nearly two-thirds the height of the trigonid, and is consequently more highly elevated with respect to the trigonid than in *M. morgani*.

ANCESTRAL RELATIONSHIPS

The phylogenetic relationships of the early and middle Tertiary families and subfamilies of the insectivores are difficult if not impossible to determine with reasonable accuracy. This is largely due to the paucity of adequate materials. Well preserved skulls are seldom found and usually upper and lower teeth are not found in association as parts of an individual. Parts of jaws or isolated teeth are sometimes all that we may know of an important genus or subfamily. The interpretation frequently placed on dental features is difficult or impossible to verify because the samples for the most part are insufficient for an insight into variation. Furthermore, different parts of the dentitions are often not available for evaluations of combinations of characters.

Authors differ in their opinions as to which characters represent convergent or possibly parallel evolution and which are indicative of basic relationships. Some feel that cranial morphology, especially the distribution of nerves and blood vessels, location, shapes, and relationships of the orbital bones, construction of the auditory region, etc.–, is the solution to relationships of the higher categories. There can be no doubt about the importance of these studies, but it must be realized there are too few good crania to substantiate the consistency of these characters. The crania and all of their parts also have been subject to evolution, and the trends are as yet even more obscure than those of the dentition. Characters in M^1_1-$^2_2$ are usually fairly reliable in familial classification. Those of M^3_3 are somewhat less so. Fortunately one or more of these teeth can be compared in most specimens. In any event the patterns of the molars must not be ignored irrespective of the other evidence available. The other teeth may be useful, especially P^4_4, in the recognition of some families and subfamilies, but the other premolars are usually more subject to adaptive modifications or possess too little complexity. Characters, however, that are stable in one group may not necessarily be so in another.

The most reliable means of determining the phylogenetic relationships of a family is to trace it back through its genera and species to a common origin with another family. No one has been able to do this in the Insectivora, although approximate relationships have been suggested on gross morphology, or on certain combinations of characters, with some confidence.

As might be assumed, we have not been able to determine the ancestry of the Micropternodidae, nor is there conclusive evidence that these genera belong in the Erinaceoidea. Russell's (1960) suggestion, however, that they arose from an erinaceoid ancestry in the Eocene is logical. No known Eocene genus, however, possesses the minimum of the characters one might expect of the ancestral group. The Leptictidae are generally eliminated on the molariformity of P^4_4.

Talpavus nitidus Marsh, 1872, as represented by M^1 and M^2 in *Nyctitherium nitidum* Matthew, 1909, pl. 50, 6, A.M.N.H. 11489, has an expanded talon and an emargination of the posterobasal outline at the labial end of the talon much like that in *Micropternodus*. Nevertheless, the presence of a prominent anterolingual cingulum and a deep narrow ectoflexus of the labial margin seem to exclude Matthew's Bridger specimen from the ancestry of *Micropternodus*. Unfortunately P^4 is not known.

The lower molars of *Talpavus*, as seen in Matthew's illustrations (1909, pl. 50, 7) of M_2 and M_3, are not unlike teeth that might be expected of an ancestral form in the middle Eocene. The talonid, although not high, is higher in relation to the height of the trigonid than in *Micropternodus*, and the anterior spur of the hypoconid that connects to the base of the protoconid at the midline of the tooth is not as high at that point as in the Micropternodidae. These *Talpavus* teeth also differ in that the upper half of the trigonids do not curve posteriorly, although this might be attributed to the lack of trigonid height attained by *Micropternodus*. The trigonid bears a prominent anterior cingulum, as should be present in a *Micropternodus* ancestor, and the positions of the paralophids and paraconids, and the talonids being narower than the trigonids, are early erinaceoid features that are in keeping with the pattern in *Micropternodus*. Apparently a P_4 from Myton Pocket, mentioned by McKenna, Robinson and Taylor (1962, p. 26), is somewhat like *Micropternodus* in the trigonid, but those authors do not mention the talonid. In contrast to *Micropternodus*, McKenna, Robinson and Taylor (1962) state that the entoconid on the molars of A.M.N.H. 55686 from the Bridgerian of Tabernacle Butte is the highest cusp on the talonid. These comparisons seem to indicate that *Talpavus* is not ancestral to *Micropternodus* although some characters are alike in the two genera.

Another middle Eocene genus that may be related is *Scenopagus* (McKenna and Simpson, 1959). M^1 and M^2 also show the possibility of evolving a deep emargination of the posterior basal outline and a wide talon. Like *Talpavus*, however, each of these teeth has an anterolingual basal cingulum, which is not a formidable obstacle because it could gradually be lost. The labial margin has a shallow ectoflexus, as might be expected in the ancestral genus, but the paracone and metacone are much more widely separated than in

Micropternodus, especially on M^1, and there is a well-developed labial cingulum. The merging of the paracone and metacone could well be an evolutionary trend in some lineages, if a *Scenopagus*-like form gave rise to *Micropternodus*, instead of the twinning of one cusp and eventual wider separation, as has been so widely adopted. Upper premolars like those of *Scenopagus* could give rise to those of *Micropternodus*.

The three lower molars called *Diacodon edenensis* by McGrew (1959, p. 148), and referred to the same genus and species as *Scenopagus mcgrewi* McKenna and Simpson (1959), with the name now recognized as *Scenopagus edenensis* (McGrew), are even less like those of *Micropternodus* than are the lower molars of *Talpavus*.

The mandible described by Matthew (1909) as *Myolestes dasyplex* and the referred specimen of McKenna (1960) offer another possibility. The trigonids of the molars and of P_4 are high and appear to have a slight backward curvature in the upper parts of the crowns, but the talonids are very low. In contrast with *Micropternodus*, the entoconid, not the hypoconid, is the one cusp on the talonid as in *Geolabis*. The upper cheek teeth of *Myolestes* are not known.

TABLE OF MEASUREMENTS

CRANIUM

	M. borealis	*M. strophensis*	*M. morgani*
	CM	USNM	UCMP
	8674	18870	60801
Length:			
as preserved	17.8	16.8	18.3
tip of rostrum through M^3	15.0	——	——
I^2 through M^3 (inclusive)	13.5	——	13.4
I^2 through M^2 (inclusive)	11.5e	——	11.0
canine through M^3 (inclusive)	11.3	11.9	11.8
from posterior border of canine to posterior border of M^2	6.6e	7.0	6.5
P^3 through M^3 (inclusive)	8.8	8.9	9.0
P^3 through P^4 (inclusive)	——	3.6	3.6
M^1 through M^3 (inclusive)	5.8e	5.8	5.8
Width:			
of rostrum at I^2	4.5	——	5.5e
of rostrum at level of I^2	4.6	——	5.1

	M. borealis CM 8674	*M. strophensis* USNM 18870	*M. morgani* UCMP 60801
of rostrum at level of canine	5.7	6.0	7.7
of rostrum immediately behind canine	5.3	5.9	7.7
of rostrum at level of M^2 (excluding zygoma)	9.6e	10.8	11.8e
between inner margins of I^3	3.1	——	3.7
between inner margins of canine alveoli	3.0	3.2es	3.4
between inner margin of M^1 and palate midline	1.4	1.9	2.1
Depth: (excluding teeth; perpendicular to labial edge of maxillary unless otherwise specified)			
of rostrum at level of canine alveolus	2.3	2.4	2.7
of rostrum* immediately behind canine	2.7	2.9	3.7
of rostrum at level of P^3	3.7	3.7	3.7
of rostrum* at alveolus of P^4	3.8	3.8	4.8
of rostrum at level of M^1	5.2	6.0	6.0

UPPER TEETH

	M. borealis CM 8674	*M. strophensis* USNM 18870	*M. morgani* UCMP 60801
Anteroposterior diameter:			
I^1 (alveolus)	1.0	——	——
I^2	0.7e	——	0.7
I^3	0.5e	——	0.8
C (at alveolus level)	——	1.5	1.7
C alveolus	1.9	1.8	2.4
P^2 (alveolus)	0.2	0.2	——
P^3	——	1.4	1.4
P^4	2.1	2.3	2.4
M^1	2.3	2.4	2.4
M^2	1.9	2.0	2.1
M^3	——	1.4	1.9
Transverse diameter:			
I^1 (alveolus)	1.4	——	——
I^2	0.6e	——	0.7

	M. borealis CM 8674	*M. strophensis* USNM 18870	*M. morgani* UCMP 60801
I^3	0.5e	——	0.9
C	——	0.9	1.2
C (alveolus)	0.9	1.1	1.7
P^2 (alveolus)	0.2	0.2	——
P^3	——	1.3	1.7
P^4	2.6	2.4	2.9
M^1	3.1	2.8	3.1
M^2	2.9	2.8	2.4i
M^3	——	2.2	2.4

MANDIBLE AND LOWER TEETH

	M. borealis CM 8674	*M. strophensis* USNM 18870	*M. morgani* UCMP 60801
Length, P_3 through M_3		——	9.1
Depth of mandible, level of M_2			
Width of mandible, level of M_2		1.5	2.2
Anteroposterior diameter:			
P_3		——	1.3
P_4		——	1.9
M_1		——	2.4
M_2		2.2	2.4
M_3		1.9	2.1
Transverse diameter:			
P_3		——	1.1
P_4		——	2.0
M_1		——	2.0
M_2		1.9	2.1
M_3		1.6	1.7
Crown height above alveolus (labial side)			
P_3		——	2.0
P_4		——	3.7
M_1		——	3.8
M_2		3.1	3.6
M_3		2.2	3.0e

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* depth measured perpendicular to dorsum of cranium
e estimated
es estimated by doubling half-dimension
i incomplete

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THREE NEW TYPES OF INVERTEBRATES EXTRACTED FROM MIOCENE PETROLIFEROUS NODULES

W. Dwight Pierce[1]

The extraction by means of acids (formic and hydrochloric) of the ancient life concealed in the petroliferous nodules of our California volcanic mountains continues to disclose treasures which dismay our systematists.

Nodules and rocks containing petroleum have been found in close relationship to boron deposits in the Calico Mountains and Lane Mountain on the axis of the Mojave triangle; on Mt. Pinos and Mt. Frazier in Frazier Mountains at the fulcrum; in the Tehachapi Mountains and in Death Valley along the northern zone above the Garlock Fault; and Tick Canon south of the San Andreas Fault. Earlier I have discussed the significance of the petroliferous nodules (Pierce, 1962).

The peculiar processes of preservation have saved many soft-bodied creatures and plants in original 3-dimensional form, silicified or otherwise crystallized; such as moss leaves, algal tissues, larvae, pupae, and eggs, nerves, and brains, and other internal organs.

Therefore, it was no surprise that the several forms of Turbellaria which I have already described (Pierce, 1960), were preserved.

I now present preliminary studies of a nematode, and two organisms belonging to Vermes Bilateria, which do not seem to fit into the picture of any presently described group of invertebrates, one resembling the rotifers, and the other seemingly between Turbellaria and Mollusca, all three silicified and disclosing their internal anatomy. We can presume that all three lived in the detritus at the base of the algae. The nodules from which the nematode and the pseudorotifer were extracted contained no insects, but each had many fairy shrimp coprolites and plant tissues present. Mr. Gibron did not keep a record of the micro-contents of the nodule from which he extracted the pseudoturbellarian.

I present brief descriptions, illustrations and names for these curiosities, for they must have handles by which they can be further discussed, and await the verdict of specialists as to their proper position in classification.

In the Southeast Quarter of Section 23, R.1.E., T.10.N., Calico

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[1] Research Associate, Los Angeles County Museum.

Mountain Quadrangle there is an unusual geological formation between Camp Rock on Mule Canon Drive and the entrance to Odessa Canon, traversed by the deep trough of Calico Fault, about 3,500 feet east of the parking lot of the town of Calico, and a little over 2,000 feet east of Odessa Canon.

A series of seven parallel ridges dip down into the fault, and crossing these in almost vertical lines are six nodule-bearing strata running east and west, over the ridegs and down into the ravines.

John Gibron, Sr., who discovered this interesting nodule site, roughly measured the strata on the second ridge as 264 feet, containing six nodule zones. These six zones from south (latest) to north (oldest) are sites 118-123. Site 121 seems to be the same stratum as site 125 opposite on the ridge to the east. On September 28, 1962, there were 10 of us, each at a different nodule exposure on these ridges. Russell Gamage at site 122, collected the nodule containing the nematode specimen, No. 6178; while opposite him at site 125, I collected the nodule that contained the pseudorotifer, specimen No. 6071.

John Gibron collected in Southeast Section 24 at Dr. Palmer's site No. 19057, which is very close to the Calico Fault, and only about 5,000 feet east of the other sites, a nodule which yielded the interesting specimen No. 6086, which has many characters of the Turbellaria, but is ruled out of that group as presently interpreted.

Thus in the immediate locale of the Calico Fault, three remarkable soft-bodied creatures of Vermes Bilateria have been preserved through unusual chemical means to give us a glimpse of ancient Miocene aquatic life. I have previously reported on the Turbellaria (Pierce, 1960).

Phylum BILATERIA
Near Class TURBELLARIA

Gibronea miocenae, NEW GENUS AND SPECIES

Figures 1-4

The interesting worm (Specimen No. 6086) was extracted by John Gibron, using hydrochloric acid, from a nodule found at Pal-

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Figure 1. Specimen No. 6086, fossil worm, possibly Turbellarian, *Gibronea miocenae*, n. g., n. sp., ventral view. *Figure 2.* Stalked eye of specimen No. 6086. *Figure 3.* Mouth opening of specimen No. 6086. *Figure 4.* Simple eye of specimen No. 6086. *Figure 5.* Specimen No. 6178, fossil nematode, *Mioaphelenchus gamagei*, n. g., n. sp. *Figure 6.* Specimen No. 6071, fossil rotifer (?), *Pararotifera enigmatica*, n. g., n. sp. *Figure 7.* Specimen No. 6071, left side. All illustrations drawn by the author.

1.

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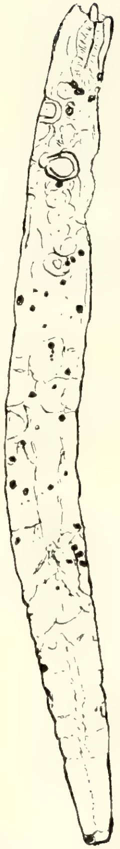
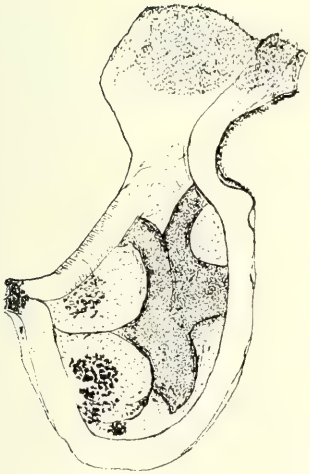


5.



6

7.

mer's government site 19057 in SE. Quarter, Section 24, just east of Mule Canon Drive and just north of the Calico Fault, at altitude 2,400 feet.

It is unusual in that there are two stalked spherical bodies, covered with lenses, which I take to be separate ocelli. And laterally on a line with the mouth are two large single eyes, in the center of which is a rod or nerve. The mouth opening is a short tube margined with retrorse spines, possibly indicating predatory or parasitic habit.

I have sketched the lateral canals, intestine, and anal area, but must leave their interpretation to experts.

The stalked and simple eyes seem to exclude from Turbellaria and Trematoda as now defined. The spiny mouth opening seems to exclude from Mollusca.

Phylum NEMATODA

Mioaphelenchus gamagei, NEW GENUS AND SPECIES

Figure 5

Specimen No. 6178 placed in phylum Nematoda, tentatively in Class Phasmidia, Order Rhabditida, Suborder Tylenchina, Family Aphelenchidae.

On September 28, 1962, at the same time I was collecting specimen No. 6071, at site 125, Russell Gamage, opposite me on the next ridge at site 122 picked up nodule No. 30949, which weighed 17.8 grams and measured 36.5 x 28.5 x 17.5 mm. From this I extracted by use of formic acid, a perfect crystallized nematode, specimen No. 6178, measuring 4.16 mm. in length and 0.32 mm. in width, which I place under a new generic name, **Mioaphelenchus,** next to *Metaphelenchus* for the tail is bluntly rounded. The specimen is so transparent in the anterior portion that it can only be seen by manipulation of the light.

The head end is only slightly narrower than the rest of the body, but is anteriorly blunt, with a blunt stylet. The esophagus is short extending only half way to a very distinct nerve ring.

The body is filled with coils and tubes, and there are numerous pigmented bodies as indicated by the drawing. In the posterior quarter the excretory canal is distinct, terminating in a pigmented spot at a corner of the bluntly rounded apex.

Near Class ROTIFERA

Pararotifera enigmatica, NEW GENUS AND SPECIES

Figures 6 & 7

In the sludge from formic acid extraction of a smooth, unlayered, pale colored Miocene nodule, No. 30908, slightly oval in form, weighing 9.8 grams, and measuring 24 x 20.5 x 13.5 mm., which I collected, September 28, 1962, at site 125, in lot 421, close to 2,400 feet altitude in the Southwest Quarter of Section 23, R.1.E., T.10.N., Calico Mountains, I found this strange little crystallized body, speciman No. 6071. It measures 1.076 mm. in length, and 0.576 mm. in greatest width.

The same nodule contained many fairy shrimp (Anostraca) coprolites, and one complete crystallized mammal hair, but no plant tissues. There was a little color (petroleum) in the specimen when first extracted.

The drawing shows a broad duct arising on the head, and passing down the front and around and up to an anal opening where it is joined by a similar duct that must be connected with the first in the neck area, and margins the dorsum to the anus. There are no visible organs in the head, but beyond the neck the body is filled with ducts and organs. I will not attempt to name these parts. The head is covered with tiny particles which obscure anything inside.

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A QUANTITATIVE STUDY OF THE BENTHIC POLYCHAETOUS ANNELIDS OF CATALINA HARBOR, SANTA CATALINA ISLAND, CALIFORNIA

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Introduction

This study is another in the series of papers on the quantitative distribution of benthic polychaetes in the bays and harbors of Southern California and Baja California undertaken by the author (see Literature Cited). Previous quantitative studies of the marine benthos of the Eastern Pacific Ocean have been summarized by Reish (1963b). The purpose of this survey was to compare the polychaete fauna of a bay of an off-shore island with bays located on the mainland.

Polychaetes have been collected from the Santa Catalina Island by the *Albatross* and *Velero III* and *IV* expeditions. The polychaetes have been reported in some of the papers by Moore and Hartman (see Hartman, 1951, 1959, 1961 for citations to both authors). These collections were made from the deeper, off-shore waters from these oceanographic vessels; the polychaetes of the shallow, in-shore waters of Santa Catalina Island have not been studied previously.

Materials and Methods

The samples were taken August 29, 1963, from a skiff using a size one Hayward orange-peel bucket. The samples were washed through a size 24 screen (0.7 mm. opening); the material retained on the screen was preserved in formalin. The author thanks Mr. and Mrs. David Bryan for collecting and washing the samples. A sample of the substrate was taken at each station. The particle size of the sediments was analyzed according to the techniques summarized in Barnes (1959). The sediment type for each station was named according to the median diameters of the particles; these data are given at the bottom of Table I.

Description of Catalina Harbor

Santa Catalina Island is one of the channel islands located off the coast of Southern California. The island (Fig. 1) is approximately

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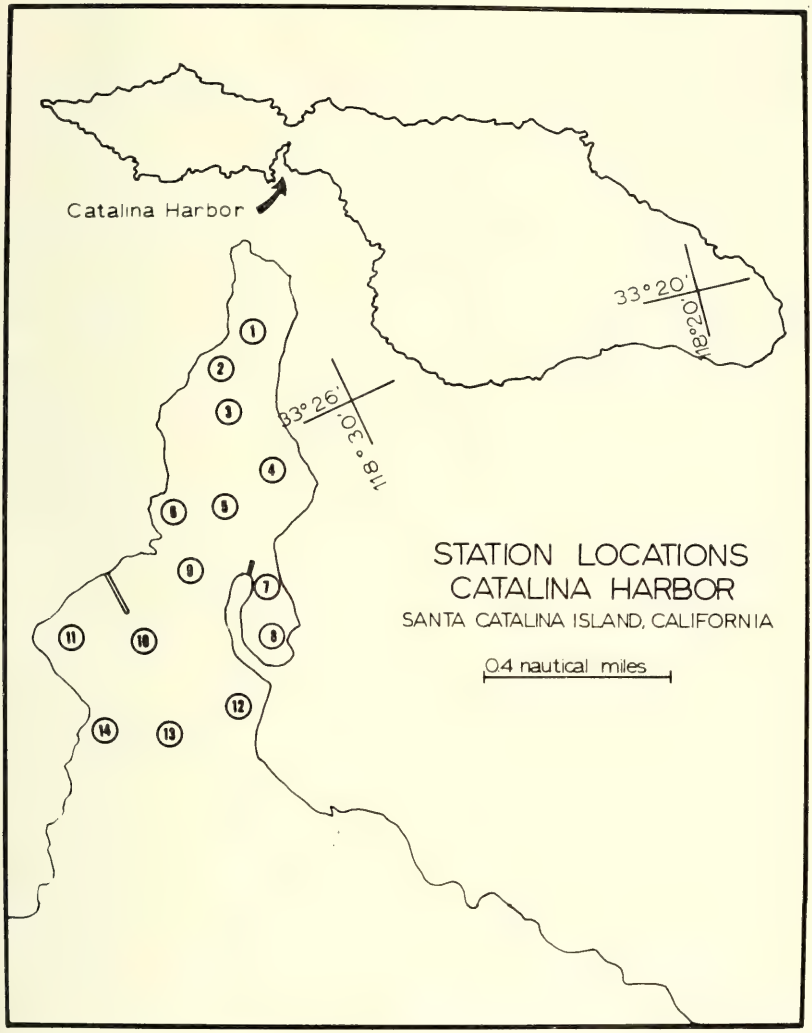

Figure 1. Map of Catalina Harbor, Santa Catalina Island, California, showing station locations.

20 miles in length and about the same distance to the nearest point on the mainland. Catalina Harbor is situated on the ocean side of the island at the narrowest part, which is referred to locally as the "Isthmus." The depth ranged from about 10 feet at station 1 to about 60 feet at station 13.

TABLE 1

Station List of Polychaetes from Catalina Harbor, Santa Catalina Island, California

STATIONS: SPECIES	1	2	3	4	5	6	7	8	9	10	11	12	13	14	TOTALS	COMPARISONS*
Halosydna johnsoni (Darboux)						1			1	2					4	c,d
Sthenelanella uniformis Moore										3				2	5	d
Eteone dilatae Hartman									2		2				4	c,d,e
Eumida sanguinea Oersted											1		1		2	b,c,d
Ophiodromus pugettensis (Johnson)					2				5		2	4		1	14	a,b,c, e
Exogone lourei Berkeley & Berkeley			1	13		1	1		1		3	3			23	
Odontosyllis sp.					1										1	
Sphaerosyllis pirifera Claparède					1									1	2	a d
Typosyllis alternata (Moore)	1														1	
Ceratonereis mirabilis Kinberg									1	1					2	
Nereis procera Ehlers										2					2	a,b,c,d
Platynereis bicanaliculata (Baird)					3							1	2		6	a,b,c,d,e
Nephtys californiensis Hartman					2				2					1	5	a
Glycera americana Leidy										4				1	5	a,b,c,d,e
Goniada littorea Hartman										1			1		2	b,c,d,e
Lumbrineris erecta (Moore)							1								1	b,c,d,e
L. minima Hartman	2	21	1	39	77	1		2	219	154	36	11	99	37	699	b,c,d,e
Dorvillea articulata (Hartman)	2								1				1	1	5	b,c,d,e
Haploscoloplos elongatus (Johnson)	2	1		4	15				28	31	4	4	13	19	121	a,b,c,d,e
Scoloplos acmeceps Chamberlin										4			3		7	a e
Naineris sp.						1									1	
Paraonis gracilis oculata Hartman			5		2			1			2		3	3	16	b d
Nerinides pigmentata (Reish)	1	1		1							1		1		5	d
Polydora brachycephala Hartman										1		1	1		3	a,b
P. ligni Webster	2	1	1	1		1				5					11	a,b,c

TABLE 1

Station List of Polychaetes from Catalina Harbor, Santa Catalina Island, California

SPECIES / STATIONS:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	TOTALS	COMPARISONS*
Prionospio h. newportensis Reish	53	27	40	98	25	4	6	146	75	72	55	14	35	11	661	b,c,d
P. cirrifera Wirén		1													1	a,b,c,d
P. pinnata Ehlers									1					1	2	b,c,d
Sphiophanes missionensis Hartman					1				1	4				1	7	b,c,d,e
Chaetopterus variopedatus (Renier)									1				1	5	7	
Telepsavus costarum Claparède														1	1	
Tharyx parvus Berkeley	20	6	1	5	6			3	8	6	27		14	8	104	a,b,c,d
Pherusa capulata (Moore)										1			1		2	c
Polyophthalmus pictus (Dujardin)													1		1	c
Capitita ambiseta Hartman				2	3				2	3	1		5	2	18	a,b,c,d,e
Scyphoproctus oculatus Reish						3			1						4	d,e
Axiothella rubrocincta (Johnson)					1	1					1		9	1	13	a d,e
Praxillella a. pacifica Berkeley		1	2	2	9	1			12	2	8		8		45	d
Amaeana occidentalis (Hartman)	2							1	1	1					5	b,c,d
Pista alata Moore				1	1					2	1		2		7	c,d,e
Chone mollis (Bush)					1										1	b d,e
Fabricia limnicola Hartman	3		3				4	2		1					13	d,e
Megalomma pigmentum Reish					1				4						5	b,c,d,e
Number of species	10	8	8	10	17	9	4	6	19	20	14	7	19	17	43	
Number of specimens	88	59	54	166	151	14	12	155	366	300	144	38	201	96	1844	
Sediment type	med. sand	very fine sand	coarse sand	med. sand	fine sand	very coarse sand	fine sand	coarse sand	very fine sand	very fine sand	very fine sand	very fine sand	very fine sand	silt		

*a = San Francisco; b = Los Angeles-Long Beach Harbors; c = Alamitos Bay; d = Newport Bay; e = San Quintin Bay

POLYCHAETES OF CATALINA HARBOR

A total of 1844 specimens representing 43 species of polychaetes was taken from the 14 stations sampled in Catalina Harbor. The species and number of specimens at each station are listed in Table 1. The greatest diversity of polychaetes and the largest number of specimens were taken from the stations with the finer sediments. *Prionospio heterobranchia newportensis* was collected at all stations. *Lumbrineris minima*, the most frequently encountered species, was taken at all but station 7. Other dominant polychaetes were *Haploscoloplos elongatus*, *Tharyx parvus*, and *Praxillella affinis pacifica*. *Lumbrineris minima* was the most abundant species at the stations where the sediments consisted of very fine sands; whereas *P. h. newportensis* was dominant at the stations where the sediments consisted of either coarse or median sands.

All but one species collected from Catalina Harbor have been encountered previously from the bays or harbors of Southern California (Table 1). *Ceratonereis mirabilis* is unknown from mainland protected waters, but it has been reported off-shore from Southern California (Hartman, 1961). Comparisons of the polychaetes from Catalina Harbor to those of bays and harbors of California and Baja California (Table 1) indicate 29 species in common to Newport Bay (Reish, 1959a), 24 with Alamitos Bay (Reish, 1961; 1963a), 22 with Los Angeles-Long Beach Harbors (Reish, 1959b), and 18 with Bahía de San Quintín, Baja California (Reish, 1963b). Fourteen species are in common with San Francisco Bay (Hartman, 1954; Jones, 1961). The closer similarity with Newport Bay may be attributed to the greater diversity of substrate types there than found in the other nearby bodies of water. The 12 most commonly encountered polychaetes in Los Angeles-Long Beach Harbors, Alamitos Bay, and Newport Bay were listed in Reish (1961, Table 2). Two of these 12 species, *Cossura candida* Hartman and *Capitita ambiseta* Hartman, were not taken at Catalina Harbor.

Relationship of polychaetes to type of sediment. The sediment type, based on median diameters, is listed at the bottom of Table 1. The coarser sediments are located in the upper reaches of the harbor, particularly on the west side. As noted above, the largest number of species and specimens were taken at stations characterized by fine sediments. A relationship of the average number of specimens per station of the principal polychaetes to the general sediment type gives some indication of substrate preference (or tendency). On the basis of this type of analysis, the most abundant species may be grouped as follows:

Relationship to coarse sand: *Prionospio h. newportensis.*

Relationship to medium sand: *Exogone lourei.*

Relationship to fine and very fine sand: *Haploscoloplos elongatus, Capitita ambiseta, Praxillella a. pacificus.*

Relationship to very fine sand: *Ophiodromus pugettensis, Lumbrineris minima, Tharyx parvus, Axiothella rubrocincta.*

No apparent relationship: *Paraonis g. oculata.*

These data are in close agreement for the four species in common in a similar analysis made of the dominant polychaetes of Bahía de San Quintín (Reish, 1963b). *Haploscoloplos elongatus* and *A. rubrocincta* were present in fine or very fine sands at both areas. *Lumbrineris minima* and *C. ambiseta* were taken more frequently from slightly finer sediments at Bahía de San Quintín.

OTHER INVERTEBRATES

While the major emphasis of this study was concerned with polychaetes, the other invertebrates were identified insofar as possible. The identified animals include the pelecypods *Chione californiensis* (Broderip), *C. undatellum* (Sowerby), *Laevicardium substriatum* (Conrad), *Lysonia californica* Conrad, *Macoma secta* Conrad, and *Solen rosaceus* Carpenter; the gastropods *Bulla gouldiana* Pilsbry and *Tephtys* sp.; the brachipod *Glottidia albida* (Hinds). Among the unidentified groups were nemerteans, sipunculids, oligochaetes, ostracods, cumaceans, tanaids, isopods, amphipods, decapods, aplacophorans, scaphopods, phoronids, ophiuroids, and enteropneusts.

SUMMARY

1. A quantitative study was made of the subtidal benthic polychaetes at Catalina Harbor, Santa Catalina Island, California.
2. Forty-three different species of polychaetes were collected and compared to similar protected areas studied in California and Baja California. The polychaetes of Catalina Harbor were more like those of Newport Bay than elsewhere.
3. The relationship of the principal species of polychaetes to sediment particle size was discussed.
4. The other invertebrate species encountered in Catalina Harbor were listed.

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AMPHIBIANS AND REPTILES FROM CAVE DEPOSITS IN SOUTH-CENTRAL NEW MEXICO

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In 1929 and 1930 a series of cave deposits in limestone cliffs on the western flank of Pyramid Peak, Organ Mountains, Dona Ana County, New Mexico, were explored and excavated by W. M. Strong, H. A. Wylde, F. R. Fosberg, and R. P. Conkling, all then of the Los Angeles County Museum. The caves, Shelter, Conkling, Wylde, and Fosberg, were of unusual interest in that: 1. they contained one of the first records of human remains associated with extinct mammals (*Nothrotherium*, *Tetrameryx*, *Camelops*, etc., Bryan, 1929; Howard, 1935; Stock, 1936); 2. the amount of material preserved was large, (there are, for example, among the herpetological material, over 3000 rattlesnake vertebrae preserved); and 3. the material was unusually well preserved. Excellent preservation is the rule in deposits found in dry caves in the southwest; a large number of the snakes from these caves even had fragments or portions of skin surrounding the skeleton. Indeed, one of the complete skeletons of *Elaphe subocularis* excavated from under much bat guano had the skin so well preserved that the outlines of the color markings could be seen.

Description of Caves

The caves explored by the Los Angeles County Museum party included two fairly large caves, Shelter and Conkling, and two small, almost crevice-like caves in the limestone cliffs of the Organ Mountains. The caves were all being used by bats and there were extensive layers of bat guano on the floors of the caves. Two caves, Shelter and Conkling, were explored and excavated with some care. The two smaller caves apparently did not warrant extensive exploration.

The main reasons for the accumulation of material in the caves appears to be: 1. that caves such as these offer, in such a harsh, semiarid environment, a shelter from intense solar radiation during the day; 2. the caves provide natural "homes" for the smaller carnivores; and 3. the caves harbor numerous bats which are known to be fed upon by snakes (Barbour and Ramsden, 1919; Herreid, 1962).

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AGE

In spite of the interest in the caves and the material available, there have been no radiocarbon dates recorded. There is no reason not to assume that the caves are relatively equal in age, though Wylde and Fosberg caves have no adequate material for relative age dating. The fauna of the caves, which includes some extinct forms and many living forms, plus the indications of contemporaneous occupancy by humans (burned tortoise shells, burned bones of extinct animals, artifacts, etc.) suggest that the caves are: 1. Post-Wisconsin, 2. Post-human occupation of North America, and at least in part, 3. Pre-extinction of such forms as *Camelops*, *Canis dirus*, *Tetrameryx*, *Nothrotherium*, etc. This, plus the radiocarbon dates that are available for other caves in the southwest, suggest an age for Shelter and Conkling Caves as from 10,000 to 6,000 bp. Stock (1936) thought Conkling cave to be a little older than Shelter Cave. Since there are no extinct forms in Wylde and Fosberg Caves they may be younger, and indeed, accumulation may have occurred in them as well as in the upper layers of Shelter and Conkling Caves from 6000 years ago to the present.

SHELTER CAVE

Shelter Cave is located in limestone cliffs, about 450 feet below the summit of Pyramid Peak, Organ Mountains, Dona Ana County, New Mexico. The collections from this locality in the Los Angeles County Museum are labeled LACMVP 1010. In addition, since the cave was excavated in five-foot sections, most of the material is labeled with section data. All specimens collected from talus, fill, or other areas are labeled 1010 Dump or 1010D. Those specimens labeled by C 1010 were collected by R. P. Conkling.

Two profiles within the cave deposit are in the original field notes, one of these in section S-5-7 reads from bottom to top: rock bottom of cave, 5″ angular fragments, 8″ smooth concretionary limestone fragments mixed with brown dust, 6″ ash mixed with angular fragments, 10″ of layered gray (volcanic?) ash grading into a layer of brown, 4″ of hard, burned guano, 4″ of unconsolidated bat guano, top. Most of the bones were found in the brown and gray ash. Another section 53″ thick reads from bottom up: floor of cave, 17″ broken concretionary limestone fragments, 16″ of brown ash, 12″ of gray layered ash grading into the brown below it, 8″ of bat guano, top.

Some of the original field notes are illustrative of the position of some of the material. They read: "Sloth in place, S-5-4 in upper guano layer and in direct association with bits of knots of vegetative material," "S-6-5, sloth bone in upper yellow layer," "Mummified rat and snake on top of rocks in bat guano," "S-5-6, S-5-5, horse jaws in brown ash," "S-5-6, sloth skull fragment in gray ash below overhanging rock. In same section above rock was an indian grindstone," "S-4-7, beads and sandal found beneath guano layer and also below overhanging rock," "S-4-9, badger and deer skulls in gray ash."

In addition to the amphibians and reptiles reported here, the fauna of Shelter Cave includes: *Nothrotherium*, *Tetrameryx*, *Camelops*, *Equus*, (two species, one large, one small), *Spilogale leucoparia*, *Taxidea taxus*, *Mephitis mephitis*, *Lynx rufus*, *Breameryx*, *Canis latrans*, fox, gopher?, *Neotoma* (Stock, 1930, 1932, 1936; Hill, 1936).

Scaphiopus cf. *couchi* Baird. - Couch's Spodefoot.

From section S-3-15 there is one left ilium that appears more like *S. couchi* than any other anuran. It does not have the subiliac process as in *Rana* nor the shape of *Bufo* ilia. Among the *Scaphiopus* examined (*couchi* and *hammondi*) it is similar to *couchi* in the curvature of the anterior portion and in the shape of the acetabulum. The identification, however, must be considered tentative considering that there is only one bone.

Rana cf. *pipiens* Schreber. - Leopard Frog.

A sacral vertebra with two posterior centra, an oval anterior process, and relatively narrow transverse processes is referred to the *genus Rana* on the basis of these characters and to the species on the basis of size, shape, and geography. The specific determination, however, is tentative.

Gopherus sp. - Tortoise.

Brattstrom (1961) referred the isolated bones and shell fragments of tortoises from Shelter and Conkling Caves to *G. agassizi* noting that many of the bones were burned, presumedly by indians that inhabited the cave, and that the isolated and fragmentary nature of the material did not allow for comparison with many of the other species in the genus. He did note that the specimens did not resemble *G. berlanderi* other than in being generally smaller than the average *G. agassizi*. Subsequent to the submission of Brattstrom's paper of

1961, Legler (1959) described and redescribed (Legler and Webb, 1961) the recent Bolson Tortoise, *Gopherus flavomarginatus*, from regions south of, but adjacent to, southern New Mexico (northern Coahuila, Chihuahua, and Durango). The Shelter Cave material represents a small tortoise, hence is unlike *G. flavomarginatus*, which is said to be larger. The isolated and fragmentary nature of the cave material prevents checking to determine if the Shelter Cave material is, in fact, *G. flavomarginatus*. In the material recorded by Brattstrom (1961) gular mid-line measurements are shorter than humeral mid-line measurements. Legler and Webb (1961) note that one of the distinguishing characteristics of *G. flavomarginatus* is that the intergular seam is considerably longer than the interhumeral. On this basis, the Shelter Cave material agrees better with *G. agassizi*, even though the cave is far to the east of the present range of *G. agassizi*.

Since many of the tortoises in Shelter Cave were burned, it is possible that the tortoises in the cave deposits may have been carried there by indians for food either from the south (hence *flavomarginatus* material) or from the west (hence *agassizi*). It is also possible that the tortoises were burned as the result of a naturally occurring fire in or near the cave. The Shelter Cave fragments come from N-2-5, S-3-15, S-7-4-A, and dump.

Eumeces obsoletus (Baird and Girard). - Great Plains Skink

One broken right lower jaw measuring 17.0 mm. is referred to this species. The dentary length is 11.1 mm. There was no section data with this jaw. See the discussion under this species from Wylde Cave.

Phrynosoma cornutum (Harlan). - Texas Horned Lizard.

Six parietals (one from S-2-8), one frontal, 1 scapula, and one fragment of a maxilla are all nearly the same as modern *Phrynosoma cornutum* and do not differ from a specimen of this species (BHB 2080) from Valentine, Texas.

Crotaphytus collaris (Say). - Collared Lizard.

Collared lizards are quite numerous in the Shelter Cave material. The cave material is somewhat larger than the two specimens of *C. c. baileyi* at hand and includes 9 frontals (2 from S-4-16, one each from S-2-14, S-3-15, S-4-14) measuring 10.9, 11.2, 11.2, 11.8, 12.0, 12.2, 12.6 mm. long. The frontals on two recent skeletons are: 8.5

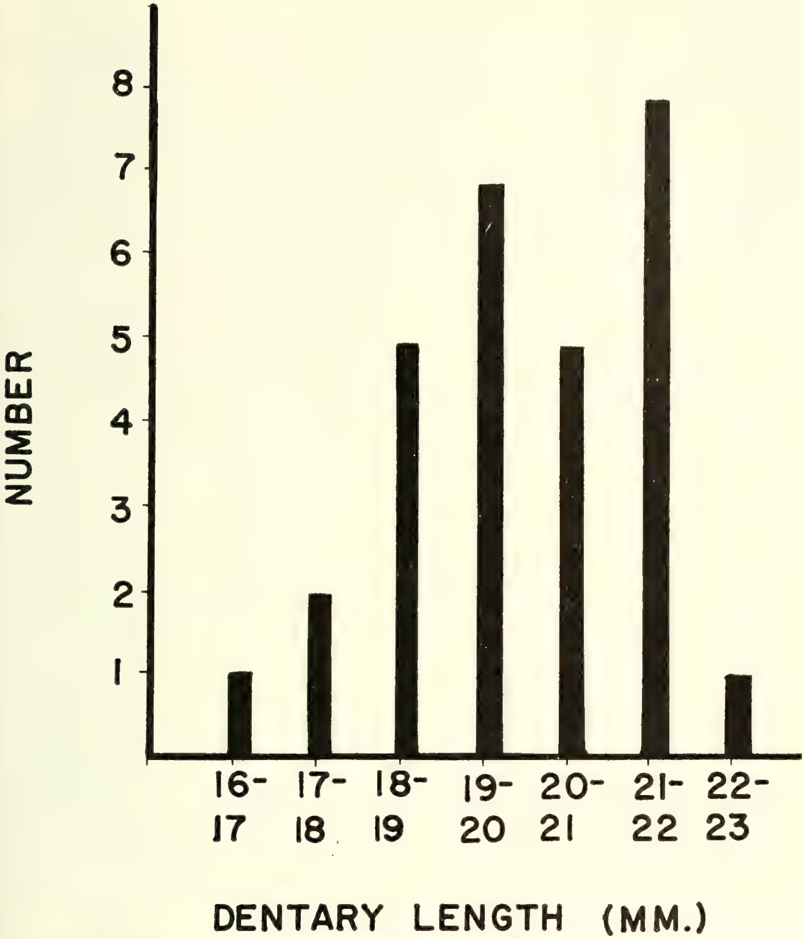

Figure 1. Histogram of dentary lengths of collared lizards, *Crotaphytus collaris*, from Shelter Cave, New Mexico.

and 11.4 mm. long. There are 43 dentaries, 16 with section data, ranging from 16.3 to 23.0 mm. (see fig. 1) long. The dentaries were measured from the anterior end to the most posterior extent of the posterior dentary process. In addition, there are two maxillae (one from S-3-15, one without section data), eight parietals (S-3-15, S-5-10, S-3-14, and 3 without section data), one right pterygoid (S-3-15) which is larger (21.7 mm.) than the two recent skeletons (12.7 and 15.9 mm.), and two occipitals (one from S-4-14 and one without section data), both of which are larger than the recent skeletons available.

From the "dump" there is a complete skull of a collared lizard, with skin, but without color pattern. I could find no major differences between these specimens and preserved specimens of *C. c. baileyi* from California except that the head of the fossil is not as pointed as the preserved specimens and the scales in the parietal area are slightly larger than in the preserved material. The head length of the fossil (=lower jaw length) is 23.0 mm. and the greatest head width is 6.6 mm.

Coluber constrictor Linnaeus. - Racer.

This species of racer is represented by 78 vertebrae from various sections in the cave and from the dump. Centrum length measurements for a few of these vertebrae are: 4.1, 5.7, 5.7, 5.7, 6.1, 6.2, 6.2, 6.3 mm.

Masticophis flagellum (Shaw). - Coachwhip.

Three vertebrae, one from the gray ash of section N-2-13 with a centrum length of 6.5 mm. and two from section S-5-7 are the same general size as *Coluber constrictor* but are tentatively referred here on the basis of a more flattened subcentrum keel.

Lampropeltis getulus (Linnaeus). - Common Kingsnake.

Kingsnake material comes from sections S-8-5, S-4-13, S-6-8, N-3-10 (1 vertebra each), S-7-6 (2 vertebrae) and nine are without section data. Centrum length measurements on seven of the latter are: 4.9, 5.5, 5.5, 5.9, 6.3, 6.4 mm.

Pituophis catenifer (Blainville). - Gopher Snake.

Over 412 vertebrae of bull snakes are included in the material from the cave. The snakes come from most of the sections, the dump, and many have no section data. Centrum length measurements from various sections include: S-8-9, 6.5, 6.6, 6.7, 7.3, 7.4; S-6-10, 6.6, 6.9, 7.0; S-5-13, 5.2, 7.0, 7.1, 7.4; S-2-14, 5.9, 6.2, 6.3, 6.6 mm.

By virtue of their rarity, abnormal vertebrae found in the fossil record are of interest. From section S-1-14 there are three vertebrae, two of them united and abnormal in that the subcentrum keel of one vertebra is flattened and fused with the centrum and keel of the following vertebra. From section S-3-14 there are 14 vertebrae, of which two are united and fused with the keel passing the intervertebral junction to join and fuse with the following vertebra. One vertebra, among 7, from S-3-12 has two postzygapophyseal processes on the right side.

Elaphe subocularis (Brown). - Trans-Pecos Rat Snake.

This rat snake is represented in the cave material by 127 vertebrae from many sections and many series of vertebrae, some with mummified skin about them. From S-2-11 there is a skull with a few vertebrae surrounded by skin. Some pattern is preserved in the skin and the subocular scales are discernable on the skin below the eye. The lower jaw length of this snake is 24.5 mm. From S-3-9 there is a mummified body with skin in which the pattern is discernable. The pattern and the scales are similar to preserved specimens of *E. subocularis*. The lower jaw length of this snake is 33.4 mm. and the snake is approximately three feet long.

Crotalus atrox Baird and Girard. - Western Diamondback Rattlesnake.

The number of diamondback rattlesnake vertebrae in the cave deposit is amazing. In one box, representing material with no section data, there are over 3000 vertebrae. In addition vertebrae come from almost every section excavated in the cave. Many of the vertebrae are in united groups with bits of skin about them. Some maximum measurements of the vertebral material are: height: 28.6, width: 13.9, centrum length: 11.2, width across prezygapophyses: 23.2 mm. The vertebral and other skeletal elements all appear similar to present *C. atrox*. The other skeletal material includes: articulars (10, all with subarticular ridges), dentaries (4, teeth socket counts on three are: 10, 10, 11), basisphenoid (1), basioccipital (1), ectopterygoid (2, the length of one: 19.5 mm.), parietals (5, length and width measurements: 12.5 x 25.6, 12.7 x 22.4, 9.8 x 15.0, 11.4 x 18.0, 9.0 x 16.4 mm.), lower jaws (6, lengths: 24.2, 37.0, 47.0 mm.), a maxilla (height: 22.3 mm.) with a fang (length: 11.0 mm.), and many ribs. From section S-4-9 there is an entire skull with skin with the following measurements or counts: lower jaw length: 23.9, head width: 23.9, fang length: 13.0 mm., palatine teeth: 3, pterygoid teeth: 8, 9, interocular scales: 5. The articular has a ridge below it. A section of skin with vertebrae from S-7-9 appears to have a scale row count of 20. Material from N-2-13 was found associated with a horse skull and a deer metapodial in the brown ash layer and included one broken burned vertebra and a section of 4 unburned vertebrae. One abnormal hyapophysis on a vertebra from S-5-13 was noted.

CONKLING CAVE

In addition to human remains, the fauna of nearby Conkling Cave includes: *Equus*, *Nothrotherium*, *Canis dirus*, *Canis latrans*, *Tanupolama*, *Camelops*, *Bison*, *Tetrameryx*, *Breameryx*, *Urocyon*, *Ursus*, *Vulpes*, hawks, eagles, falcons, owls, grouse quail, turkey, roadrunner, woodpecker, and song birds (Bryan, 1929; Stock, 1936; Stewart, 1951).

Gopherus sp. - Tortoise.

The tortoise material from this cave has been discussed above and by Brattstrom (1961).

Coluber constrictor Linnaeus. - Racer.

Two vertebrae with centrum lengths of 6.4 and 7.3 mm. are referred to this species.

Pituophis catenifer (Blainville). - Gopher Snake.

Though this species was common in Shelter Cave, only one vertebra with a centrum length of 6.2 mm. was found in the Conkling Cave material.

Elaphe subocularis (Brown). - Trans Pecos Rat Snake.

One vertebra with a centrum length of 5.5 mm. is referred to this species.

Crotalus atrox Baird and Girard. - Western
Diamondback Rattlesnake.

There are 27 rattlesnake vertebrae from this cave of this species.

WYLDE CAVE

A small bat cave in the limestone cliffs near Shelter Cave is referred to by the collectors as Wylde Cavern, named after one of the collectors Henry A. Wylde. The locality, LACMVP 1132 has a small herpetofauna.

Crotaphytus collaris (Say). - Collared Lizard.

Collared lizard material from this cave includes one section of 12 abdominal vertebrae and one lawer jaw with a dentary that measures 19.6 mm. long.

Eumeces obsoletus (Baird and Girard). - Great Plains Skink.

Skink material from this cave includes one section of the vertebral column pelvic girdle with skin around it. These specimens and the skink from Shelter Cave are referred to *E. obsoletus* on the following basis: (I am indebted to Fred Gehlbach for measurements and counts on 9 *E. multivirgatus* and 6 *E. obsoletus* from the Cornell University collections): 1. The lower jaw agrees in size with *E. obsoletus* (lower jaw length: *multivirgatus:* 9.8-11.7, *obsoletus*: 17.0-21.5, Shelter Cave Jaw: 17.0 mm.). 2. The pelvic girdle, if used as an index of the length and width of the lizard would give a snout-vent length for this specimen of from 3½ to 4½ inches long. This would agree in size with *E. obsoletus* but be much too large for *E. multivirgatus* (snout vent length for 9 recent *multivirgatus:* 47-69, for 6 *obsoletus:* 96-121, cave specimen: probably between 90 and 110 mm.). 3. The height and width of the body of the fossil, measured at the region of the sacrum, appears similar to *E. obsoletus* (*multivirgatus:* 5.0-6.8 x 5.5-7.9, *obsoletus:* 10.0-14.5 x 10.5-15.0, cave specimen: 9.8 x 14.0). 4. The scales around the body appear to be about 28-30 scale rows which would be within the range for *obsoletus* (25-30) but too high for *multivirgatus* (24-26). 6. The scales on the Wylde Cave specimen appear to be diagonal instead of parallel. The former is characteristic of *E. obsoletus*, but the character is difficult to use in the pelvic region.

Elaphe subocularis (Brown). - Trans-Pecos Rat Snake.

Rat snake material from Wylde Cave includes four sections of the vertebral column, five separate vertebrae, and a posterior portion of a skull with frontals and parietals present. The material does not differ from Recent or Shelter Cave specimens.

Fosberg Cave

Another limestone fissure or cave was named by the collectors for one of the collectors, F. R. Fosberg. The cave, LACMVP 1154, includes one section of the vertebral column with 18 mid-thoracic vertebrae of the rattlesnake, *Crotalus atrox.*

Discussion

Several of the cave deposits in New Mexico have contributed significantly to the discussions of climatic change on the southwest

(Stock and Bode, 1936; Murray, 1951). The herpetological material from the four caves studied does not, in this case, contribute significantly to the discussion, as all of the forms found in the four deposits, with the pragmatic exception of the tortoise, occur in the region of the deposits today (Lewis, 1950). The herpetological material does, however, show that many of the forms existing in Dona Ana County, New Mexico today have existed there for some time, and at least for a while coexisted with such extinct forms as ground sloths, camels, and horses.

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NEW LOCATIONS FOR CHAGAS' TRYPANOSOME IN CALIFORNIA

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Introduction

The progress of discovery of sylvatic *Trypanosoma cruzi* Chagas continues in California without proof of the parasite infecting man. Reasons for this are unclear. The ease with which these trypanosomes can be put into native and laboratory mammals experimentally suggests ample infective ability (Wood, 1934). The widespread persistence in natural reservoir white-footed mice, *Peromyscus*, and wood rats, *Neotoma*, bespeaks wide-ranging contacts by these mammals with infected insect vectors (Wood, 1952; Wood & Hughes, 1953). The more numerous and widespread the insect vector, *Triatoma*, the greater are the number of possible contacts for man (Ryckman, 1962). The changing seasonal temperature cycle stimulates more intense mammal parasitemias in winter and higher rectal concentrations of infective trypanosomes in the bugs in summer. This provides maximum opportunity for natural infection of the hematophagous insect vectors before their succeeding active dispersal periods in summer (Wood, 1962). During the winter periods of stress for the mammal, the trypanosomes are picked up more easily and frequently by the bugs because of the higher parasitemias. The opportunity for *Triatoma protracta protracta* (Uhler) to ingest trypanosomes from the blood of zoo animals as at the San Diego Zoological Park and at Griffith Park, Los Angeles, suggests the possibility of introduction of more virulent strains of *T. cruzi*, with higher infective potential for man, into native mammal reservoir hosts.

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This is a challenge to the interested research physician who may receive live or dead conenose bugs from patients at the office (Table 1, Placerville). During the high temperatures of summer, the food drive stimulates dispersal of the infected bugs insuring greater frequency of contacts with man. In well populated areas, more and more annoyance to man by trypanosome-infected bugs is being reported to the writers (Wood & Wood, 1964). Examination of at least 10 live conenose bugs from any single locality is advisable for a minimum test sample. This summary covers the field work of the writers since 1949 (Wood, 1950).

OBSERVATIONS

A chicken ranch on Hildreth Road, Madera Co., Table 1, in the Sierra Nevada foothill country near O'Neals is apparently attractive to *Triatoma*. Inspection of a newly-constructed residence revealed an unscreened fireplace vent as the site of entry for night-flying conenose bugs. The wife of the rancher reacted so violently to the feeding of *Triatoma* that she refused to occupy this location overnight. The presence of dogs for property protection furnished another strong attraction for conenose bugs to this well-built mountain home. Such animals are prime suspects for maintaining infections with *Trypanosoma cruzi* and could easily become infected by chewing up an occasional infected bug. At least a ten-year period of annoyance by *Triatoma* was known for this location (Augustson & Wood, 1953).

The Knowles specimens were from a wood rat house built in the corner of one room inside a recently abandoned mountain home, indicating the advisability of good rodent and insect protection for homes in such locations (Augustson & Wood, 1953).

The Placerville bugs were all received by James W. Elliott, M.D., interested in *Triatoma* annoyance. His eight year cooperative donation represents a minimum infection rate for the region since many specimens were received too dry for successful direct microscopic examinations. An additional ♂ from El Dorado County and ♀ from Auburn were negative for trypanosomes.

The Alpine, San Diego County, location represents a 12-year cooperative donation of interested housewives. Forty-two specimens were from one home, seven from homes immediately adjacent and two from within one mile of the others. The low infection rate is probably due to the receipt of most specimens in a very dry condition wherein trypanosomes could be unrecognizable with the wet maceration technique employed. Recorded observations on 24 *Triatoma* by Mrs. E. A. Wilcox in her home reveal that 15 bugs were found in the kitchen and bathroom. Nine were taken from the kitchen sink and one from the bathtub during spells of hot weather. Other collecting sites were living room (3), bedrooms (3), upstairs landing (1), and back room where the dog slept (2). Collection of ten of these bugs was between 5:30 and 8 a.m., most bugs being found around 6 a.m. Ten of the 24 specimens were collected between 7:45 and 10:15 p.m. One bug was found hiding in a slipper and another in a boy's sock. One bug flew in and landed near the refrigerator one summer evening.

There were more home invasions by *Triatoma* than usual in the Pauma Valley during the summers of 1957, 1958 and 1959, since most of the specimens forwarded were collected in 1957 and 1958 (Wood, 1960). Mrs. F. D. Fitzsimmons and neighbors reported at least 50 specimens destroyed up to July 21st during the spring and summer of 1959. She reports that many times she observed bugs lying on their backs on the floor probably as a result of insecticide contacts as previously noted by Wood (1951). She observed an adult bug feeding on the paw of a sleeping cat on the davenport in the living room without disturbing the pet. She reports the first case in California known to the authors of a *Triatoma* feeding on the face (eyelid) of man, with subsequent edema.

The extension of the range of infected *Triatoma* to the Oroville area at 39° 30′ N is most interesting biogeographically since naturally-infected raccoons have recently been reported in the eastern United States at 39° 03′ N by Herman and Bruce (1962). The writers thank J. A. Robertson for the opportunity to examine these specimens. Oroville is the most northerly location now known for the natural occurrence of *Trypanosoma cruzi* in California and the United States.

The Mulholland Drive Overcrossing at Sepulveda Canyon, the Westwood, and the Roscomare Canyon sites suggest a dispersal area of naturally-infected mammals and bugs centering in the vicinity of the Stone Canyon Reservoir in the Santa Monica Mountains and extending into the nearby San Fernando Valley at Sherman Oaks and Tarzana. Although the freeway construction and brush fires in Sepulveda Canyon have destroyed some natural habitats, the more open "breezeway" created may offer stronger air currents favorable to dispersal of new yearly generations of *Triatoma*. The collecting locale at the Mulholland Drive Overcrossing is an aggregation site for conenose bugs because of (1) their sensitivity to heat and possibly light and (2) its location bisecting the warm canyon air flow (Wood & Wood, 1964).

The Kernville bug was found beside a sleeping bag under a sock by an interested camper and brought to the laboratory for examination.

An additional source of infected *Triatoma* is reported by Ryckman (1952) for Riverside, Riverside County.

The Westwood locations reported here are unique in that the specimens represent a cooperative collecting project of a junior entomologist, Laurel Woodley. Maintenance of a blacklight near her canyon home and knowledge of *Triatoma* annoyance have furnished information on the regularity of occurrence of night flights in the area.

The Roscomare Canyon bugs reached our laboratory as a result of special interest by local physicians in the presence of this home-invading disease vector. It is most unusual for single samples that both bugs from inside these homes harbored heavy infections of Chagas' trypanosome.

DISCUSSION

The authors hereby urge other interested research zoologists and physicians to find and test these trypanosomes from *Triatoma* in laboratory animals. At present, leishmaniform development in laboratory infected mammals is known for trypanosomes of *Triatoma* from Griffith Park, O'Neals, Plymouth, San Diego, and Sanger sources. All other identifications are based on the close similarity of these parasites to *Trypanosoma cruzi* on stained smears or sight recognition in the dejecta of the bugs. Although it is unlikely that *Trypanosoma conorhini* or *T. rangeli* occur in our North American vectors, this possibility must be constantly borne in mind especially in this age of jet air transportation and in view of the accidental introduction of *Triatoma rubrofasciata* in Hawaii (Wood, 1946, Zimmerman, 1948) and the relatively recent discovery of mixed infections of *Trypanosoma cruzi* and *T. rangeli* in Central and South America (de Leon, 1949, Pifano, 1954, and Deane, 1958).

Therefore, proof of the developmental cycle in the mammal is essential for the accurate identification of *Trypanosoma cruzi*. Especially important morphological features of the trypanosome are the

20 μ total length of the blood forms, centrally located nucleus, and large kinetoplast complex near the posterior end of the cytosome.

An interesting verification of the continued existence of Chagas' trypanosome in the Pasadena locality (Eaton Canyon, Wood, 1938) appeared recently in the form of three bugs forwarded from a physician's office on Wilshire Boulevard in Los Angeles through the entomologist at the Los Angeles County Museum. Two of these bugs showed heavy infections of *Trypanosoma cruzi*. This indicates the continued existence for 25 years of the animal reservoirs in an urbanized area and the first record of recovery of naturally infected insect vectors from a human habitation in Pasadena.

The total count of conenose bugs for the authors to 1963 in California is 2,693 collected or received with 2,245 examined and 529 or 23.5% found harboring *Trypanosoma cruzi*. This infection rate for bugs compares very favorably with other known areas in North, Central and South America where human cases of Chagas' disease have been reported. The principal ecologic factor limiting human infection in the southwestern United States is probably the small number of prolonged contacts and subsequent opportunities for dermal, ocular or oral contamination with trypanosomes in adults and children.

Considering the Sherman Oaks-Tarzana-Mulholland Overcrossing-Westwood region as one location, there are at least 18 localities now known in California for the recovery of *Triatoma* naturally infected with *Trypanosoma cruzi*.

TABLE 1
Additional California Localities for *Trypanosoma cruzi* in *Triatoma p. protracta*

Locality	Bugs Coll.	Bugs Exam.	No. Inf.	% Inf.	Years Sampled
Hildreth Road, Madera Co.	32	4	2	50.0	1951
Knowles, Madera Co.	2	2	1	50.0	1952
Placerville, El Dorado Co.	29	22	2	9.0	1954*, 1955, 1957*, 1958*, 1959, 1961*, 1962*
Alpine, San Diego Co.	51	48	6	12.5	1950*, 1951*, 1956*, 1958, 1959, 1960, 1961, 1962*
Pauma Valley, San Diego Co.	75	8	3	37.5	1959
Oroville, Butte Co.	4	4	2	50.0	1960
Mulholland Overcrossing, Los Angeles Co.	216	205	47	22.9	1960, 1961
Westwood, Los Angeles Co.	20	20	2	10.0	1960
Sherman Oaks, Los Angeles Co.	5	5	2	40.0	1960
Kernville, Kern Co.	1	1	1	100.0	1960
Roscomare Canyon, Los Angeles Co.	2	2	2	100.0	1960
TOTALS	437	321	70	21.4	1951 to 1963

*Years when *Trypanosoma cruzi* was not found in the bugs.

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THE LIZARD GENUS *AMEIVA* IN ECUADOR[1]

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INTRODUCTION

The teiid genus *Ameiva* is represented in Ecuador by five species, one of which will be described as new in this paper. The other four species have been known to herpetologists for many years, although two of them (*bridgesii* and *septemlineata*) have been occasionally confused and have at least once been synonymized (Burt and Burt, 1933:53). The species are most common in the lowlands of the country, although specimens have been collected at localities as high as 1700 meters on the western slopes of the Andes. The maximum altitude reached on the eastern slopes is clearly less than 1000 meters, and perhaps even less than 500 meters. Populations are large when the species is present, and it is not expected that the genus is to be found outside the limits currently established.

This survey of the genus was begun in 1958-1959 during my tenure of a Fulbright professorship at the Universidad Central in Quito, Ecuador, based on materials I collected, as well as the collections of the Escuela Polytecnica Nacional of Quito and of Dr. Gustavo Orces-V., who was most helpful and generous to me during this and other stays in Ecuador. I have had field experience with all except one species, *Ameiva ameiva petersi*, known only in the lower part of Amazonian Ecuador (Nuevo Rocafuerte and Loreto). Descriptions of all species are included except *A. edracantha*, which has been clearly recognized and is sharply distinct from the other species. Abbreviations used in this paper include EPN for Escuela Nacional Polytecnica of Quito, JAP for James A. Peters collection, MSU for collections of Michigan State University, and OV for Gustavo Orces-Villagomez personal collection.

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SPECIES ACCOUNTS

Ameiva ameiva petersii Cope

This species was originally described by Cope (1868:99) from "the Napo or Marañon," referring to the rivers followed by the Orton Expedition. Most of the Napo and all of the Marañon are now Peruvian, since the Río de Janeiro decisions assigned a large part of Amazonian Ecuador to Peru. It is, of course, quite uncertain from whence the type actually came. Barbour and Noble (1915:466) had a series of specimens they thought belonged to this taxon, from Teffe and Manaos, Brazil, but in their description they do not describe the scutellation of *petersii* except to say it is the same as that of *A. ameiva ameiva.* When the latter description is compared with the available specimens from Ecuador, there are some striking differences. At any rate, the series described here was collected on the Río Napo, and represents the first available specimens from within the region mentioned in the type description.

Description: Anterior nasals in broad contact behind rostral; frontonasal, prefrontals, and frontal normal; a pair of frontoparietals and five occipitals, outermost lying slightly posteriorly to inner three, with center occipital often divided into pair of scales; area between occipitals and granular dorsal scales occupied by flat, polygonal scales; four supraoculars, middle two large, anterior smaller, and posteriormost smallest; posterior margin of supraocular region covered by several rows of small scales extending forward between frontoparietals and supraoculars to level of about ⅓ to ½ of third supraocular, and between supraoculars and superciliaries to level of first supraocular. A single loreal; a very elongate superciliary followed by several much smaller ones; 3-4 larger scales in semicircle around anterior and ventral border of orbit; a single row of enlarged scales extending horizontally from dorsal margin of eye to temple; usually six definable upper labials. Six or seven lower labials, a single postmental and a series of paired infralabials, all except the first and part of the second of which are separated from the labials by granules or slightly enlarged scales; a broad band of enlarged scales running transversely across throat between angles of jaws and anterior gular fold; a transverse patch of enlarged scales across mesoptychium.

Dorsal and lateral scales tiny, granular, and undifferentiated. Venter with 28-32 transverse rows of rectangular, flat, imbricate plates, with 10 scales in a single row, bordered laterally by one and sometimes two slightly smaller but still enlarged scales, which can increase count of ventral rows to 12. Forelimb with 2-3 rows of enlarged scales on anterior margin, one much larger than others; a patch of enlarged scales behind the elbow, rest of arm covered with granules. Hindlimb with strongly enlarged flat scales anteriorly and ventrally, with smaller but still enlarged scales extending to femoral pore series; 13-17 femoral pores. Tail with enlarged, flat, abutting plates in concentric whorls, with degree and magnitude of keeling increasing throughout length of tail to end.

Dorsum marbled with black on an olive ground color in juveniles, unicolor blackish-olive in old adults. Sides with light spots in three to five horizontal series, practically forming stripes in juveniles, but very broken up in adults, on which vertical fusion can take place, or the spots may be lined up in vertical series. Dorsum of head lighter than dorsum of body. The chin and throat are blue-black, with irregular white spotting on the labials; the ground color of the body and limbs ventrally is cream-white, heavily invaded by blue or black laterally and with bluish spotting on mid-venter. The area around the vent extending onto tail and hind limbs is the lightest ventral region.

Variation within species: There are 28 specimens available from Ecuador, all except one from Nuevo Rocafuerte. One of these has the frontal divided by a transverse suture, another has it partially divided by a longitudinal suture, but it is entire in the remainder. In only one specimen are the frontal and the frontoparietals separated from supraoculars by granules, although in all cases the granules reach between the third supraocular and frontoparietals a short distance. The ventral scales are sometimes divided longitudinally, resulting in obviously smaller scales, and if a count is made across such a transverse row there will be occasionally eleven but more often twelve in the series, and if the enlarged scales at the ends of the ventral rows are included, as many as fourteen in a series. The femoral pores are most often 15 or 16, with these counts recorded for 35 out of 44 legs.

Specimens examined: O.V. 1037, from Loreto, Napo Province; O.V. 1302-28, from Nuevo Rocafuerte, Napo Province.

Ameiva septemlineata Duméril and Duméril

Although Burt and Burt (1933:53) indicated that the range of this species was "Bolivia and possibly northern Chile, northward into Colombia," it is very likely that they did not clearly recognize the taxon. They were convinced that *A. bridgesii* was a synonym of *sep-*

temlineata, and felt that the specimen described by Barbour and Noble (1915:477) as *septemlineata* was actually a representative of the species *A. edracantha*. I have compared the description by Barbour and Noble with specimens of both species, and I am sure that they had a specimen of *septemlineata*. This species is a member of the Chocóan fauna, living only in northwestern Ecuador and the lowlands of Pacific Colombia, and the record of a specimen from Huachi, Bolivia, by Burt and Burt (1931:311), is not only doubtful, it is clearly impossible. Since it appears that some confusion exists as a consequence of these older papers, I re-describe this species on the basis of material in my collection and that of Escuela Polytecnica Nacional of Quito.

Description: All scales on dorsum of head posterior to frontonasal small, with from 1 to 7 scales lying between the widely separated and much reduced prefrontals (when these scales can be recognized) and from 4 to 8 scales in area occupied by frontal in other *Ameiva;* occiput and temples occupied by many small polygonal scales. Two enlarged supraoculars, usually surrounded by 1 to 3 rows of granular scales, but occasionally in contact with scales in frontal area. Usually all head scales with irregular surface as consequence of swollen, raised areas irregularly distributed but occasionally lying in position of a keel, or forming part of a ridge running across several scales. Scales of chin from infralabials to anterior gular fold subequal, although in older individuals some slightly enlarged scales occupy central area; scales on mesoptychium distinctly and strongly enlarged, flat, and lying in one to several transverse rows.

Scales on dorsum and sides of body granular and undifferentiated. Ventral scales in 25-29 transverse rows, with six rectangular, flat scales in a single row. Preanal patch of 3-5 enlarged scales, surrounded by granules. Forelimb with 1-2 rows of greatly enlarged scales on anterior margin of humeral region, continuous with enlarged series on forearm; a small series of enlarged scales lies on postbrachium near elbow. Hindlimb with strongly enlarged scales on anterior margin and venter of thigh, continuous with enlarged scales on venter only of lower leg; rest of limb covered with granular scales; 17-25 femoral pores.

Middorsal ground color brownish-gray, with regularly arranged black marbling; vertebral stripe of bright blue or greenish-blue from tip of snout to end of tail, but tends to fade and finally disappears with age, dorsolateral and lateral lighter bluish lines set off a much darker reddish-brown to brownish-black area; the lateral blue line often broken into series of dots and spots, and often participates in formation of vermiculated area on sides; a ventrolateral light line often vaguely present but not well marked may also contribute to lateral vermiculation. Head unicolor dark to black except for middorsal stripe. Venter may be light in juveniles, but usually gunmetal blue to blackish in most specimens.

Variation within the species: A total of 82 specimens have been used in making this analysis. The total rows of ventrals, ranging from 25 to 29, are distributed as follows (number of specimens in parentheses): 25 (5); 26 (14); 27 (36); 28 (23); 29 (4). The anteriormost row of ventrals, which is wider than the belly rows, extends across the shoulder girdle, and may be followed by one or two additional rows of the same nature. The first ventral row with four scales in it is the third in five individuals, the fourth in 25, the fifth in nine, and in two specimens there is no row with as few as four ventrals. The count remains four to the level of the fifth through ninth rows, then increasing to six to the level of the 24-27 rows. Four specimens have a count of eight ventrals for a very few rows.

There is a considerable variability in the femoral pore counts, distributed as follows: 17 (5); 18 (14); 19 (32); 20 (42); 21 (24); 22 (20); 23 (15); 24 (5); 25 (2).

This species is compared below with *A. bridgesii*, to demonstrate the differences between them. The scales of the forelimb are shown in fig. 1, and the arrangement of scales on the mesoptychium in fig. 2.

Specimens examined (all from Ecuador): Chimborazo Prov.: Chilicoy—JAP 2578, 2 km. south of Pallatanga—JAP 3503. Esmeraldas Prov.: Hacienda Equinox, 30 km. NNW (airline) from Santo Domingo de los Colorados—JAP 1755-60, 1762-65, 1799-1802, 1805-06, 1853, 1894-96, 1911-14, 1919. El Oro Prov.: 7 km. SSE of Machala—JAP 3577-79. Guayas Prov.: Bucay—EPN 1051-58, Headwaters of Rio Congo—EPN 1048-49, Milagro—JAP 2529. Los Ríos Prov.: Quevedo— EPN 1034-36, 1044. Pichincha Prov.: Santo Domingo de los Colorados—EPN 389-95, 408-10, immediate environs of Santo Domingo de los Colorados (± 6 km. east—JAP 3960, MSU 1384-86, 1388-89, 1391-92, 15 km. east—JAP 4108, 18 km. west —JAP 4028-33). Hacienda Lelia—EPN 412-13. Puerto Ila—EPN 414-15. Río Caoni—EPN 1068. Río Toachi—EPN 1045-47, 1064-66.

Ameiva bridgesii Cope

This species has been recognized as valid by most authors since Cope described it in 1868 (p. 306), but Burt and Burt (1930:29) sank it in *Ameiva septemlineata* without explanation. They repeated this synonymy later (1931:311), indicating those characteristics shared by the two species and using these as the basis for their action. It happens that no author has discussed this species since the appearance of the series of papers by Burt and Burt, and it thus becomes necessary to indicate that I am rejecting the synonymy of *bridgesii* with *septemlineata*, and restoring it to the status of a full species.

Description: All scales on dorsum of head posterior to paired anterior nasals, which are in contact on midline, usually very small. Frontonasal sometimes as large as in other *Ameiva* sp., sometimes divided into two scales by midline suture; from 3 to 9 small scales separating the reduced prefrontals (which may be so small as to be undistinguishable from rest of small scales); from 3 to 9 scales in area occupied by the frontal in other Ameiva. Temples and occiput occupied by many small, keeled, almost granular scales. All dorsal head scales either keeled fairly heavily or with raised, swollen areas forming part of a ridge continuous across several scales. Scales from postmental to anterior gular fold small, almost granular, with none enlarged; scales on mesoptychium also small, with no row of distinctly enlarged, flattened scales lying transversely across fold.

Scales of body granular and undifferentated except ventrally, where large, flat, rectangular scales lie in 24-26 transverse rows, with six scales in single row. Preanal patch of 2-4 enlarged scales surrounded by small granules. Humeral part of forelimb without enlarged flat scales on anterior margin, although few slightly enlarged and heavily keeled scales may occur there; very small patch of enlarged flat scales on posterior margin of upper arm near elbow; series of enlarged scales on anterior margin of forearm. Hindlimb with strongly enlarged flat scales on anterior edge, extending onto ventral surface but separated from femoral pore series by granular scales; ventral surface of tibia-fibula area with large plates; rest of limb covered with granules; 19-27 femoral pores.

Coloration very similar to that given above for *septemlineata*, except that even in juveniles the entire venter is slaty-black to jet black in preservative.

Variation within the species: 21 specimens have been available to me, and this provides the opportunity to survey species variability more adequately than has been possible previously. Some of this variability has been presented above in the description. The ventral plate arrangement calls for more extended comment, however, since

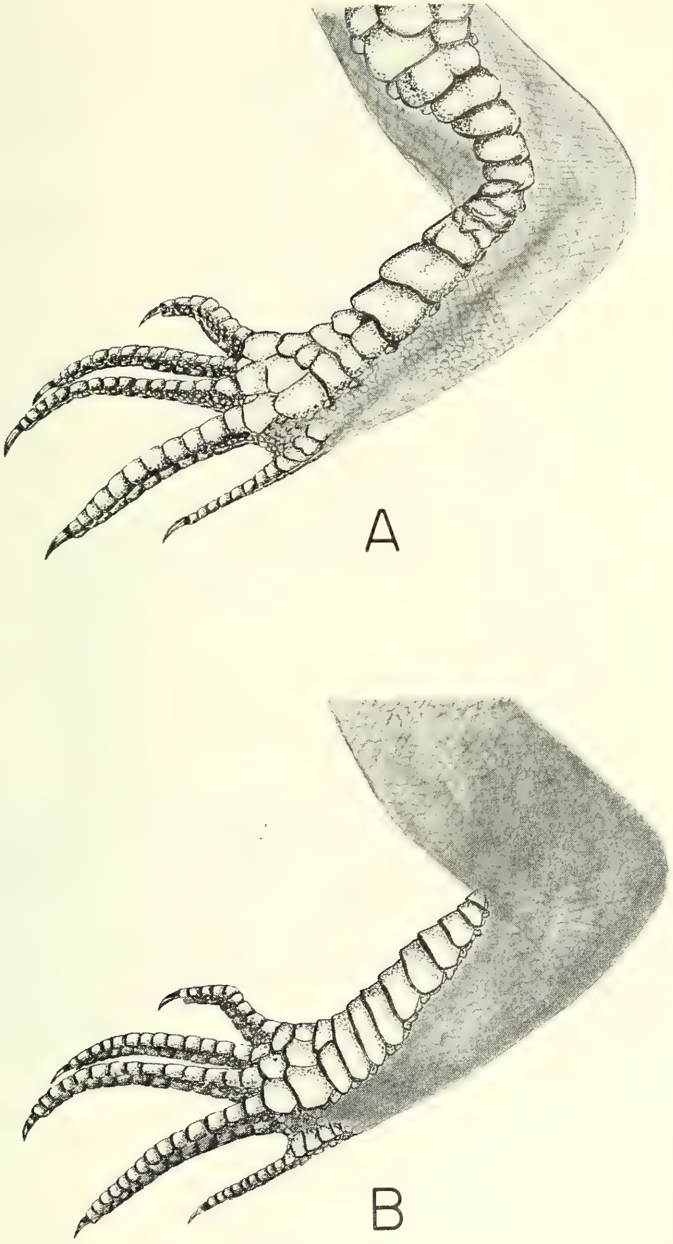

Figure 1. The forelimb of (a), *Ameiva septemlineata,* and (b), *Ameiva bridgesii,* to show the differences in the scales on the upper arm.

Figure 2. The chin and throat of (a), *Ameiva septemlineata*, and, opposite, (b), *Ameiva bridgesii*, to show the difference between the scales occupying the mesoptychium in the two species.

B

these counts play a role in species assignment. The anteriormost row of ventrals, lying across the shoulder girdle, is generally larger than the others, includes more large scales, and extends further across the ventral surface, and may be followed by one or two additional rows of the same nature. The first row with only four ventrals is the second in one specimen, the third row in seven, and the fourth row in two, in the ten individuals for which data is available. There are four scales in the ventral rows to the fourth through ninth rows, after which they increase to six, staying at that count to the 22nd to 24th rows. The next to last row usually has two to five scales, the last row two or three. The total rows are 24 in seven specimens, 25 in seven, and 26 in five.

The femoral pore count ranges from 19 to 27, with the following distribution (number of occurrences in parentheses following the number of pores): 19 (1); 20 (2); 21 (3); 22 (7); 23 (10); 24 (5); 25 (6); 26 (4); 27 (1).

The scales on the anterior margin of the brachial region are always small, although there may be a series or two of slightly enlarged, heavily keeled scales in the area. This contrasts strongly with the enlarged, flat, smooth scales in the same area in *A. septemlineata*, and constitutes one of the best reference points for quickly distinguishing the two forms, as is seen in Figure 1. The size and shape of the scales on the mesoptychium is also quite different in the two species, as shown in Figure 2. There is a marked difference in the scales of the dorsum of the head, for in *bridgesii* all head scales are finely broken up into many small scales, most of which are heavily keeled, while in *septemlineata* the breakup of the scales has not progressed so far, and the scales are swollen irregularly, with true keeling present in only a very few scales on a few specimens.

Specimens examined (all from Ecuador): Cotopaxi Prov.: valley of Río Toachi below Sigchos—EPN 1-5. Pichincha Prov.: Palma Real near Río Guallabamba—EPN 1038-39, Río Blanco below mouth of Río Toachi—EPN 1942-43. Imbabura Prov.: Below Chota in valley of Río Chota—EPN 1040-41. Esmeraldas Prov.: El Placer—JAP 2842, JAP 2852, Cachaví and environs—JAP 2877-78, JAP 2947-49, Río Cayapa at Sapallo Grande—MSU 1400, MSU 1403. Carchi Prov.: 1 kilometer N of Lita—JAP 3042.

Ameiva edracantha Bocourt

This species is easily recognized, is well characterized by Boulenger (1885:349), and has been adequately identified by most authors since its original description. Burt and Burt (1930:29) indicated that the specimen described as *Ameiva septemlineata* by Barbour and Noble (1915:477) was actually a specimen of *edracantha*, but I do not understand how they arrived at this decision. *A. edracantha* is the only species of the genus found on the western side of the mountains that is characterized by the normal arrangement of head scales, while all the others have a more or less complete division and subdivision of the head scales resulting in the absence of identifiable prefrontals, frontals, and in some cases parietals or occipitals. The specimen described by Barbour and Noble possessed these subdivisions of normal head scalation, and could not be *edracantha*, although its femoral pore count is low (14 in the specimen, 17 lower limit in specimens I have examined).

In addition to the points mentioned in the description by Boulenger of this species, I should like to point out that enlarged preanal plates occupy all of the preanal area in this species, from the lip of the anus to the end of the broad transverse rows of ventrals. In all other species from Ecuador, the enlarged preanals are separated from the transverse ventrals by several rows of much smaller, often granular scales. The enlarged scales on the gular area of the neck, anterior to the first gular fold, are grouped centrally in a small circle, while in *petersii* these enlarged scales lie in a band across the throat, and in *bridgesii* and *septemlineata* these enlarged scales are completely missing. In the other Ecuadorian species there is a prominent development of granular scales surrounding the supraoculars, but in *edracantha* there is practically no such development. The fourth supraocular mentioned by Boulenger as occasionally present in *edracantha* appears to be a remnant of the granular scales so well developed in other species.

Boulenger says that the frontoparietals are united or distinct; Barbour and Noble indicate that the frontoparietals are perhaps abnormally united. There is only a single frontoparietal in the three specimens in my collection, but I have not had an opportunity to check this characteristic for the many individuals represented in collections.

Specimens examined: Guayas Prov.: 1 km. North of Playas—JAP 3059-60, 12 km. southeast of Playas—JAP 3075.

Ameiva orcesi, NEW SPECIES

Holotype: United States National Museum 149655, adult male from half kilometer northeast of Abdon Calderon, Azuay Province, at

1600 meters altitude, collected by James A. Peters, February 28, 1959.

Topoporatypes: JAP 3534-39, all collected at the same time and place as the holotype. PARATYPES: JAP 3544-46, from 4 kilometers southwest of Abdon Calderon, 1700 meters. JAP 3575, from Río Minas, 20 kilometers west of Santa Isabel, 1250 meters. EPN 1060-63, from Santa Isabel, ± 1400 meters.

Range: The valley of the Río Jubones, at moderate altitudes (between 1250 and 1700 meters, as currently known), on the western slope of the Andes in Azuay Province, southwestern Ecuador.

Diagnosis: Differs from other *Ameiva* in possession of a number of small scales occupying the position of the frontal scale of other species; prefrontal scales separated medially; six rows of ventrals anteriorly increasing to eight on much of the belly; in general coloration; and in the distinctive combination of characters given in the description below.

Description: Rostral forms obtuse angle behind; nostril in suture between two nasals, anterior nasals in contact on midline; frontonasal ovate, often with posterior projection; prefrontals either separated by a single median scale or by a contact between frontonasal and scales in frontal area, occasionally in contact; frontal usually bisected both transversely and longitudinally, making 3-5 small scales; two frontoparietals usually distinguishable; interparietal equal to or slightly longer than 2-4 other parietals; 3-4 rows of small occipitals, which are distinctly larger than dorsal scales; two supraoculars, anterior larger, posterior separated from all other head scales by 1-3 rows of granular scales, anterior separated from supraciliaries by single row of small scales; usually several small scales anterior to the first supraocular separate it from a single, slightly larger, elongate scale between the first supraciliary and the prefrontal. Loreal quite large, undivided; five supraciliaries, second largest; a series of four to five scales below eye, all except last ridged along upper margin, the first is higher than long and occupies a preocular position, the others are longer than high and are subocular; a few enlarged, irregular postoculars; a short series of enlarged scales extends posteriorly from upper corner of eye to end of head over ear opening, rest of temporal region with granular scales; 6-7 upper labials, 5-6 lower labials, third very elongate; a single postmental followed by three pairs of chinshields, of which only the first is in contact on midline; third chinshield followed by 3-4 enlarged scales about ½ size of chinshield; all scales on throat anterior to first gular fold small; two strong collar folds; mesoptychium occupied by several rows of enlarged scales. Body dorsally and laterally covered by granular, smooth scales; a strong lateral fold from axilla to groin; ventrals in 27-29 transverse rows containing six rectangular, flat scales anteriorly, increasing to eight at the level of 10-13 rows, reducing to six again at level of 22-27 rows, outermost row almost always narrower than others. Preanal plates in a longitudinal series of three, forming an irregular rectangle, posteriormost of series often divided into a pair of scales. Upper arm with a series of broad, flat, smooth plates along anterior edge, bordered above by scales slightly larger than granules, and continuous with an even larger series of scales on the lower arm; a patch of moderately enlarged scales on posterior aspect of upper arm at elbow; all other arm scales granular; digits covered with smooth scales, not denticulate. Hind limb with several rows of enlarged smooth scales anteriorly and ventrally; all dorsal and posterior scales granular; digits denticulated; 18-24 femoral pores. Caudal scales abruptly larger than body granules, in concentric whorls; the dorsal and lateral caudals are keeled; the ventral caudals are smooth on the anterior half of the tail, from which point on they become more and more strongly keeled.

Color in alcohol: Dorsum dark bluish brown, with three light blue lines from occiput to tail, one middorsal and often very obscure or entirely absent, the others dorsolateral; sides below dorsolateral line a very dark reddish-brown, and sharply set off at middle sides from light blue of lower sides. Ventral surfaces from almost entirely bluish, spotted with white to almost entirely cream-white, spotted with blue.

Color in life: Middorsal stripe, beginning at shoulder, a slightly lighter red than rest of middorsum, which is a pale rust red. Dull yellow dorsolateral lines begin on shoulder, extend to base of tail. A dark, rusty red area extends from these dorsolateral lines to the midside, where it stops abruptly at a poorly defined pale yellowish stripe. Lower sides a greenish-gray; edges of ventrals deep bluish; rest of belly light blue. Head olive above, slightly tinged with red posteriorly. Bluish lips, light blue chin and throat. Tail not as distinctly red dorsally as body, fading into olive posteriorly. Venter of tail yellowish-white. (From JAP 3575, as noted by myself shortly after the specimen was collected.)

Description of Holotype: As for the species, with the following individual variations; a single scale medially between the prefrontals, followed by a pair of scales between anterior corners of the eyes, and then a single scale, a pair of scales, and three scales in anteroposterior sequence between the supraoculars; a row of four enlarged scales in parietal region, the outermost much larger than the inner two. Six upper labials, five lower labials. Ventrals in 29 transverse rows, with 11 scales in first row, 10 in row 2, 8 in row 3 (with outermost divided), 6 in row 4, 5 in row 5, 6 in rows 6-11, 8 in rows 12-25, 7 in rows 26-27, 6 in row 28, and 3 in row 29. Anteriormost preanal much smaller than following two. Femoral pores 22-21. Posterior part of tail regenerated. Body length 105.6 mm .

Habits and Habitat: The general area from which these lizards come is very dry, lying in a rain shadow part of the western slopes of the Andes. There are several running streams in the area, and these are widely utilized by the farmers for irrigation, but even the higher banks of these streams carry only xeric vegetation. The specimens collected one-half kilometer northeast of Abdon Calderon were all extremely active at the hottest part of the day, moving in and out of the roots and stems of low bushes and small, thorny shrubs on the embankment of the roadway, just above a small irrigation ditch through dry, dusty soil. The three specimens from 4 kilometers southwest of Abdon Calderon were shot along the roadside in and near scrubby thickets in a very dry area, and the Río Minas specimen was shot in a grassy tangle among rocks by a small stream. The species is diurnal, and active primarily during periods of sunshine, often retiring completely when a cloud darkened the sun. The individuals are incessantly active when out in the open, practically never stopping as they prowl among the roots and stems looking for food.

KEY TO THE SPECIES OF AMEIVA KNOWN OR EXPECTED IN ECUADOR

1. Frontal plate replaced by smaller scales; prefrontals either absent or if present, not in contact on middorsal line 2
   Frontal plate entire or divided into two scales by a horizontal suture; prefrontal scales in contact on middorsal line 4

2. Mesoptychium with enlarged scales; humerus with row of very large, flat, smooth scales on anterior aspect 3
   Mesoptychium with subequal scales; humerus with 1-2 rows of slightly enlarged, strongly keeled scales . . . . . *bridgesii*

3. Eight rows of ventrals on much of venter; single scale or frontal-frontonasal contact separating prefrontals; dorsal head scales not ridged and pitted . . . . *orcesi*

Six rows of ventrals on all of venter; several small scales separating prefrontals; dorsal head scales heavily ridged and usually pitted . . . . *septemlineata*

4. Eight rows of ventral plates; males with group of spines on each side of preanal region . . . . *edracantha*
   Ten to twelve rows of ventral plates; no spines in preanal region 5

5. Last two or three supraoculars bordered entirely by granules, do not contact frontal and frontoparietals (not yet known from Ecuador) . . . . *bifrontata divisa*
   No supraoculars except tiny fourth bordered entirely by granules, all others in contact with frontal and frontoparietal . . . . *ameiva petersii*

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TOOTH WEAR AS A CORRELATE OF DESCRIBED FEEDING BEHAVIOR BY THE KILLER WHALE, WITH NOTES ON A CAPTIVE SPECIMEN

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Tooth wear in the Atlantic killer whale, *Orcinus orca* (Linnaeus, 1758), under apparently normal, non-injury, conditions, was described by Caldwell, Layne and Siebenaler (1957). The types of wear described, and the structure of the mandibular fossae and articular condyles of the lower jaw, suggested that the jaws of this delphinid perform not only vertical movements (as are typical of most of the odontocete cetaceans which feed on relatively small and weak prey) but lateral and palinal ones as well. This freedom of jaw movement in the killer whale would permit an efficient crushing and rending action as well as the grasping action alone permitted by the mandibular articulation of a typical dolphin such as *Tursiops*. The teeth of the killer whale also were noted as being more curved than those of a typical dolphin and thus would be more effective for tearing in that they would be more firmly interlocking than the pegs provided, for example, by *Tursiops* teeth. While such comparatively increased curvature may be true in many instances, such is not always the case and the more firm interlocking action seems to be due more to the fact that there is less space between the teeth than is found in most odontocetes. On the basis of these factors, it was stated in the earlier paper (p. 195) that "these structural and supposedly functional modifications of the teeth and jaws of the killer whale appear to be correlated with its highly predatory nature and the relatively large size of its prey as compared to the majority of the odontocetes."

In a paper describing the tooth wear in another specimen of the Atlantic killer whale, Ulmer (1941:3) noted that the method and velocity with which the killer whale attacks its prey could easily twist the mandible out of alignment. It was such misalignment, he

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believed, that accounted for the uneven and extreme tooth wear he illustrated (p. 4) as having occurred on one side in his specimen. He also felt that such misalignment was not uncommon in killer whales. Tomes (1873) also had described similar uneven and extreme tooth wear, also, he felt, apparently resulting from a twisted jaw, in a killer whale taken in British waters. In both of these instances, the tooth wear was of such a nature that considerable cavitation had re-

Figure 1. Teeth of the Washington State killer whale, arranged to show approximate relationships to opposing teeth in life. The indented areas are the result of natural wear, and are not the result of fracturing or splintering of the teeth during removal from the jaws. Note the horizontal labial grooving on all but the tooth at the upper right. Teeth not necessarily in actual order as in life. Photograph by Cliff Brown, Marineland of the Pacific.

sulted and both animals were considered as probably having succumbed as a result of it. Ulmer's specimen had washed ashore dead, and Tome's individual was "apparently in an enfeebled condition" and easily was killed by fishermen as it came up a river. In both of these reports, the emphasis with regards tooth wear was placed on the abnormal wear resulting from the injured jaws, and the type of wear described by Caldwell *et al.* (1957) was not indicated.

We now report on tooth wear in eleven other killer whales. Although considered by most recent writers (see Scheffer and Rice, 1963:8) as belonging to the cosmopolitan species *O. orca,* these animals were from both the Atlantic population (*O. orca*) and the Pacific population, which is recognized by some workers as *O. rectipinna* (Cope, 1869).

Caldwell, *et al.* (1957:195, and fig. 3) were unsure if the horizontal grooving they found was a typical feature of tooth wear in the killer whale. It therefore is of special interest to note that a number of teeth (Figs. 1 and 2) removed from an adult female did show the horizontal, apical, anterior and posterior wear described and illustrated by Caldwell, *et al.* This animal, about 20 feet in length, was taken in September, 1962, in Puget Sound, Washington, by collectors from Marineland of the Pacific. There had been no reported evidence of jaw misalignment through injury in his robust animal. The teeth showed heavy wear on their anterior and posterior surfaces, brought about by the interlocking action in vertical movements of the jaw (Fig. 1). The teeth also showed the horizontal grooving at the gum line (Figs. 1 and 2) discussed by Caldwell, *et al.* (1957). Several teeth showed strong horizontal grooving on both their labial and lingual sides, suggesting that in moving palinally the great flexibility of jaw movement in a lateral manner permits the tips of one row of teeth either to rub inside or outside the opposing row receiving the wear. This supports the hypothesis suggested by Caldwell, *et al.* (1957) as to the relationship of the anatomy of the jaw suspension of the killer whale to its feeding behavior and resulting tooth wear.

Several posterior teeth in another adult specimen (USNM 23004, from "Norway," complete skull) showed horizontal grooving. Several of the anterior and posterior teeth in this individual also exhibited apical wear, while the teeth in the middle of the row did not.

The few remaining teeth in two additional adult specimens (USNM 16488, from "California," complete skull; USNM 11980, from "South Atlantic?," complete skull, most teeth present) showed

Figure 2. Series of teeth, both upper and lower from both sides combined, and not a complete set, from the Washington State killer whale. Note variation in patterns of wear. The indented areas above the gum line are the result of natural wear, and are not the result of fracturing or splintering during removal from the jaws. The ruler is calibrated in centimeters. Photograph by Cliff Brown, Marineland of the Pacific.

apical wear, with that on the teeth of the California specimen being considerably more extreme than that in the other.

Although we have not examined either specimen, Mr. Robert Brownell did so and reported (personal conversation with Caldwell, September, 1963) that the teeth of two adults taken in the San Francisco region showed only the anterior and posterior wear noted above. These specimens, complete skulls, are: (1) From a 24-foot male taken on 1 July 1963 off Point Reyes, near San Francisco, California. The specimen is now preserved at the U.S. Fish and Wildlife Service Marine Mammal Laboratory (as DWR 832), Seattle, Washington. (2) A complete skull, MVZ 129686, in the Museum of Vertebrate Zoology, University of California, Berkeley. This specimen, a male, was taken on 15 May, 1962, approximately 70 miles west of San Francisco.

From still another animal, there is a presumably complete set of teeth in the collections of the Los Angeles County Museum (LACM, M-781) taken from a "juvenile" killer whale collected on 6 May 1927, at Hermosa Beach, Los Angeles County, California. The small size of the teeth and their large pulp cavities, and the size of the other skeletal elements, support the "juvenile" notation on the label.

However, in spite of its early age, the teeth had begun to show the wear discussed in the Washington specimen above. Almost all of the teeth showed wear on their anterior and posterior sides, several showed wear of varying degrees on their apices, and one was beginning to show evidence of a horizontal groove on its lingual side. This latter tooth also had wear on its apex and on its anterior and posterior sides. There was no evidence, either in the appearance of the skeletal elements or on the catalog card, that the animal was injured and we assume that the wear on its teeth was typical. It is of special interest in that it had begun to appear at such an early age.

The available teeth in two other juvenile specimens (USNM 13018, from "California," mandible only; USNM 219326, no locality data, complete skull) showed no significant wear except some on the anterior and posterior interlocking surfaces.

The teeth of an 18½-foot female in robust condition, taken on 9 January 1964 approximately 12 miles SSW of San Miguel Island, California, and made available to us by Mr. Dale W. Rice, showed the following wear: The most anterior teeth in both jaws were worn flat, nearly to the gum line, so that their pulp cavities clearly showed. Apical wear continued posteriorly, in successively lesser degree, until the most posterior teeth were only partially worn in this manner.

Figure 3. Lateral view of dissected jaws of the Newport killer whale, showing extreme tooth wear. Tape measure calibrated in inches. Photograph by Cliff Brown, Marineland of the Pacific.

While no such wear could be seen in the anterior teeth, because they were worn flat, the partially worn posterior teeth showed anterior and posterior wear as well as lingual undercutting (except for the last two teeth in each row which showed no undercutting). There was no evidence of injury to the jaws of this animal, and, other than the extreme wear, the teeth appeared to be healthy.

Our final specimen, a 17-foot female, was taken alive in a turning basin in the harbor at Newport, near Los Angeles, California, on 18 November 1961. Later in this report we include a discussion of the details of her behavior at capture and in captivity and of pathological facts brought out in a necropsy performed after her death.

This animal evidenced extreme tooth wear (Fig. 3), but she was in good enough health to be extremely difficult to capture and was by no means "enfeebled" or in poor condition. To the contrary, she was in excellent and robust form (Figs. 4 and 5). Necropsy showed death to be the result of pathologic conditions which will be discussed below.

From her pre-capture behavior, the animal was suspected to have

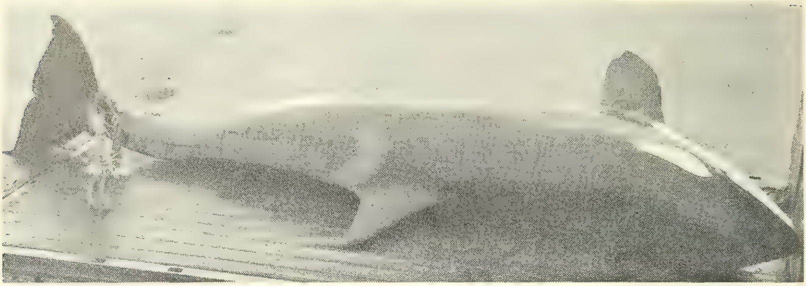

Figure 4. Dorsal view of the Newport killer whale. Photograph by W. F. Monahan, Marineland of the Pacific.

been feeding on small fishes, rather than an expected diet of larger, usually warm-blooded, animals (see Nishiwaki and Handa, 1958: 92). The extreme wear of the teeth undoubtedly restricted the animal in her diet, but did not prevent the successful ingestion of smaller kinds of food. At the time of her capture, it was felt that the animal had entered the relatively enclosed turning basin in quest of fishes. Also, because she was alone, instead of a member of a normal hunting pack (Kellogg, 1940:71), the animal was forced into an abnormal feeding pattern as well as being restricted in her diet. Thus the animal, while still able to survive, had had to undergo a marked change of social status as well as a change in feeding behavior.

All of the teeth in both sides in both jaws of the Newport specimen were worn flat on their crowns, almost even with the gums. The teeth otherwise appeared to be healthy above the gum line, and not diseased as those in the examples cited by Ulmer (1941) and Tomes (1873). Without further comment, Eschricht (1866:172) and Slijper (1962:273) indicated that such extreme wear was not uncommon in killer whales.

The wear did not appear to be the result of a misaligned lower jaw, although the right ramus of the mandible had been fractured for some time near its anterior end (see results of necropsy, below). Such a break might have been the result of voracious feeding activity at an earlier stage of life. The tooth wear, on the other hand, gave every indication of being normal as the jaws opposed each other in the expected manner, and the wear appeared to result from a grinding action permitted by the great freedom of movement by the jaws. A few of the teeth showed decay, but as this condition was lateral and below the retracted gum line, we felt that it was not directly

Figure 5. Ventral view of the Newport killer whale. Photograph by W. F. Monahan, Marineland of the Pacific.

related as a cause for the extreme tooth wear or for the death of the animal.

Rather than the obvious explanation that such wear as evidenced by the Newport specimen is a simple wearing down of the apices of the teeth, the factors accounting for such extreme wear, assuming it was not the result of injury to the jaw, might be more complex.

For example: first, the typical interlocking action of the incurved teeth results in wear on their anterior and posterior faces (Fig. 1), brought about by vertical movements of the jaws. Second, direct opposition during vertical, lateral and palinal movements of the jaws results in some grinding wear on the apices of the teeth (Fig. 2). Third, the horizontal grooving, apparently caused by the palinal movement of the opposing teeth past one another, eventually could result in a serious undercutting effect (Fig. 2). The point of this undercutting is near the gum line (see Caldwell, *et al.*, 1957: fig. 3; Fig. 2 herein). Such undercutting may occur on both the labial and lingual sides of the tooth (see Figs. 1 and 2, especially the third, sixth and eighth teeth from the right in Fig. 2), permitted by the varied lateral positions of the free-moving opposing lower jaw. Combining these patterns of wear, which all must occur in a normally active individual, the result eventually would be the condition exhibited by the Newport animal. The tooth wear in the San Miguel Island specimen indicates that the progression of wear essentially is from anterior to posterior, although the wear on the teeth of other specimens suggests that there is some variation in this. The above combination of wear patterns and resulting progression of wear was suggested from our study of the series of specimens examined and noted herein. A similar progression of wear was suggested in less detail by Eschricht (1866: 172).

The wear might be expected to be hastened by the violent feeding actions of the animal, which include grasping and then twisting the large body to tear large portions of flesh from its prey. The more anterior teeth thus might be expected to be brought into play first, and hence the more rapid (earlier) wear on these. Wear on the more posterior teeth, with the center ones relatively less worn (see USNM 23004), might be the result of jaw movement with the mouth partially opened, as in tearing off chunks from a large prey. In such an instance, the teeth in the center of the row would not come in contact, while those in the anterior and posterior parts of the row would either be engaged in tearing (anterior) or simply wearing (posterior). With increase in age, all of the teeth eventually would be worn down as the progressive wearing of the more anterior teeth permitted the remaining teeth to come into greater and more frequent contact. Although violent feeding actions might often result in mandibular misalignment, such misalignment thus need not necessarily be indicated in order to produce extreme tooth wear of the sort found in the San Miguel Island and Newport specimens.

Such extreme tooth wear, not necessarily resulting from mandibular injury, might only be expected in older individuals. That such was the case with the Newport animal (the San Miguel Island animal was even larger and presumably as old or older) was suggested by Dr. David E. Sergeant, after an examination of one of its teeth. On 11 December 1961, Dr. Sergeant wrote (to Brown): "The animal is certainly old, as shown from the excessive wear of the crown of the tooth, and the fact that the root is almost completely filled with dentinal layers. Owing to the wear of the crown, some dentine layers have doubtless been lost. I can estimate about 25 such layers and root-ridges (between dentine and cement) visible in the remainder. By analogy with *Tursiops*, this would indicate an age of at least 25 years."

The skull of the Newport specimen was damaged by dissection for brain recovery, and most of the upper teeth were removed and lost before they could be preserved. However, the mandible, still bearing most of the teeth, and other cranial and postcranial elements are now on permanent deposit in the vertebrate paleontology collection of the Los Angeles County Museum (LACM, M-1790).

BEHAVIORAL, ANATOMICAL AND PATHOLOGICAL DATA ON THE NEWPORT SPECIMEN

On 17 November 1961, Brown was notified by officials of the Harbor Department, Newport Beach, California, that a killer whale had been seen in the yacht turning basin of Newport Harbor. This animal had been observed swimming in the general area for several days prior to the call. On the same day, a party from Marineland of the Pacific drove to Newport, and upon sighting the animal's dorsal fin as it surfaced to breathe, it became immediately apparent that the animal was a female.

The following morning, 18 November, Frank Brocato, Marineland's Director of Collections, together with his crew, arrived at Newport at 6:30 AM aboard the fishing vessel *Geronimo* and made an attempt to capture the animal. The techniques usually employed to capture cetaceans failed, owing mainly to the turbidity of the harbor water and the whale's refusal to run the bow of the vessel. It was therefore decided to attempt to capture the animal by using a large net. The net, 1200 feet long by 75 feet deep, was successfully set in a large circle around the whale. However, after the collectors had bunched the floats and had restricted the whale's movements to a circle approximately 100 feet in diameter, the animal broke through the meshes. Shortly before her escape, she was seen to lie on the surface and emit a number of loud eructations through the pursed blowhole, after which the animal was observed to lie on her back in the water and smack her flukes upon the surface with great force.

Upon breaking the net she resumed her normal swimming pattern. After recovering the net and effecting repairs, another attempt was made. The animal appeared to anticipate the intentions of the men and evaded the net, surfacing to breathe some 50 feet outside the encircled area. The final attempt to capture the animal was made at 3:00 PM, and Captain Brocato and his crew were successful at this time in netting and finally securing the whale alongside *Geronimo*'s hull. A deflated rubber raft was pulled in position beneath the whale. This, after inflation, was towed ashore and the animal was lifted onto a truck and successfully transported to Marineland.

Upon being placed into the 100- by 50- by 19-foot oval fish tank at approximately 10:00 PM, the whale initially struck her snout a glancing blow on one of the walls. She then commenced to swim slowly around the confines of the tank, her behavior being similar to that of newly-introduced smaller delphinids. The following morning, the whale was observed holding a newly-killed ocean sunfish, *Mola mola* (Linnaeus) in her mouth. This fish was not consumed, however, and during the remainder of the day many attempts were made to induce feeding. Marineland divers attached lines to bonita, *Sarda*, and "worried" the killer whale with these as she slowly encircled the enclosure. The animal made several attempts to bite the food and it was at this time that the worn condition of her teeth was first observed (see discussion above).

At 8:30 AM on 20 November, the whale became violent and after encircling the tank at great speed and striking her body on several occasions, she finally swam into a flume way, convulsed and expired.

Upon her removal from the tank the following measurements were obtained. The measurements were made over the curve of the body, from point to point, on the left side.

Weight	9007	kilograms
Total length (tip of snout to fluke notch)	521	centimeters
Tip of snout to middle of eye	55	"
Tip of snout to inside corner of mouth crease	41	"
Tip of snout to anterior origin of flipper	115	"
Tip of snout to apex of cephalic melon	15	"
Tip of snout to center of blowhole	73	"
Tip of snout to center of anus	364	"
Tip of snout to center of dorsal fin	239	"
Anterior origin to tip of left flipper	73	"
Anterior origin to tip of right flipper	74	"
Axilla to tip of left flipper	59	"
Greatest width of left flipper	45	"
Depth of median notch of flukes	9	"
Width of spread flukes, tip to tip	135	"
Median notch in flukes to closest portion of the posterior curve of dorsal fin	262	"
Length of dorsal fin base	64	"
Height of dorsal fin	53	"
Blowhole width	11	"
Projection of upper jaw beyond lower jaw	14	"
Length of genital slit	47	"
Girth at blowhole	116	"
Girth at origin of flippers	134	"
Girth at origin of dorsal fin	159	"
Girth at anus	88	"
Girth at origin of flukes	40	"
Tip of snout to eye patch	55	"
Length of eye patch (patch gray in color)	50-55	"
Profile of caudal stock	slightly falcate	

Pathologists from the Los Angeles County Livestock Department performed a necropsy the same morning. Death was due to acute gastroenteritis and pneumonia. The former condition was no doubt secondary to a massive nematode infestation of the first and second stomach compartments. Also it was felt that the great stress experienced by the animal during capture and confinement contributed to the pathologic condition.

Of particular interest was the discovery of an advanced athrosclerosis. Both the heart and the major blood vessels showed considerable disease.

The animal's brain weighed 4500 grams, and showed remarkably high development.

During the dissection of the head and jaws, a fracture of the right ramus of the mandible was found. This was comminuted, and numerous sequestra were found encapsulated in the affected area. The lesion appeared to be of long standing and probably caused the animal great discomfort during life. It should be repeated, however, that the fracture apparently had not displaced the jaw to suggest that the excessive tooth wear was a result of such an injury.

Discussion

It appears that the types of tooth wear reported in killer whales can be correlated with their ferocious and highly predatory feeding behavior, or to the functional modifications of their cranial anatomy which support this behavior.

The great movement permitted by the structure of the lower jaw suspension results in distinctive wear patterns on the anterior, posterior, lingual, labial and apical surfaces of the large incurved teeth. In addition, the force with which the animals often attack their prey apparently may frequently result in a permanent misalignment of the mandibles, bringing about atypical and often pathologic tooth wear. The predatory forces may also hasten normal tooth wear.

Acknowledgments

In particular we wish to thank Dr. David E. Sergeant of the Fisheries Research Board of Canada for his examination and subsequent comments on one of the teeth of the Newport killer whale. The pathologists of the Los Angeles County Livestock Department and Dr. John C. Lilly of the Communication Research Institute of Miami, Florida, also were of great assistance during the post mortem examination of the Newport animal.

Captain Frank Brocato of Marineland of the Pacific oceanarium provided information on the Washington state specimen and kindly permitted our examination of several of its teeth in his possession.

Dr. Charles O. Handley, Jr., of the United States National Museum (USNM), kindly assisted Caldwell in seeking out specimens scattered about in various storage spaces at that Museum and in helping make them available for study. Mr. Robert L. Brownell of Long Beach State College, Long Beach, California, examined two of the California specimens for us and generously made his findings on the teeth available for inclusion here.

Melba C. Caldwell of the University of Southern California and Dale W. Rice of the United States Fish and Wildlife Service made a number of helpful suggestions regarding various versions of our manuscript.

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PLEISTOCENE INVERTEBRATES FROM THE DUME TERRACE, WESTERN SANTA MONICA MOUNTAINS, CALIFORNIA[1]

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Introduction

A recently discovered assemblage of late Pleistocene invertebrates from near Point Dume, Southern California (lat 34° N) marks the most northwesterly occurrence of warm water mollusks in upper Pleistocene deposits of the Pacific Coast of North America. The large, well-known fauna of the western Los Angeles Basin (Fig. 1) to the southeast of Point Dume is characterized by a small but persistent element of warm water mollusks that are now limited to latitudes far to the south. Late Pleistocene assemblages in the Ventura-Santa Barbara coastal area to the northwest of Point Dume are of a cooler water aspect. They usually contain some species which are now limited to latitudes north of Point Conception. As first noted by Woodring (1952:407) these differences are sufficiently well-defined to permit the recognition of two faunal provinces. The Point Dume assemblage is of significance in accurately delimiting the boundary between the two late Pleistocene provinces, and the assemblage also provides additional control for regional paleoecologic interpretation.

The marine fossils were discovered by R. F. Yerkes of the U.S. Geological Survey in the course of mapping a portion of the Point Dume quadrangle. He assisted the writer in securing collections from the locality and furnished geologic mapping and stratigraphic data on this area. The large representation of minute gastropods is the result of careful screening and preparation of bulk samples by J. W. Miller. Dr. L. G. Hertlein has kindly provided access to the collection of Recent Mollusca of the California Academy of Sciences which was used in identifying some of the material.

Marine terraces of the southern margin of the Santa Monica Mountains were studied by Davis (1933) who recognized and named two wave-cut platforms from exposures at Point Dume. The only marine Pleistocene fossils that have been definitely identified with

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[1] Publication authorized by the Director, U.S. Geological Survey.

[2] Branch of Paleontology and Stratigraphy.

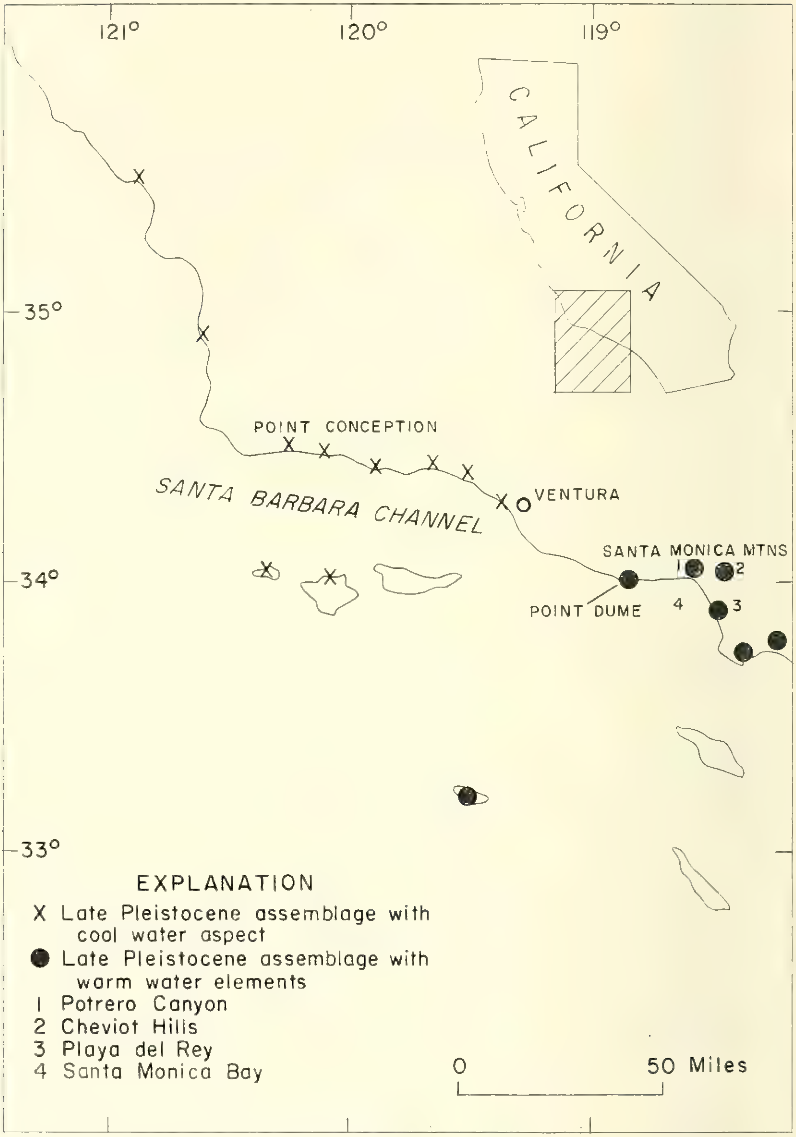

Figure 1. Index map showing location of Point Dume assemblage with respect to some other late Pleistocene assemblages from Southern California.

these terraces are from Potrero Canyon near the eastern end of the Santa Monica Mountains. They have been described and listed by several workers, notably Woodring (*in* Hoots, 1930) and Valentine (1956). Alleged Pleistocene fossils exposed in reddish-colored sand near the mouth of Las Flores Canyon, about 10 miles east of Point Dume, were noted by Soper (1938). The present area of interest is within the boundaries of a detailed geologic map of the coastal part of the Point Dume quadrangle made by Schoellhamer and others (1962).

GEOLOGIC SETTING

Point Dume is a prominent headland which separates the west-trending coastline bordering Santa Monica Bay, to the east, from a west-northwest-trending segment to the west. The point is broadly triangular in shape with the southerly apex anchored by a knob of volcanic rock of middle Miocene age. The headland is bordered on the north by the Malibu Coast fault which brings a section of Upper Cretaceous to lower Miocene strata in contact with middle and upper Miocene formations to the south. The latter rocks consist of northward dipping, interbedded sandstone and diatomaceous shale in the vicinity of the fossiliferous Pleistocene locality. They are mapped as the Monterey Shale by Schoellhamer and others (1962).

Two prominent abrasion surfaces are cut into the Monterey Shale at Point Dume. The higher of the two has been named the Malibu platform by Davis (1933:1051). No marine fossils have been reported from sedimentary deposits overlying this platform. The lower abrasional surface, named the Dume platform by Davis (1933:1051), is narrower and closely parallels the configuration of the present coast. Its shoreline angle, as well as that of the higher Malibu platform, merges with the steep bluffs bounding the modern shoreline both to the east and to the west. Since the terraces have been covered with surficial alluvial deposits and subsequently dissected by stream drainage, recognition of precise shorelines is difficult, particularly that of the upper or Malibu platform. The terraces are shown diagrammatically in the type area by Davis (1933:1089, fig. 21) whose figure is here reproduced (Fig. 2). In addition to the previously known local fauna from the Dume terrace in the eastern part of the Santa Monica Mountains (Valentine, 1961:382f.), there are fossils from localities in the Cheviot Hills, farther inland (Hoots, 1931:122; Rodda, 1957), which presumably are correlative.

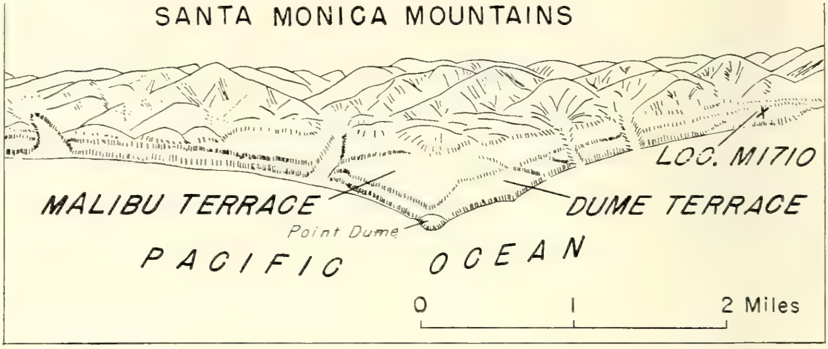

Figure 2. Sketch diagram showing terraces at Point Dume and late Pleistocene invertebrate locality (modified from Davis (1933, p. 1089)).

Fossil invertebrates here considered were collected from cuts along U.S. Route 101 Alternate near the eastern end of Escondido Beach about 2½ miles northeast of Point Dume (Fig. 2). They occur in thin lenses of light yellow-brown, poorly bedded, silty, very fine-grained sand which directly overlie the bedrock surface. Locally the sand becomes coarse grained and contains scattered detritus from the underlying Monterey Shale. The surface of the terrace platform is fairly smooth; locally it is pitted with holes of boring organisms, presumably pelecypods. The overlying terrace deposits are about 5 feet thick at this locality (USGS Cenozoic loc. M1710). They consist of sandy gravel composed of cobbles and boulders of the underlying Miocene sandstone and shale which is capped by a 1- to 2-foot zone of dark-brown soil.

Composition of the Assemblage

The known assemblage from the Point Dume locality consists of 81 invertebrate taxa including 51 gastropods, 24 pelecypods, a scaphopod, and a few crustaceans and echinoids (Table 1). Some of the identifications are qualified or questioned because of incomplete or abraded specimens. The list could very likely be enlarged by continued collecting, but it is believed that at least the more common forms have been collected. With the exception of one gastropod, *Balcis monicensis* (Bartsch), all of the species are still living.

TABLE 1. Pleistocene invertebrates from Point Dume

MOLLUSCA

GASTROPODA

Acmaea insessa (Hinds)
Acmaea paleacea Gould
Calliostoma doliarium (Holten)
Calliostoma gemmulatum Carpenter
Norrisia norrisi (Sowerby)
Margarites cf. *M. parcipictus* (Carpenter)
Tegula aureotincta (Forbes)
Astraea undosa (Wood)
Tricolia aff. *T. compta punctulata* (Carpenter)
Balcis micans (Carpenter)
Balcis monicensis (Bartsch)?
Epitonium sp.
Lacuna unifasciata Carpenter
Alvania cf. *A. acutelirata* (Carpenter)
Barleeia cf. *B. marmorea* (Carpenter)
Fartulum cf. *F. occidentale* Bartsch
Serpulorbis squamigerus (Carpenter)
Cerithiopsis sp.
Triphora cf. *T. hemphilli* Bartsch
Triphora cf. *T. johnstoni pazensis* Baker
Triphora sp.
Hipponix antiquatus (Linné)
Crepidula cf. *C. nummaria* Gould
Crepidula adunca Sowerby
Crepidula sp.
Neverita (Glossaulax) recluziana alta (Arnold)
Cypraea (Zonaria) spadicea Swainson?
Ocenebra cf. *O. interfossa* Carpenter
Ocenebra squamulifera (Carpenter)
Acanthina spirata (Blainville)
Amphissa versicolor Dall
Mitrella carinata (Hinds)
Mitrella carinata gausapata (Gould)
Mitrella tuberosa (Carpenter)
Nassarius cerritensis (Arnold)?
Nassarius fossatus (Gould)
Nassarius perpinguis (Hinds)

TABLE 1 *continued*

?*Fusinus* sp.
Mitra (Strigatella) cf. *M. catalinae* (Dall)
Cypraeolina pyriformis (Carpenter)
Marginella californica Tomlin
Olivella baetica Marrat *in* Sowerby
Olivella biplicata (Sowerby)
Conus californicus Hinds
?*Terebra* sp.
Mangelia cf. *M. variegata* Carpenter
Bulla gouldiana Pilsbry
Odostomia sp.
Turbonilla (Pyrgiscus) aff. *T. (P.) almo* Dall and Bartsch
Turbonilla (Pyrgiscus) cf. *T. (P.) jewetti* Dall and Bartsch
Turbonilla (Pyrgiscus) tenuicula (Gould)
Turbonilla sp.

PELECYPODA

?*Lithophaga* sp.
Modiolus fornicatus (Carpenter)
Mytilus californianus Conrad
Hinnites giganteus (Gray)
Leptopecten latiauratus (Conrad)?
Pecten diegensis Dall
Anomia peruviana d'Orbigny
?*Pododesmus* sp.
Pseudochama exogyra (Conrad)
Lucinisca nuttalli (Conrad)
Trachycardium quadragenarium (Conrad)
Tivela stultorum (Mawe)
Transenella tantilla (Gould)
Saxidomus nuttalli Conrad
Protothaca staminea (Conrad)
Petricola carditoides (Conrad)
Tresus nuttalli (Conrad)
Tellina bodegensis Hinds
?*Macoma* sp.
Gari cf. *G. edentula* (Gabb)
Solen sicarius Gould?
Platyodon cancellata (Conrad)

TABLE 1 *continued*

Chaceia ovoidea (Gould)
?*Entodesma* sp.

SCAPHOPODA
Dentalium neohexagonum Sharp and Pilsbry

ECHINODERMATA
?*Dendraster* sp.
?*Strongylocentrotus* sp.

CRUSTACEA
CIRREPEDIA
Balanus tintinnabulum californicus Pilsbry
Balanus sp.

DECAPODA
Fragment of a chela

Environmental Inferences

The Pleistocene invertebrates are an open-coast assemblage presumed to have inhabited shallow depths in the inner sublittoral zone (low tide to 50 fathoms). Although it is difficult to classify outer coast faunas from depths below the zone of vigorous marine abrasion as "open" or "protected," in this case, reference to the associated late Pleistocene shoreline suggests a semi-protected position in the lee of a westerly headland. Although most of the faunal constituents have modern bathymetric ranges that extend from the intertidal zone to moderate depths in the sublittoral zone, four taxa in the Point Dume assemblage are indicative of shallow depths in the inner sublittoral zone. They are: *Modiolus fornicatus* (Carpenter), *Pecten diegensis* Dall, *Gari* cf. *G. edentula* (Gabb), and *Dentalium neohexagonum* Sharp and Pilsbry. These mollusks are characteristically taken offshore at depths of from 5 to 15 fathoms in the southern California area according to data assembled by Burch (1944-1946).

The small element of offshore, shallow sublittoral species seems particularly diagnostic of the bathymetric environment in view of the physical setting of the fossil locality with reference to the inferred late Pleistocene shoreline. The altitude of the platform in the vicinity of the fossiliferous sand lenses is about 25 to 50 feet lower than the inferred shoreline angle. This relationship suggests that the terrace platform, at this point, was about 4 to 8 fathoms below sea level and perhaps 500 feet offshore.

The assemblage is composed predominately of taxa which are directly or indirectly associated with rocky substrata. Most of these species live on rock surfaces. Others may nestle in holes or crevices in rock or bore into indurated sediments. A few species, such as the acmaeids, live attached to marine grasses or algae. About 25 percent of the assemblage are forms which characteristically burrow into sandy substrata or nestle in gravel. The indicated association of rocky and sand covered bottom seems to be analogous to the modern distribution of nearshore bottom types mapped by Stevenson and others (1959) along the northern margin of Santa Monica Bay.

Zoogeographic Significance

The Point Dume assemblage represents the most northwesterly late Pleistocene occurrence of a small element of warm water species which are now restricted to southern latitudes. These species are usually identified with the Panamic molluscan province (Dall, 1909: 185), the northern boundary of which is generally drawn off the coast of southern Baja California, Mexico. Panamic species in the Point Dume assemblage are *Nassarius cerritensis* (Arnold), *Triphora hemphilli* Bartsch, and *Triphora johnstoni pazensis* Baker. Other species suggestive of a marine hydroclimate comparable to that of the Californian molluscan province (Point Conception to southern Baja California, Mexico) are: *Tegula aureotincta*, *Bulla gouldiana*, *Tricolia compta punctulata*, *Cypraea spadicea*,[3] *Norrisia norrisi*,[3] *Astraea undosa*, *Ocenebra squamulifera*, *Trachycardium quadragenarium*, and *Gari edentula*. There are no exclusively cool temperate Oregonian species in the Point Dume assemblage.

Correlative local assemblages from the western part of the Los Angeles basin which seem to be comparable bathymetrically are the Potrero Canyon local fauna (summarized by Valentine, 1956) and the Playa del Rey local fauna (Willett, 1937). Nearly 90 percent of the molluscan taxa from Point Dume are also present in these assemblages. However the Playa del Rey and Potrero Canyon assem-

[3] Although one specimen of each of these species has been reported from Monterey, California (latitude 36°35′ N), there are no other recorded occurrences north of Point Conception.

blages contain a significantly larger representation of warm water, extra-limital species indicating, perhaps, a relatively warmer, more protected environment than that suggested by the mollusks from Point Dume. A possible local source of cool water is implied by the presence of a submarine canyon offshore from Point Dume. If this canyon was present during the late Pleistocene it could have been a site of local upwelling of cool water. Such a phenomenon has been observed in an inshore area near the head of Monterey submarine canyon in central California (Marine Research Committee, 1952: 32).

Late Pleistocene faunas from the apparently correlative lowest marine terrace along the northern coast of Santa Barbara Channel are of a cool water aspect comparable to the modern Oregonian molluscan province (southeastern Alaska to Point Conception, lat 55° N-34°30′ W). The most southerly occurrence of this fauna along the mainland coast is near Ventura (Valentine, 1961: 384). The late Pleistocene provincial boundary has been recognized by many workers, notably Grant and Gale (1931), Woodring (1952), and Valentine (1958). Its position is marked by the western end of the Santa Monica Mountains which can be projected westward into the offshore Channel Islands. The modern provincial boundary of comparable magnitude, but based upon different molluscan ranges, is located near Point Conception (lat 34°30′ N) about 80 miles to the northwest. The late Pleistocene molluscan provinces separated by the Santa Monica Mountains have been named Cayucan, to the north, and Verdean, to the south (Valentine, 1961: 392).

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LIFE HISTORY NOTES ON *CATOCALA EUPHEMIA*

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Much has been published on the ranges and life histories of the American phalaenid moths of the Genus *Catocala*, culminating in the beautifully illustrated Memoir by Barnes and McDunnough (1918). This was based largely on the research of William Beutenmuller and the excellent colored illustrations by Mrs. Beutenmuller.

The memoir lacks some facts concerning the western and southwestern species, due to their rarity, and the comparative inaccessibility of the areas where they occurred.

One such species is *Catocala euphemia* Beutenmuller, which was illustrated in color by Barnes and McDunnough (1918: pl. 8, fig. 2), with no mention of its early stages or host plant.

In June, 1956, as a member of a Los Angeles Museum field party working at the Tonto Creek camp ground near Kohl's Ranch, Gila County, Arizona, I found four larvae of a *Catocala* which, on rearing, proved to be *C. euphemia*. These were picked up under black walnut trees on June 24 and 25, 1956. Photographs were taken of a mature larva, and the following notes were made.

Mature Larva

Length, 60 mm.; greatest width at 7th segment, 9 mm.

Head, relatively small; the cheeks marked with a geometric pattern of irregular black lines on a gray ground; front, gray; mouth parts, gray; antennae, light gray, slightly tinged with pink; ocelli, black.

Body, ground color is apparently gray, but is actually a dull smoky white on which innumerable small black and gray dots and dashes produce the gray effect.

In the middorsal area a longitudinal series of fused diamond-shaped elements produce the effect of a wide serrated band. These diamonds are alternately light and dark gray.

Lateral to this is a wide zig-zag crenulated dark longitudinal band, heavily sprinkled with black dots, and edged with a narrow somewhat broken black stripe. Latero-inferior to this is a still wider light band, the lower half of which is nearly white, but is slightly shaded by sparsely scattered light gray and brown dots. Below this is a narrow stigmatal band which is alternately restricted and expanded on each segment, the restricted portion being located near the spiracle. Below this is a wide light area, heavily spotted with small black and gray dots, which ends abruptly on the edge of the venter.

The ventral area is rosy-pink, free of the small black dots, but on each typical segment there is a prominent velvety black spot.

Legs, mottled gray, sparsely clothed with whitish setae; prolegs, mottled gray and white; under surfaces slightly tinged with pink; crochets, light gray. The first prolegs are small, and each succeeding pair is progressively larger caudally. The spiracles are black.

Two of the four examples began spinning cocoons between walnut leaves on June 28, and pupated July 3, 1956. The cocoon was thin and fragile. It was formed on the floor of the rearing cage, with dried leaves and debris incorporated in it.

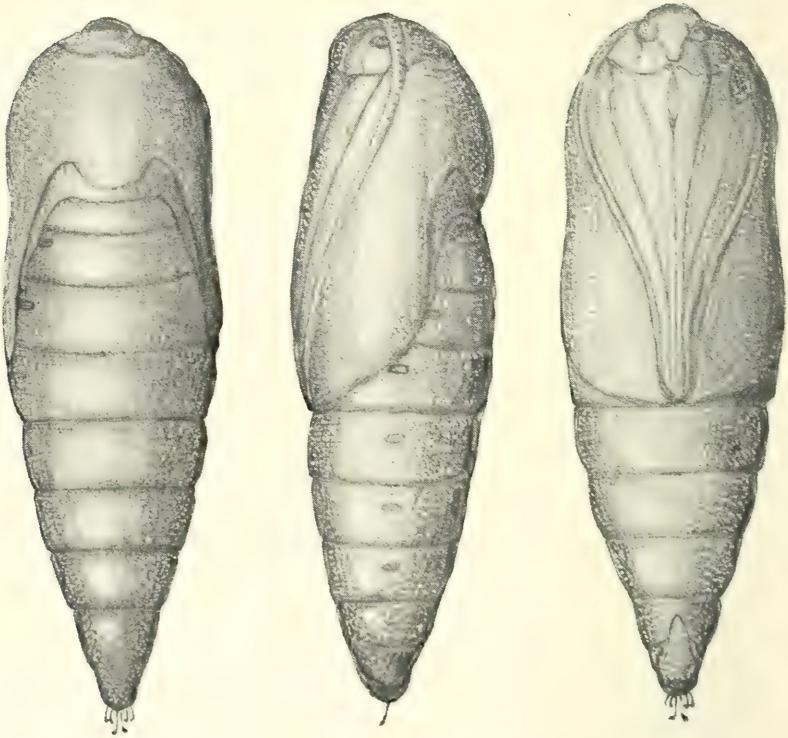

Figure 1. Pupa of *Catocala euphemia.* Dorsal. lateral and ventral aspects, enlarged approximately × 2½.

Reproduced from water color drawing by J. A. Comstock.

The first imago emerged August 21, 1956 after about 20 days in the pupal stage.

PUPA

Figure 1. Length, 33 mm.; greatest width, 11.6 mm. Color, at first chocolate, later becoming covered with a bluish-white powdery coating on most of the surfaces, which somewhat obscured the chocolate ground. Eyes, not prominent, finely ridged transversely; maxillae extending to the edge of wing-cases; antennae 1 mm. short of wing tips.

Body texture finely pitted, except on movable margins of abdominal segments; spiracles, elongate, concolorous with body.

The cremaster bears a pair of spines with recurved tips, which curl laterally. These spines are .75 mm. long. Lateral thereto on each side are two or three short hooklets, with points curling medially.

The larva is a nocturnal feeder on black walnut.

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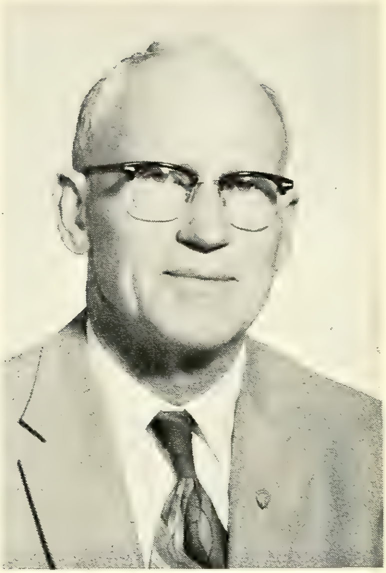

A. WEIR BELL

October 6, 1899-August 15, 1963

A native son of Los Angeles, he received his early education at Redlands including 3 years at the University of Redlands, followed by a B.A. at the University of California at Berkeley in 1922, an M.A. in 1927, and a Ph.D. in 1936. His career as an educator began as a Teaching Assistant in Zoology at UC Berkeley from 1922-24 after which he joined the faculty of Sacramento Junior College from 1924-29 when he moved to Los Angeles City College as Chairman of the Life Sciences Department, a post he held with distinction until his retirement in 1961. On leave from City College in 1945, he taught in the University Training Center of the U.S. Army in Italy. He became Professor of Biology at California Lutheran College, Thousand Oaks, in September, 1961, where he was elected a Fellow of the California Lutheran Educational Foundation in appreciation of his support of that growing institution.

In 25 years of close association as a fellow teacher, assistant laboratory instructor, science colleague, field trip companion, fellow churchman and friend, I learned to respect his sound judgment and fair decisions. No zoologist ever strived more constantly and continuously for perfection and accuracy. This was especially well shown in his accurate pronunciation and use of scientific terms, revealing his respect for the value of Latin and Greek in the understanding of scientific names. He was very strongly motivated by his University training to hasten the second year college zoology student toward quality independent performance by means of adequate instructions and reference reading. It was difficult for him to accept the fact that all college students enrolling in zoology could not excel in laboratory work and he expended much thought and energy toward bringing out the best in these students.

His many years as a department chairman and student adviser gave him added insight into the success potential of both students and teachers. He was quick to evaluate and recognize skills for learning and teaching by observing work performance. His outstanding enthusiasm for zoology never weakened and was reflected in his scholarly writing and lecturing. He considered all lectures substandard if not delivered from memory and was often seen concentrating on his meticulous notes five minutes before the presentation. His work load included 10-15 hours per week of teaching with both laboratory and lecture preparations, gathering of field specimens to stretch the budget, leading biannual marine field trips, cheerfully checking endless lists of supplies and equipment, and supervising all departmental classroom teaching by the required periodic visits. His cheerful performance reflected the solidly strong physique and love of hard work which were outstanding charasteristics of his personality. Few zoologists have the drive and energy for quality teaching and productive research demonstrated by A. Weir Bell. Few of us closely associated over the years realized the intensity of the exemplary behavior until his first heart attack in the Spring of 1953. He lived in the spirit and practice of a true Christian and shared his knowledge and work techniques with all interested students and fellow scientists. He often directed the questioning student back to his dissection for the laboratory motto was THE SPECIMEN IS THE AUTHORITY!

His research interests were dominated by a curiosity about the comparative anatomy and speciation of earthworms. Some of his best work was done in the "sink end" of the general zoology laboratory where beginning students were learning the fundamentals under his selected assistants—a remarkable example of diligence and concentration plus the sharing of new discoveries with his students. His most popular work was on the circulation of blood in the earthworm, with live demonstrations for students in the laboratory and constant encouragement for independent observation and discovery. He received more requests for and comments upon these technical papers in Turtox News than any others. He approached each laboratory specimen each semester as a challenge and a new learning situation for himself and the student. His was a labor of love and searching inquiry into the detailed anatomy of the earthworm as shown by his last, most excellent, publication on the "Enchytraeids (Oligochaeta) From Various Parts of the World" in the Transactions of the American Microscopical Society. The skillfully executed drawings were often completed between phone calls and office conferences. Even though he became a world authority on Micro-Oligochaete (Enchytraeid) Worms, he remained humble to the end in his respect and admiration for science and scientific research.

His sense of responsibility to high quality education and assigned responsibility for efficient conduct of all classes in the Life Sciences Department led to outside recognition of outstanding performance and brought many students from neighboring colleges interested in the basic classes. Zoology majors, Pre-Medical, and Pre-Dental students vied for his recommendation. He actively sponsored the Archiatrists Society, Pre-Medical and Allied Professions Club, and personally organized, directed, and maintained each semester a strong, up-to-date speakers' program of outstanding doctors, dentists and professional scientists, many of whom were his former zoology students. This led to the organization of the present Medical Orientation Class. He maintained a personal card file of all his zoology students and took justifiable pride in annotating their later acomplishments. Many of these grateful alumni returned to favor their "master teacher" with lectures, demonstrations, or a friendly visit.

Outside the classroom he was active in many phases of life of the community especially The First Congregational Church of Los Angeles where he enjoyed recognition for friendly service as an usher and membership on numerous committees. He retained his youthful interest in ranching by maintaining "Blue Haven" Ranch in the Santa Monica Mountains. One of his hobbies was hybridizing irises and other flowers. The landscaping at his ranch reflects his wide interest in living plants, especially trees and native wildflowers.

His professional affiliations began in 1924 with membership in the A.A.A.S. After a period of active participation in the Federation of Natural Sciences of Southern California, he joined the Southern California Academy of Sciences in 1941, served on the Board of Directors from 1943-1958, and the Advisory Board from 1959-1963. He was elected Fellow in 1945, serving as First Vice President in 1945-46, and President in 1947-48. He actively supported and promoted the Science Division of the Los Angeles County Museum. His interest in genetics was expressed through membership in the American Genetics Association, the American Eugenics Society, and the American Institute of Family Relations. In 1958 he became a member of the New York Academy of Sciences. He often supported conservation programs through the Cooper Ornithological and Wilderness Societies. He was also a member of the American Association of University Professors, the Society of Sigma Xi, and the American Institute of Biological Sciences.

He is survived by his wife, Josephine Hohberger Bell, and by the four children of his first wife, the late Elizabeth Jones Bell. These are Donald Gordon Bell of Walnut Creek, Arlova Louise Pierce of Reseda, Elliott Redfield Bell and Marilyn Elizabeth Getty of Oakland, and 6 grandchildren, all in California.

SHERWIN F. WOOD
Los Angeles City College
February 15, 1964

STRUCTURAL SIGNIFICANCE OF CLASTIC DIKES IN A SELECTED EXPOSURE OF THE MODELO FORMATION, SANTA MONICA MOUNTAINS, CALIFORNIA

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Department of Geology
University of Southern California

INTRODUCTION

In the last few decades numerous housing developments have been constructed in the Santa Monica Mountains and adjoining hills. Valley Circle Estates, presently under construction, is located in the east-central portion of Calabasas Quadrangle, California, between the Santa Monica Mountains and Simi Hills along the western edge of San Fernando Valley (Fig. 1). Several cuts have been made into hillsides, exposing unweathered sections of Late Miocene Modelo Formation. The particular cut slope under study is approximately 0.2 miles northwest of the intersection of Philiprimm Street and Blanco Avenue in Valley Circle Estates. Many vertical clastic dikes were observed on this cut across gently warped beds of diatomaceous shale. As the general north to northeast trend of the dikes suggested structural control, a detailed study of the dikes was undertaken.

PREVIOUS WORK

Origin of clastic dikes. Shrock (1954:212-220) essentially summarizes present knowledge concerning clastic dikes. These dikes consist of bodies of clastic material—gravel, sand, shale, clay, silt, bituminous sand, asphalt, calcareous matter or coal—which transect sedimentary bedding. According to Vitanage (1954:493), the dikes may vary in width from a mere film to hundreds of feet and in length from a few feet to more than eight miles.

There are two different genetic types of clastic dikes: (1) those resulting from substratal intrusion of clastic material emplaced under abnormal pressure, and (2) those formed with material from above that is either injected under pressure or simply transported into previously formed fissures by wind, water, ice, or gravity (Shrock, 1954:212).

All authorities on clastic dikes agree that a fissure must be formed prior to formation of the dike. A crack can develop from tension and shear accompanying an earthquake; from shrinkage of unconsoli-

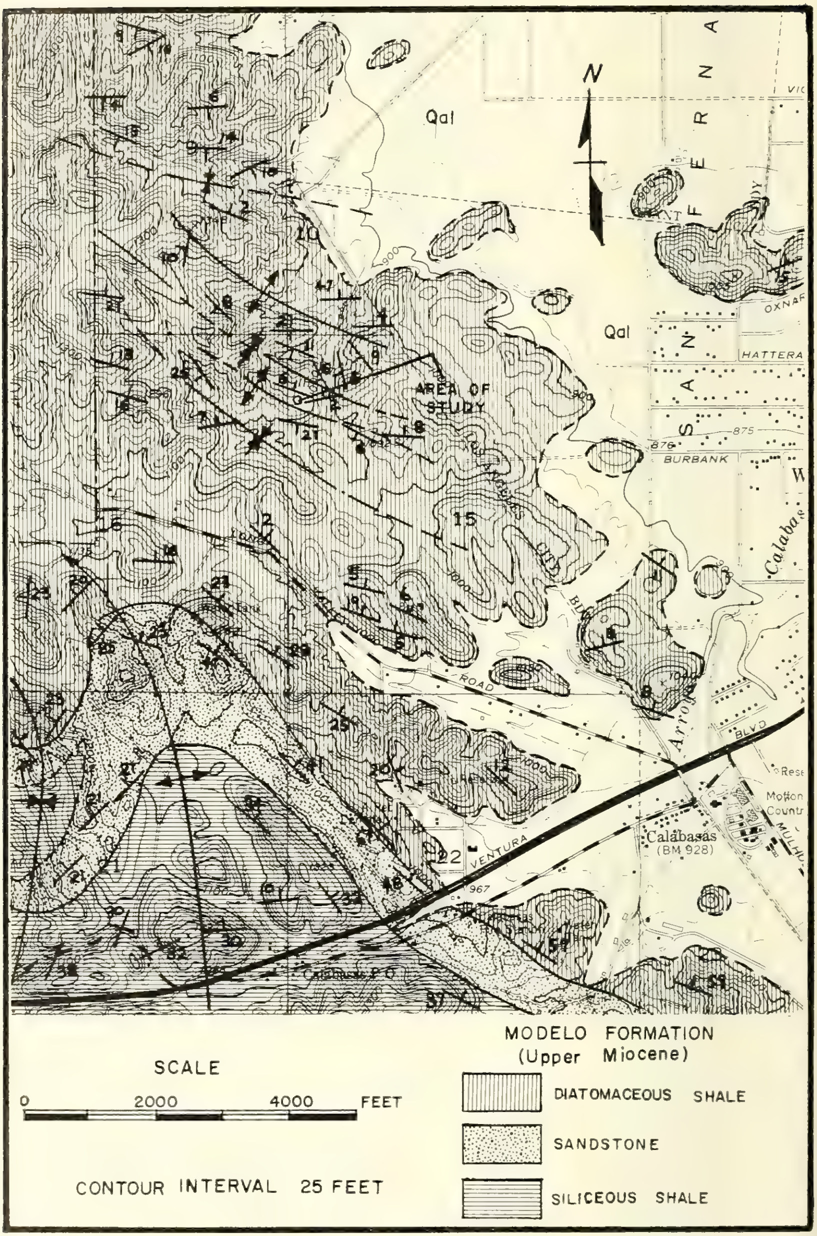

Figure 1. Location of study area and geologic map of the east-central portion of Calabasas Quadrangle. Geology mainly after Soper (1938).

dated materials; or from fracturing associated with folding, faulting, or landsliding. The pressure necessary to force material up into fissures from the substrata may arise from the weight of overburden, hydrostatic pressure or gas pressure.

Granular material can not flow within beds unless the sediment is dilated by water or petroleum to such an extent that individual grains no longer interlock, thereby allowing the mass to move about like a fluid. Professor W. J. Mead (Schrock, 1948:214) has suggested that earthquakes commonly produce the above mentioned conditions of dilation:

> The successive S and P waves deform the sand, forcing it first into loose packing, then into close packing. In the later condition interstitial water is released under pressure and forced upward into any existing fractures, carrying sand and silt with it. If the source bed is then changed to a loosely packed condition or sheared, the water just ejected may be drawn back into the sand, but the material injected into the fracture will remain there, for under these conditions it cannot flow downward.

Hubbert and Rubey (1959:115-166) have demonstrated that it is possible for abnormal hydrostatic pressure, due to rapid accumulation of a thick overburden, to build up to such an extent that the flotation limit of the overburden is approached. An interbedded sequence of sands and clays is especially susceptible to this phenomenon. Thus, it is quite conceivable for granular material to become mobile at depths of many thousands of feet.

General geology of the immediate surrounding area. Surface exposures in the study area consist of the upper member of the Modelo Formation as mapped by Soper (1938:169). This member is of Delmontian age (Late Miocene) and is approximately 1000 feet thick. It consists of soft, white to light gray diatomaceous and foraminiferal shale, and gray, punky diatomite containing a few thin lenses of yellowish sandstone. Sullwold (1958:125-127) considers the sand deposits to have resulted from deposition by turbidity currents in waters at a depth of about 3,000 feet as indicated by benthonic foraminifera in the enclosing shale. He further states (p. 127) that ". . . evidence for rapid dumping of sediment as opposed to distribution by more 'normal' currents is seen in the poor sorting, angularity of grains, and high feldspar content."

Structurally, the immediate surrounding area consists of open anticlinal and synclinal folds trending northwest (Fig. 1). Absence of Pliocene rocks from the area indicates important post-Miocene uplift, possibly accompanied by folding, but makes it difficult to give an exact date of movement. Final regional uplift may have occurred in Middle or Late Pleistocene time.

DESCRIPTION OF THE CUT SLOPE

General: The slope on which the dikes are exposed is cut 1½:1 and faces east; it is approximately 400 feet in basal length, has a maximum height of 100 feet, and consists of light yellowish-gray diatomite and diatomaceous shale or mudstone with a blocky to subconchoidal fracture. A few interbedded lenses, three inches to one foot thick, consist of easily to moderately friable fine sandy silt and silty sand.

Numerous fractures pervade the entire exposure, and bedding attitude is difficult to ascertain. Parallel sets of vertical clastic dikes and cross joints may be mistaken for bedding planes. However, when examined with a hand lens, diatom disks in the mudstone are found to be lying essentially horizontal, and this, as well as the attitude of the silty sand deposits, indicates horizontal bedding. Hence, the exposure is the crest of a gently folded northwest-trending anticline (Fig. 1).

Clastic dikes and vertical joints: Fifty-five clastic dikes were observed on the unweathered cut slope. Clastic dike attitudes, plotted on a point diagram in Figure 2, show that most are vertical and trend north to northeast. They vary in horizontal length from a few feet to 100 feet; in vertical extent from a few inches to 20 feet; in width from 0.5 inches to 2 feet. These vertical dikes generally have straight walls, though some are slightly sinuous or irregular. The clastic material of the dikes is usually easily to moderately friable, although some portions are well indurated with gypsiferous cement. Many dike walls are lined with layers, up to one inch thick, of clastic material cemented with gypsum.

The source of the dike material appears to be sandy lenses intercalated in the diatomite. Apparently, the granular material flowed down and possibly up into pre-existing fissures. Generally, the dike material is similar lithologically to the sandy lenses and consists of brownish-to light yellowish-gray sandy silt and silty sand. One large dike was traced from its source layer downward to a depth of 15 feet, where it tapered into a thin film. A small dike extends 6 or 7 inches upwards and downwards from one source lens and tapers in both directions from it. Angular fragments of diatomaceous shale are in-

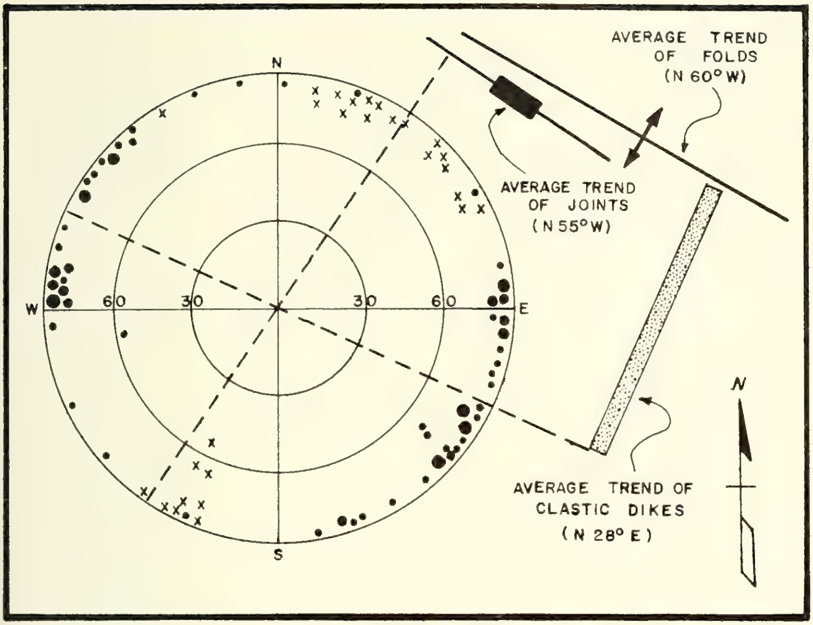

Figure 2. Point diagram (plotted on lower hemisphere) of joint and clastic dike attitudes. The "x's" represent normals to joints, and the black circles represent normals to clastic dikes. Relative sizes of dikes are indicated by circle size. Right side of figure is a diagram of general structural trends of the anticlinal fold, joints and clastic dikes.

cluded in portions of some dikes; these fragments presumably broke off the enclosing walls during emplacement.

As previously mentioned, the entire exposure is fractured and jointed. Many fractures and joints are filled with seams of gypsum up to one inch thick. An attempt was made to plot the major joints, only the widest and most extensive fractures being considered. Sometimes a single point was plotted to represent a series of small parallel joints. As illustrated in Figure 2, most joints are almost vertical and trend northwest parallel to the fold axis. They generally intersect the dikes at approximately right angles and were clearly formed after them.

CONCLUSIONS

Evidence presented suggests that sandy and silty material in the classic dikes had its source in intercalated lenses of turbidity current deposits in diatomaceous silts and clays of the Modelo Formation.

Possible northeast-southwest compressions in post-Miocene time resulted in northwest-trending folds and perpendicular north- to northeast-trending extension joints (see Billings, 1954:117-118). These joints were probably filled by turbidity current sediment put in a mobile condition by release of high confined hydrostatic pressure along with possible reorientation of poorly sorted and compacted clastic material. Grain reorientation into a more compact condition may have occurred during earthquakes accompanying tectonic activity in the area. Filling of the joints took place by both upward and downward injection of clastic material. Post-folding cessation of compressive forces resulted in release joints trending approximately parallel to fold axes. Apparently, the intercalated turbidity deposits were no longer mobile and could not fill this second joint set. Later, ground water circulated along joints, fractures and dikes in the diatomaceous shale and deposited gypsum.

The reader may doubt whether the Modelo shales were competent enough to transmit forces producing extension joints, especially in such open folds. However, shrinkage during compaction may have set up initial tensional stresses in the silt and clay. These stresses were possibly released in the direction of least opposition, which, during folding, was parallel to the fold trend. Thus, the formation of extension joints perpendicular to the fold axes could be facilitated.

Acknowledgment

The author is indebted to Dr. Gregory A. Davis of the Geology Department, University of Southern California, for critical reading of the manuscript.

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BULLETIN OF THE
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LOS ANGELES, CALIFORNIA

VOL. 63 OCTOBER-DECEMBER, 1964 PART 4

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BULLETIN OF THE SOUTHERN CALIFORNIA
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DISTRIBUTION OF THE OREGON SLENDER SALAMANDER, *BATRACHOSEPS WRIGHTI* (BISHOP)

ARDEN H. BRAME, JR.[1]
University of Southern California, Los Angeles

Since the discovery of *Batrachoseps wrighti* by Bishop in 1936, a number of localities have been recorded: to the Columbia River Gorge in the north (northern boundary of Oregon) and to central Oregon (Lane County) in the south (see map, Fig. 1). A large number of localities, thirteen, have not been reported in the literature and many of these consist of small range extensions or fill in important gaps in the recorded range. It is, therefore, desirable to publish the known localities for this species with a map plotting these records.

ACKNOWLEDGMENTS

Through the courtesy of Robert G. Crippen, Museum of Vertebrate Zoology, University of California (MVZ); Robert M. Storm, Oregon State University Museum of Natural History (OSUMNH); James Kezer, University of Oregon; Doris M. Cochran, United States National Museum (USNM); and Robert F. Inger, Chicago Natural History Museum (CNHM), specimens of *Batrachoseps wrighti* and their locality data were made available. I am especially grateful to Robert M. Storm for his special efforts (in conjunction with the Oregon Herpetological Society) in the successful searching for this species in central Clackamas County, which fills in an important gap in the range.

MATERIAL AND LOCALITY DATA

When the total range of *Batrachoseps wrighti* is carefully scrutinized (based upon all existing locality records) three basic areas stand out, since they are separated from each other by moderate gaps: the NORTHERN AREA bordering the Columbia River Gorge,

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[1] Also Los Angeles County Museum (LACM).

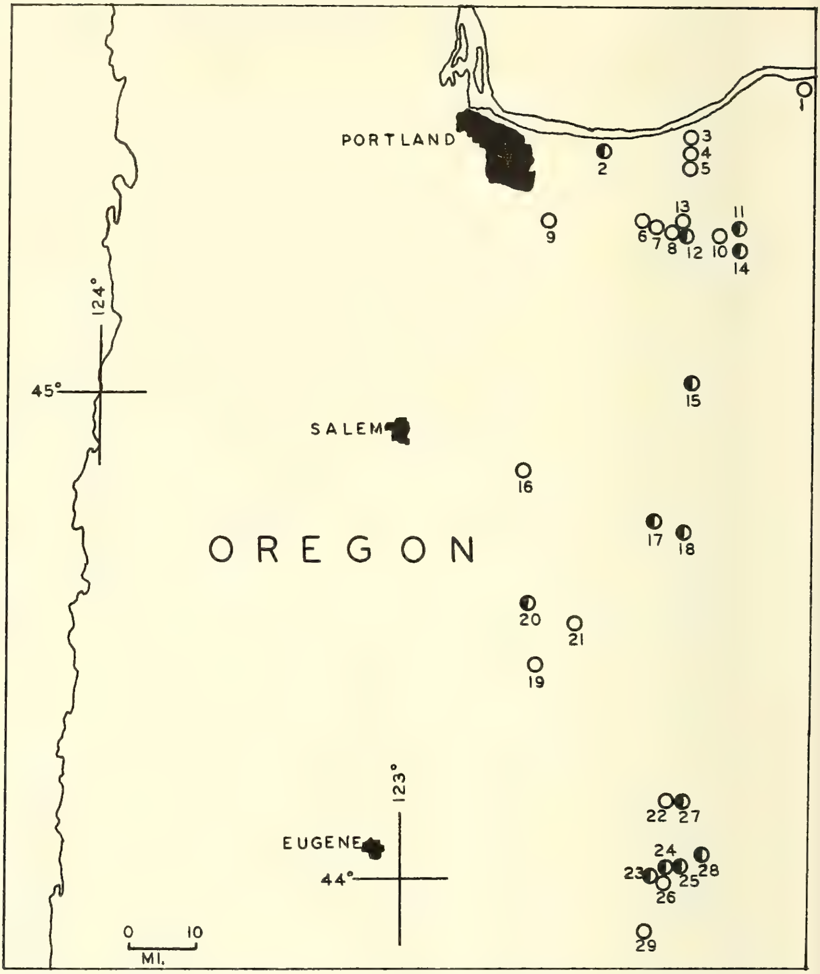

Figure 1. Map of the detailed range of *Batrachoseps wrighti* showing all known unpublished records (half-filled circles) and all published records (open circles); see text for localities corresponding to numbers.

composed of records from northwestern Hood River County, Multnomah, and northern and central Clackamas Counties; the Central Area, separated by gaps of 20 airline miles from the nearest locality in the northern area and 28 airline miles from the nearest southern area locality, is composed of records from Marion and Linn Counties; and the Southern Area composed of locality records in northeastern Lane County (see map, Fig. 1).

The following known published and unpublished locality records from each of the three major areas and specimens taken are noted below. Each locality is plotted by number on the map (Fig. 1). Locality records mentioned for the first time in this publication result chiefly from the field efforts of Storm and Kezer, and are indicated on the map by half-filled circles.

NORTHERN AREA: *Hood River County*: (1) Starvation Falls, Burns (1962); *Multnomah County*: (2) 1 mile west of Crown Point, Columbia River Gorge, collected by Robert J. Lavenberg, David B. Wake and Arden H. Brame, Jr., December 19, 1959 (LACM 1992); (3) Oneonta Creek, 1.4 miles south of U.S. Hwy. 30, Burns (1962); (4) Oneonta Gorge, Burns (1962); (5) Larch Mountain, Burns (1962); *Clackamas County*: (6) 8.7 miles southwest of Sandy (type locality), Bishop (1937) and Stebbins (1949), holotype = USNM 102455 and allotype = USNM 102446; paratypes = CNHM 86559, CNHM 86561-2, CNHM 86564; topotypes = SNHM 7613, SNHM 9824, MVZ 37355, MVZ 46285, MVZ 46287; and 8.5 miles southwest of Sandy, Storm (1953) MVZ 55354-7, OSUMNH 1714; (7) 6.3 miles southwest of Sandy, Bishop (1937) CNHM 86566 and CNHM 86568; (8) 9 miles southeast of Sandy, Tanner (1953), BYU —9 specimens; (9) 5 miles southeast of Clackamas, Jameson and Storm (1956); (10) 0.25 miles south of Wemme (14 miles east of Sandy by road) Storm (1963); (11) 2 miles north of Zigzag, OSUMNH 4422; (12) 2.4 miles south of Alder Creek, CNHM 86569; (13) Cherryville, Stebbins (1951), SNHM 4460-65. MVZ 46284; (14) across Hwy. 50 from Zigzag River to Rhododendron about 11 miles west of Government Camp, CNHM 69531; (15) Two River Forest Camp, near junction of the Clackamas and Collawash Rivers, collected by Robert M. Storm and the Oregon Herpetological Society Members, May 19 and 20, 1962, OSUMNH 7247-67.

CENTRAL AREA: *Marion County*: (16) Silver Creek Falls, Stebbins (1954), OSUMNH 9314; (17) 1 mile west of Detroit; OSUMNH 8771-81, OSUMNH 8783-90, MVZ 63846-9; (18) 1 mile above Idnaha, OSUMNH 8082-5; *Linn County*: mouth of Moose Creek above Foster on the Middle Santiam River, Storm (1953); (19) 5 miles above Foster, Graff, Jewett, and Gordon (1939); (20) 5.5 miles east of La Comb, OSUMNH 7030; (21) 1.3 miles from Moose Creek at mouth of Trout Creek, Storm (1953).

SOUTHERN AREA: *Lane County*: (22) 1 mile south and ¾ mile east of McKenzie Bridge, Storm (1953), OSUMNH 6203-6; (23) vicinity of Hidden Lake, USC-A.H.B.-59-85—six specimens and USC-D.B.W.-Osteo.-131-138; (24) 2 miles above Hardy Creek Road on Penny Creek Road from junction of the two, collected by Kezer and Brame; (25) 4 miles up Hardy Creek Road, collected by Kezer, MVZ 65426-32, OSUMNH 4423-31, OSUMNH 4652; (26) 12 miles south of Rainbow, Jameson and Storm (1956); (27) beginning of Ollalie Trail, Three Sisters Wilderness Area, OSUMNH 4828-9, OSUMNH 4432; 3 miles up French Pete Creek Trail, Three Sisters Wilderness Area, OSUMNH 3292; (29) 15 miles northeast of Westfir, Jameson and Storm (1956). BYU stands for Brigham Young University collections; SNHM = Stanford University Museum of Natural History; and USC = University of Southern California collections (to be deposited in the Los Angeles County Museum = LACM).

The discovery of an extremely large specimen of *Batrachoseps wrighti* from near Crown Point, led to a search of the literature and examination of most museum specimens for size maximums. The largest recorded standard length was 47.0 mm., Bishop (1937) and I have seen over 100 additional specimens of which the largest is 49.5 mm. snout-vent length (MVZ 46285). The Crown Point individual (LACM 1992) measures 60.1 mm. from snout to posterior edge of vent, over 10 mm. longer than the next largest known specimen, (see Fig. 2 for a comparison of a specimen 48.1 mm. standard length with the Crown Point animal). The tail of the giant *B. wrighti* measures 48.2 mm. long, giving the animal a total length of 118.2 mm., 21 mm. longer than the previous recorded total length, Bishop (1937). Other measurements and data for this individual are: head width 7.3 mm.; hind limb length 9.7 mm.; snout-gular fold distance 11.1 mm.; maxillary teeth 34 left, 32 right; 10 premaxillary teeth; vomerine teeth 19 left, 20 right; dentary teeth 40 left, 40 right. The right foot of the huge *B. wrighti* has an anomalous fifth digit. Coloration dorsally is very dark with evidence of a faint dorsal band and the venter is sparsely covered with a few large patches of guanophores (Fig. 2).

Locality number (15), Two River Forest Camp, is of particular interest since it occurs midway between the northern area populations and central area populations. A future paper by David B. Wake and the author will show an interesting clinal variation in maxillary teeth (high numbers in the northern area, moderate numbers in the central area, and very low numbers to none in the southern area) for *Batrachoseps wrighti*.

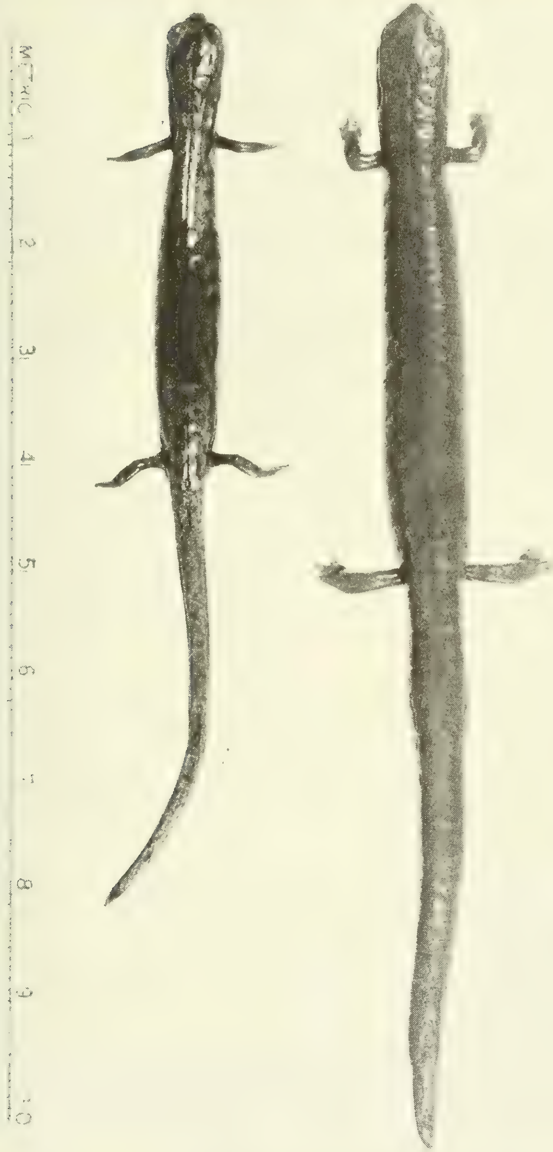

Figure 2. Giant specimen (right) of *Batrachoseps wrighti*, LACM 1992, and a large individual (previous known maximum size), on the left.

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LIFE HISTORY NOTES ON *EUPITHECIA MACROCARPATA* *(LEPIDOPTERA: GEOMETRIDAE)*

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The group of nocturnal insects known as Geometers are outstanding because of their protective adaptation. During the course of their evolution they have made beneficial changes of many different types and modifications in habits, form, color, mimicry, host plant selection, et cetera. Most of these are observed in the various stages of their metamorphosis rather than as mature moths.

Probably the most common adaptation is in protective coloration and form. This is evidenced in the moth *Eupithecia macrocarpata*, first brought to my attention by Mrs. Richard Janeway (Anne Workman Janeway) when she was working on a dwarf juniper Bonsai. The plant had been in its required outdoor environment in my garden for about a year. While working over the plant Mrs. Janeway found three green larvae appressed to terminal twigs, so perfectly camouflaged in form and color that she detected them only after they were disturbed by the clipping and she saw the larvae move.

I have no juniper on my grounds. I do, however, have Tecate Cypress (*Cupressus forbesii* Jepson). With a vigorous beating, one of these cypresses yielded three of the same larvae.

When the moths emerged and were compared with named series of *Eupithecia*, they seemed to resemble *E. unicolor* Hulst. A pair was mailed to Carl W. Kirkwood in Sunland, California, a specialist in the Geometridae, particularly the genus *Eupithecia*. His determination was that our specimens were *Eupithecia macrocarpata*. This species had been discussed in the McDunnough (1949) Revision of *Eupithecia*. Appreciation is due Carl Kirkwood, and also to Lloyd Martin, of the Los Angeles County Museum, for his comparison of our specimens with those in that museum's collections.

McDunnough described *macrocarpata* in 1944, from Half Moon Bay, California, and listed the food plant as *Cupressus macrocarpata* (Monterey cypress). This tree has been introduced along the Del Mar coast, and perhaps accounts for the presence of the moth in this southern area. Since it also feeds on *Cupressus forbesii*, it may be found on many species of *Cupressaceae*.

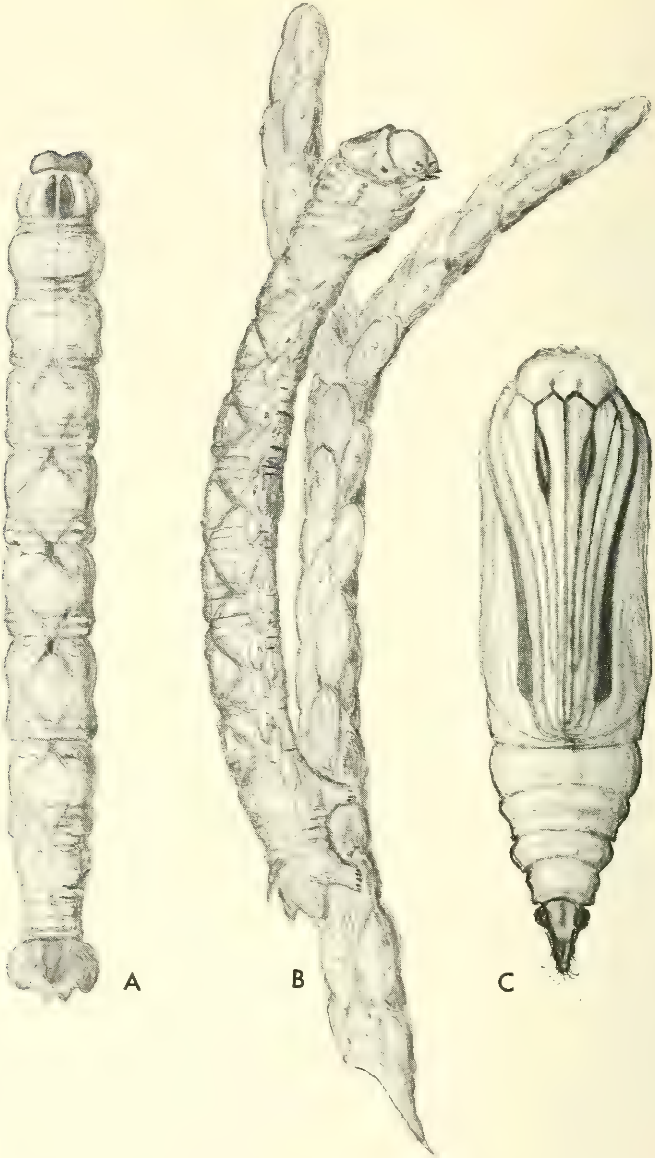

Figure 1. Larva and pupa of *Eupithecia macrocarpata.* A. Mature larva, dorsal surface, × 5. B. Mature larva, lateral aspect, on sprig of Juniper, × 5. C. Pupa, ventral aspect, × 8.

Reproduced from water color drawing by the author.

Records of the egg or early larval instars of this moth have not been worked out but the descriptions of the mature larva and pupa with illustrations are here included.

Mature Larva: (Fig. 1, A and B) cylindrical; length 21 mm.; width through center, 2.25 mm.

Head width, 1.5 mm; markedly bilobed and partly retracted during the resting periods. Color, uniform yellow-brown. Ocelli, black-tipped. Antennae, yellow.

Body. The first segment is predominantly yellow, with a pair of brownish-black elongate dashes medially, separated by a narrow yellow line. The remaining segments, except the cauda, are green, with a slight yellow cast. There is a suggestion of a middorsal gray stripe in the thoracic area only.

On each typical segment there is a light green triangular area margined with darker green lines which converge at each segmental juncture. The last caudal segment is tinged with yellow-brown. The spiracles are brown-centered, rimmed narrowly with yellow, and the legs and prolegs are translucent green.

Pupa: (Fig. 1 C). Length, 10 mm. Width through mesothoracic area, 3 mm. The head is slightly tinged with red-brown.

The body tapers gradually from the region of the wing tips to the cauda. The thorax and wing cases are predominantly straw color.

The dorsal surfaces of the abdominal segments are green, shading to tan on the venter. The segmental junctures of the antennae, legs and maxillae are clearly defined as narrow dark brown stripes, with a wider black band on the lateral margin of each antenna. This band terminates abruptly short of the wing margins but the antennae continue to the wing tips.

The cremaster is black. Two hooklets occur, one on each side at the base, and the tip bears six minute hooklets, all recurved outwardly. The cremaster is slightly more elongated than are those of the several other species which were illustrated by Rindge (1952: figs. 2-8).

The first pupa hatched July 26, and the last August 13, 1963. The moth is pictured on Plate 26, No. 25 of McDunnough's 1949 Revision.

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THE HOST RELATIONS OF A PINNOTHERID CRAB, *OPISTHOPUS TRANSVERSUS* RATHBUN (CRUSTACEA: DECAPODA)

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Among the brachygnathous decapod Crustacea, the family Pinnotheridae is well known for its commensal relations. Rathbun (1918) indicates that it least one complete North American genus, *Dissodactylus*, and many species have host relationships (defined herein as the animals which harbor or give a home to the commensal) which are obligate. Examples are numerous and sometimes the specific names, *e.g.*, *Pinnixa chaetopterana*, *Pinnotheres ostreum*, are clues to the crab's host. In a recent study of the decapod fauna of Southern California, we have been able to expand our knowledge of the commensal relations of *Opisthopus transversus* Rathbun.

DISCUSSION

Reviews of the data provided by Rathbun (1918) and Schmitt (1921) plus records from our own collections from Southern California compel us to conclude that this pinnotherid, *Opisthopus transversus*, demands no specific partnership, but is an amazingly promiscuous commensal. It occupies a wider range of hosts than any other observed North American member of its family. Furthermore among its hosts it occupies a wider assortment of sites in relation to its host. We have found *Opisthopus* in commensal association with thirteen different species of host distributed through three phyla in the San Diego area alone. Table 1 is a summary of our present knowledge of its host relations and its position in relation to the host. Table 1 indicates that *Opisthopus* is able to function quite successfully in the siphon and mantle cavity of molluscs, the tubes of worms even should these be occupied by other decapod crustaceans of larger size, and in the intestine and cloaca of holothurians. From our observa-

TABLE 1

Summary of known host relations of *Opisthopus transversus*

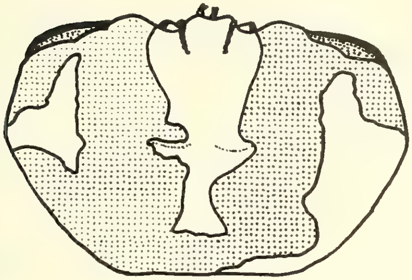
Phylogenetic class of host	*Host's name*	*Position of crab in host*
Class Polychaeta (ANNELIDA)	*Chaetopterus variopedatus*	Tube built by the worm
Class Amphineura (MOLLUSCA)	[1]*Cryptochiton stelleri*	Gill chamber
Class Gastropoda (MOLLUSCA)	*Astraea undosa*	Gill chamber
	Bulla gouldiana	Gill chamber
	Megathura crenulata	Gill chamber
Class Pelecypoda (MOLLUSCA)	*Hinnites multirugosus*	Mantle cavity
	[2]*Mytilus edulis*	Mantle cavity
	[2]*Pholas* sp.	Siphon
	Schizothaerus nuttali	Siphon
	Trachycardium robustum	Siphon
	Zirphaea pillsbryi	Siphon
Class Holothuroidea (ECHINODERMATA)	*Stichopus parvimensis*	Cloaca
	Molpadia arenicola	Intestine

tions, there is some evidence to suggest that (1) the size of the cavity occupied by the crab may have a limiting effect on the size that the crab may attain therein, and (2) the materials within the cavity of the host may exert some effects on the color of the crab harbored therein.

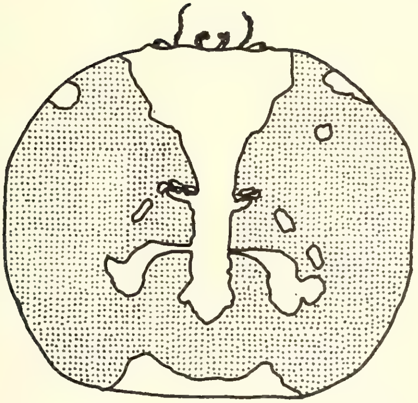
In support of these suggestions, we have found that the largest and most mature *Opisthopus* (gravid females) have been taken from the mantle cavity of *Hinnites*, the intestine of *Molpadia*, and the cavernous siphon of *Zirphaea*. *Opisthopus* inhabiting *Astraea*, *Megathura*, and *Stichopus* are somewhat smaller depending on the size of the host, and those *Opisthopus* inhabiting *Bulla* and *Chaetopterus* tubes are the smallest that we have seen. It seems plausible to suggest that in a community where *Chaetopterus* tubes abound, *Opisthopus* seeks a refuge until it reaches such a size that it can compete successfully with the *Pinnixa* or *Polyonyx* usually inhabiting the tubes, or that failing to do so, it will enter *Astraea*, *Bulla*, *Megathura*,

[1] From Ricketts and Calvin (1962: 61)

[2] From Schmitt (1921)



Pinnixa barnharti ♀ x 2



Opisthopus transversus ♀ x 2

Molpadia or *Stichopus*, all of which may be found nearby. Such a community exists in Mission Bay where we have been studying the commensal relations of *Chaetopterus* worms.

With regard to the color of the crab in relation to its host, we have found that very young specimens have the bright red-mottling described in Rathbun's original description. This pattern persists in those species such as *Astraea*, *Bulla* and *Megathura* in which the crab seems to have its own food source. But in *Trachycardium*, *Hinnites*, and *Zirphaea* we have noted that, regardless of the crab's size, its carapace is a translucent white. This suggests to us that the filter feeding habits of these three species may limit the ability of the crab to maintain a carotenoid supply sufficient to maintain the red mottling. In holothurians which ingest large masses of sand or mud rich in carotenoid pigments, the crab maintains a color pattern, different in *Molpadia* from that of *Stichopus*. The color pattern in the former is reddish brown and white forming a distinct pattern as opposed to the latter in which the crab's color is a very pale red mottling in which any pattern is hard to discern. One of the striking features of the color pattern of the crabs which inhabit *Molpadia* is their similarity to that of *Pinnixa barnharti* similarly occupying *Molpadia*. Figure 1 is a dorsal view of the carapace of the two species found to occupy the intestine of this burrowing holothurian. Attention is called to the convergent similarities of the dark areas. This pattern is not observed to occur in *Opisthopus* inhabiting any other hosts.

The occurrence of *Opisthopus* in the intestinal tract of *Molpadia arenicola* is of extreme interest because in the past only *Pinnixa barnharti* had been recorded in this host. (Exception is noted in the case of Holmes (1900) who reported a *Pinnixa faba*. Schmitt (1921) in referring to this record, states that Rathbun thought Holmes's record to be in error.) Heretofore, *Pinnixa barnharti* has been considered as obligatory to and the only commensal pinnotherid of *Molpadia*. After finding a large (20 mm.) *Opisthopus* in a *Molpadia* from Mission Bay, it seemed worthwhile to sample a portion of a population of *Molpadia* living in the entrance channel to Mission Bay, and another at the head of La Jolla canyon in order to confirm our first record. Our results are presented in Table 2. It should be noted that 52 out of 53 *Molpadia* examined harbored a commensal crab, and that a total of 13 or 25% of the combined samples (52 animals) were *Opisthopus transversus*. Calling attention to Figure 1

TABLE 2

Host relations of 52 specimens of *Molpadia arenicola* from two different localities at San Diego, California

La Jolla population
(N=24)

Pinnixa barnharti		*Opisthopus transversus*	
Male	Female	Male	Female
6	11	1	6
Total		*Total*	
17		7	

Entrance channel to Mission Bay population
(N=28)

Pinnixa barnharti		*Opisthopus transversus*	
Male	Female	Male	Female
9	13	1	5
Total		*Total*	
22		6	

Combined San Diego population
(N=52)

Pinnixa barnharti		*Opisthopus transversus*	
Male	Female	Male	Female
15	24	2	11
Total		*Total*	
39		13	

again, a convergence in gross morphology can be seen which may have allowed this species to be a competitor of *Pinnixa barnharti.*

If we consider the convergence of form shown in Figure 1, the record of Holmes to which we have referred raises an interesting question. *Pinnixa faba* and *Pinnixa littoralis* both have a form in common, and each is similar to *Pinnixa barnharti* as well as to a large *Opisthopus transversus.* All existing records that we have seen for the distribution of *P. faba* and *P. littoralis* relate these species exclusively to large Pelecypod molluscs such as *Schizothaerus.* It seems plausible to us that Holmes's record may have been an unusually large *Opisthopus* such as the kind as that which we are finding at present.

RANGE EXTENSION

On a recent expedition to Magdalena Bay, Baja California, we were able to collect 4 *Stichopus parvimensis* from San Hipolito Bay (H.O. Chart 624; 385 miles southeast of San Diego; 82 miles southeast of Pta. Eugenia Light; all distances in nautical miles drawn point to point) each of which contained an *Opisthopus* in its cloaca. The previously known southern limit for this species of pinnotherid was San Diego, California.

SUMMARY

Observations on the host relations of *Opisthopus transversus* Rathbun lead us to conclude that its abundance in nature is due especially to its ability to associate with a wide variety of hosts. By virtue of its promiscuity, it would appear to have enhanced its survival and extended its known range significantly. There is evidence presented that suggests that *Opisthopus transversus* may be exerting pressure on another member of its family, *Pinnixa barnharti* in competition for space (host association).

ACKNOWLEDGMENTS

We wish to thank Dr. Denis L. Fox, Scripps Institution, for the generous use of his laboratory space. We are grateful to Dr. Fox and to Dr. William E. Hazen, San Diego State College, for guidance and helpful suggestions in the preparation of this manuscript. We wish to thank Dr. Carl L. Hubbs, Scripps Institution, for allowing us to participate in the "MagBay" expedition of 1964. This work was supported in part by NSF grant GB-122.

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A SHARK TAIL FROM THE MIOCENE OF PALOS VERDES HILLS, CALIFORNIA

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Los Angeles County Museum, Los Angeles, California

Imprints of sharks are among the rarest of fossils, particularly in Tertiary sediments. Therefore, the discovery of such an impression in the fossil fish collection of the Los Angeles County Museum was considered worthy of description and it is hoped that this description will aid in the discovery of other shark impressions.

The slab with the tail impression was a part of the California Institute of Technology collection, which was purchased for the Los Angeles County Museum. The specimen bears the Cal. Tech. number 10212 and it is an impression of the right side of a shark's tail. None of the original organic material is present. This fossil was collected at the Cal. Tech. locality 388, the quarry of the Dicalite Company one half mile southwest of Walteria in the Palos Verdes Hills, California.

The diatomite in the Dicalite Company quarry was placed in the upper part of the Valmonte member of the Monterey shale by Woodring, *et al.* (1946). According to Kleinpell's (1938) correlation chart, the Valmonte member of the Monterey formation would belong to the Mohnian stage of the late Miocene.

The fossil impression consists of approximately 65 caudal vertebrae, 55 of which are quite distinct. Below these vertebrae, there are a number of hemal arches, the first 11 of which are very clearly imprinted. Surrounding these elements is a faint impression of the edge of the tail, visible in Figure 1. A reconstruction of the tail is given in Figure 2, in which supposed missing parts are indicated by dotted lines.

The vertebrae represented as impressions on my specimen are typically asterospondylic (Fig. 1). Such vertebrae are discussed by Hasse (1882) and are restricted to the Tertiary families Heterodontidae, Orectolobidae, Rhincodontidae, Carchariidae, Alopiidae, Cetorhinidae, and the Isuridae. The shape of the tail with the presence of a deep lower lobe eliminates from consideration the Heterodontidae and Carchariidae. The short upper lobe eliminates the Alopiidae as well as the family Rhincodontidae (Bigelow and Schroeder, 1948).

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[1] Associate Curator of Vertebrate Paleontology.

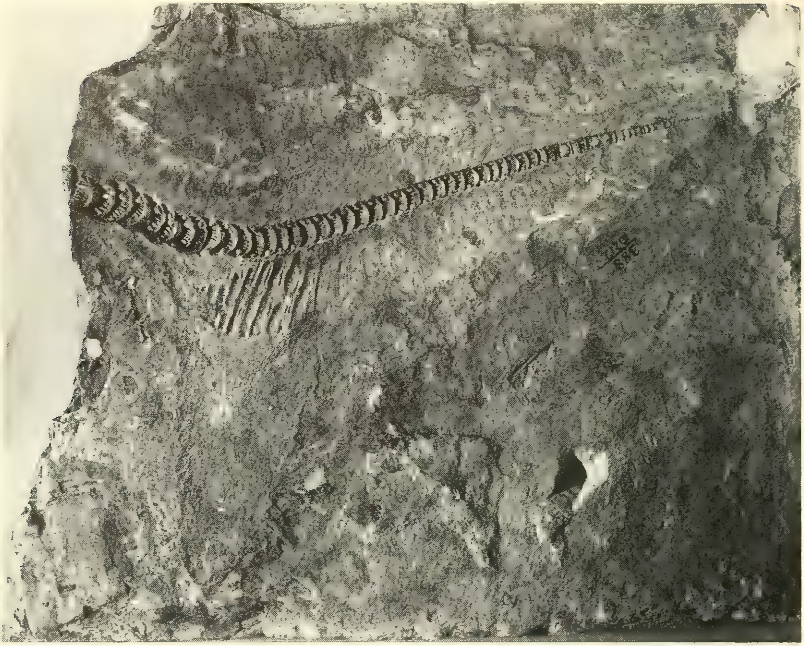

Figure 1—Imprint of *Isurus* tail from the Miocene Valmonte Diatomite at Walteria. There is no indication of a cutwater.

The Cetorhinidae lack the deep lateral incisions on the vertebrae (Fig. 1).

Within the family Isuridae (all others being eliminated) there are three known genera with a Tertiary record: *Isuris, Lamna,* and *Carcharodon.* The caudal vertebrae in *Lamna* have reduced the number of radiating lamellae (Hasse 1882, pl. 38, figs. 1-4). In the recent great white shark, *Carcharodon carcharias* (Linnaeus), the spaces made by the radiating lamellae are subdivided. This subdivision results in a honeycombed effect quite distinct from the imprints on the museum specimen (Fig. 1).

With these differences in mind, my specimen can be compared to the genus *Isurus*, with which it agrees. The genus *Isurus* has a long geological record ranging from the Cenomanian of Europe (Woodward, 1889) to the Recent. Agassiz (1843) described a number of Miocene species, two of which are now known to be from California: *Isurus hastalis* Agassiz and *Isurus plana* Agassiz.

In the Valmonte member of the Monterey shale, at the Dicalite

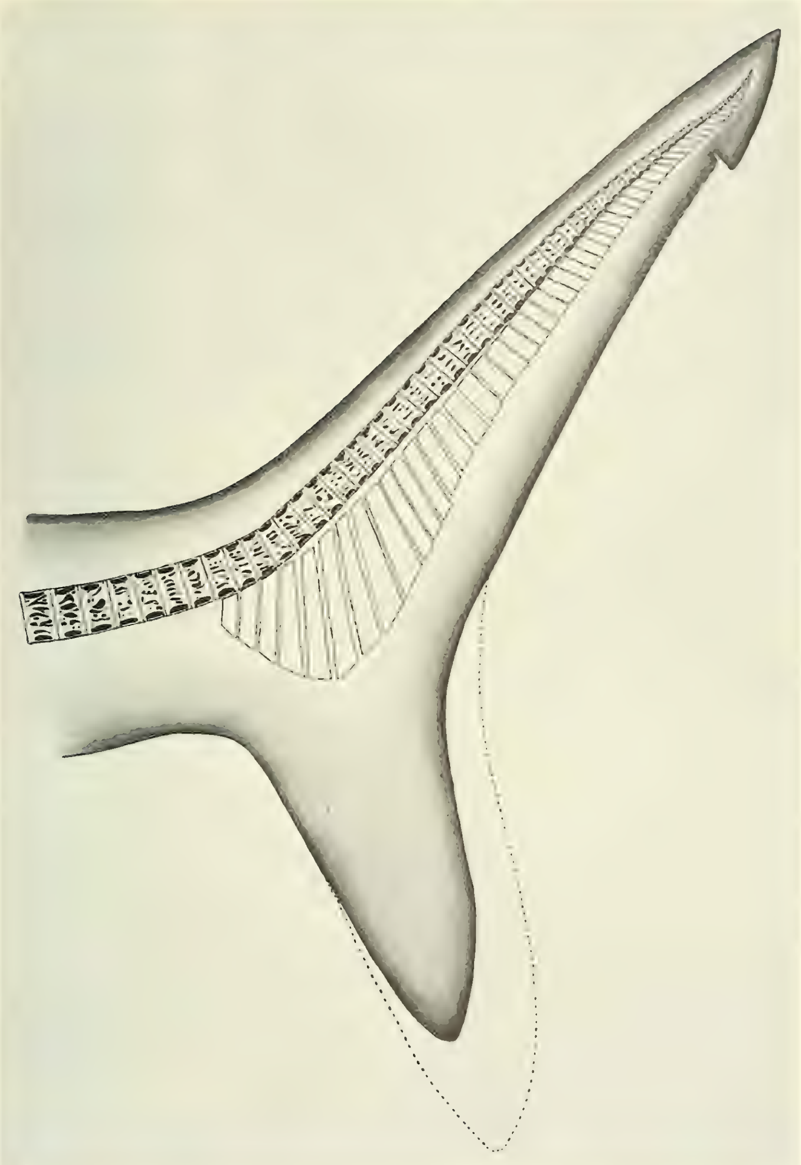

Figure 2. Reconstruction of fossil *Isurus* tail from the Miocene Valmonte Diatomite. The position of the dotted line is based on comparison with a recent isurus tail.

Company quarry. a number of fossil *Isurus* teeth have been found which are referable to *I. plana*. There is a good possibility that the tail we have under consideration may also be referable to the species. Except for the *Isurus* teeth and single tail, there is a singular lack of fossil shark material at the Walteria quarry. Perhaps this apparent lack of sharks is due to the extreme depth at which these beds were deposited and the original scarcity of sharks living in the area. Another possibility is that any shark material which had been buried was subsequently leached out by ground waters. The imprint of the shark's tail furnishes a fine example of such leaching.

The photograph used in Figure 1 was made by the Los Angeles County Museum staff photographer and the reconstruction of the tail (Fig. 2) was done by Mrs. Pearl Hanback.

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THE OCCURRENCE OF *BALANUS CONCAVUS* ON THE TEST OF *DENDRASTER EXCENTRICUS*[1] [2]

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The sand dollar, *Dendraster excentricus*, is commonly found in sheltered sand flats along the Pacific Coast from Alaska to Baja California (Hyman, 1955). In this same habitat, the barnacle, *Balanus concavus pacificus* may be found existing on the sand dollar test (Fig. 1).

Although echinoids are known to serve as host to a variety of symbionts (Boolootian, 1958), little has been written about the relationship between the echinoid, *Dendraster excentricus*, and *Balanus concavus pacificus*.

Two aspects of the relationship between these organisms are discussed in this study. First, the position of the barnacle on the sand dollar test is elucidated. Secondly, the influence of the barnacle on the survival of the sand dollar is considered.

Materials and Methods

Approximately two hundred sand dollar tests were collected at Point Mugu, California. Of these tests, thirteen percent had one or more barnacles attached, while another nine percent showed scars where barnacles once had been.

The 5-III diameter of the sand dollar was found to be directly proportional to its 1-4 diameter (Fig. 2). The 5-III diameter is used in this study, as is the rostrocarinal axis of the barnacle.

To determine the orientation of the barnacle on the sand dollar test, an outline of the barnacle was drawn and the rostrocarinal axis indicated on a sand dollar diagram. The midline of the sand dollar was then drawn, and the rostrocarinal axis was extended until the two lines converged. The resulting angle was then measured.

The percent of ambulacral area occluded by the barnacle was determined by direct measurement. This was facilitated by use of a graph which revealed a logarithmic relationship between the length of each ambulacra and the diameter of the sand dollar.

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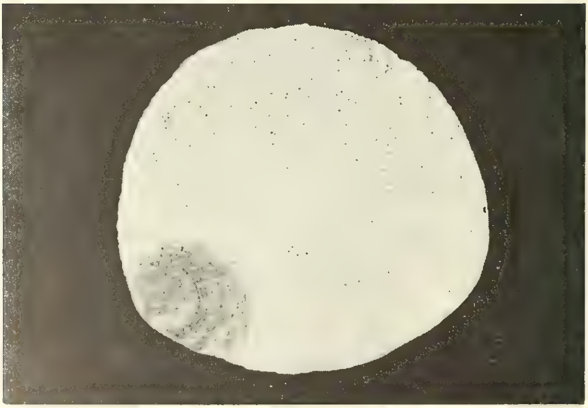
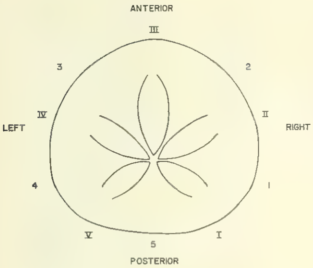
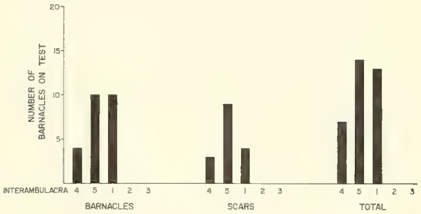
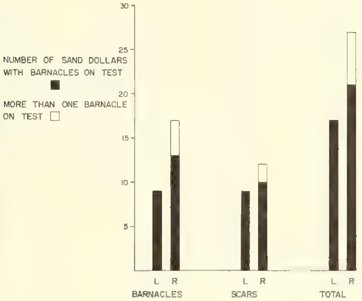
[1] Supported in part by the National Science Foundation grant G9561.

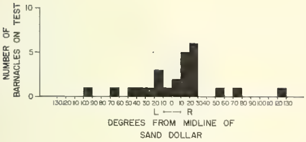
[2] Gratitude is extended to Miss Carol Hittle for the preliminary work on this study.

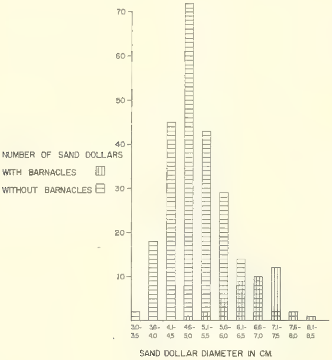



ANTERIOR
III
3
2
IV
II
LEFT
RIGHT
4
1
V
I
5
POSTERIOR


NUMBER OF BARNACLES ON TEST
20
15
10
5
INTERAMBULACRA 4 5 1 2 3
4 5 1 2 3
4 5 1 2 3
BARNACLES
SCARS
TOTAL


NUMBER OF SAND DOLLARS WITH BARNACLES ON TEST ■
MORE THAN ONE BARNACLE ON TEST □
30
25
20
15
10
5
L R
L R
L R
BARNACLES
SCARS
TOTAL


NUMBER OF BARNACLES ON TEST
10
5
0
130 120 110 100 90 80 70 60 50 40 30 20 10 0 10 20 30 40 50 60 70 80 90 100 110 120 130
L ⟷ R
DEGREES FROM MIDLINE OF SAND DOLLAR


NUMBER OF SAND DOLLARS
WITH BARNACLES ▥
WITHOUT BARNACLES ▤
70
60
50
40
30
20
10
3.0-3.5
3.6-4.0
4.1-4.5
4.6-5.0
5.1-5.5
5.6-6.0
6.1-6.5
6.6-7.0
7.1-7.5
7.6-8.0
8.1-8.5
SAND DOLLAR DIAMETER IN CM.

Discussion

Generally one barnacle was attached directly to a sand dollar test, with others attached to this barnacle. The average number of barnacles on a sand dollar was four, with as many as twenty being found on a single test. The average diameter of the barnacles and scars on the test itself was 2.04 cm. with an observed range of 0.45 cm. to 2.60 cm.

No relationships were found between (1) sand dollar diameter and the total number of barnacles, (2) sand dollar diameter and the diameter of the barnacle(s) directly attached to the test, (3) diameter of the barnacle(s) directly attached to the test and the total number of barnacles, (4) sand dollar diameter and the percent of ambulacral area occluded. Relatively few barnacles covered the madreporite, either partially or completely; and this also appeared unrelated to sand dollar diameter (Table I).

The barnacles were found exclusively on the posterior half of the aboral surface of the sand dollar. (However, one barnacle scar was found on the posterior edge of the oral surface.) This phenomenon can be readily understood in view of the fact that sand dollars generally live with the anterior half buried in the sand. Since these organisms orient themselves at an angle away from vertical with respect to a current, barnacles occur primarily on the aboral surface.

The orientation of the barnacle on the sand dollar may be influenced by the current, but it is more likely determined by a phototropic response of the cypris as it settles and attaches (Barnes, *et al.*, 1951).

Figure 3 shows the frequency of placement of the barnacles with respect to the five interambulacral areas of the sand dollar. (For pur-

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KEY TO FIGURES

1. Aboral view of sand dollar tests depicting position and number of barnacles.
   a. 7 barnacles are seen; one is directly attached to test; madreporite covered.
   b. 5 barnacles are seen; 2 are directly attached to test; madreporite not covered.
   c. 1 barnacle scar is apparent; madreporite not covered.
2. Aboral view of sand dollar test. Ambulacra in Roman numbers; interambulacra in Arabic numbers.
3. Bar graph illustrating position of barnacles on sand dollar test.
4. Bar graph illustrating position of barnacles on sand dollar test and those sand dollars with more than one barnacle on test.
5. Barnacle orientation on sand dollar test with reference to midline (5-III axis).
6. Size distribution of sand dollars with and without barnacles.

TABLE 1

Sand Dollars with Barnacles or Barnacle Scars

Specimen Number	*Diameter*	*Number of Barnacles*	*Diameter of Barnacle(s) on Test*	*Percent of Ambulacra Covered*	*Madreporite Covered*
1	5.76 cm	1	1.72 cm	5.60	no
2	6.00	2	2.00	1.54	no
3	7.28	1	1.65	7.82	no
4	6.50	5	2.28	18.67	no
5	6.73	4	1.61	0.00	no
6	6.46	6	2.34	30.40	yes
7	7.09	7	2.26	7.70	no
8	7.49	8	2.00	1.54	no
9	6.60	7	2.60	54.00	yes
10	7.19	4	2.00	17.60	yes
31	6.37	2	1.98	7.70	no
32	6.94	10	2.03 1.85 1.10	1.10	no
33	6.10	5	2.03	5.10	no
34	6.59	4	1.85	2.37	no
35	6.58	4	1.98	3.16	no
36	6.44	18	1.40 1.60	0.00	no
37	7.43	11	2.12	7.70	no
38	6.89	5	2.00	8.70	no
39	7.24	4	2.43	17.40	no
40	7.37	5	2.26 2.28	19.95	no
41	7.42	15	1.69	29.90	yes
42	7.17	5	2.43	15.40	yes
43	5.87	20	1.74	32.00	yes
44	5.70 cm	7	1.89 cm	4.60	no
45	5.46	19	1.50 1.96	16.76	no
46	5.33	1	2.00	24.60	yes
47	4.69	1	1.74	24.60	yes
		Number of Scars			
91	7.81	1	1.85	4.60	no
92	8.02	1	1.77	0.00	no
93	6.33	1	1.74	7.70	no
94	6.70	1	1.94	0.00	no
95	5.85	1	1.55	32.60	yes
96	6.24	2	1.65 1.73	14.60	no
97	6.30	1	1.25	0.00	no
98	6.34	1	1.80	2.00	no
99	6.75	1	1.62	7.70	no
100	7.10	1	1.60	9.60	yes
101	6.86	1	1.19	0.00	no
102	7.78	1	1.43	0.00	no
103	5.98	2	2.10 0.45	9.25	no
104	7.30	2	1.94 1.07	19.25	no
105	7.40	1	2.53	0.00	no
106	6.14	1	1.07	0.00	no

poses of this histogram, the dividing lines for the five areas were placed at the center of each ambulacrum.) There is a definite preference, first, for the central section (5), and secondly, for the right side (1). Figure 4 shows a slight preference for the right side where only the presence or absence of barnacles is considered, but when the number of barnacles attached directly to the test is considered, a definite preference for the right side is obvious.

Most of the barnacles are oriented with the rostrum toward the anterior portion of the sand dollar. In seventy percent of the cases, the rostrocarinal axis formed an angle of 30 degrees or less with the midline of the sand dollar (Fig. 5).

The average diameter of the sand dollar in the sample was found to be 4.87 cm. The average diameter of the sand dollars without barnacles was 4.51 cm. with a range from 3.26 to 6.97 cm. In comparison, the average diameter of the sand dollars with barnacles or barnacle scars was 6.39 cm. with a range from 4.69 to 8.02 cm. (Fig. 6).

Generally the smaller sand dollars do not have barnacles, while the larger ones do. These data indicate that the presence of the barnacles does not negatively affect the survival of the sand dollar, since the largest, and presumably the oldest, sand dollars are those with barnacles. The reason for this size distribution of sand dollars with and without barnacles is not certain, though it is likely that the larger sand dollars simply offer more area on which cypris larva may land.

It was observed that a few sand dollar tests (without barnacles) which still possessed spines, had small area from which the spines were gone. Such an area would provide a place for the cypris to attach itself without interference from the spines (Boolootian, 1958). Perhaps such areas are more likely found on the older and larger sand dollars.

Summary

The barnacle, *Balanus concavus pacificus*, may be found existing on the posterior half of the aboral surface of the sand dollar, *Dendraster excentricus*. Generally the smaller sand dollars do not have barnacles, while the larger ones do.

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THE LUMP-NOSED BAT *(PLECOTUS TOWNSENDII)* IN SOUTHERN SONORA, MEXICO

The Lump-nosed bat (*Plecotus townsendii* Cooper) is widely distributed throughout the Central Appalachian and Ozark Highlands, the western United States, southwestern Canada, and the central portion of Mexico as far south as Oaxaca. However, in Sonora it has been reported only from Saric and Pilares in the northeastern part of the state (Burt, Misc. Publ. Mus. Zool., Univ. of Michigan, 39:26, 1938), an area of pine-oak forest and mesquite-grassland. On the morning of November 24, 1963, the author, with Philip Henry and Eugene Studier, collected a *P. townsendii* 5 miles west of Alamos, Sonora, Mexico, in the abandoned mine, Minas Nuevas. This extends the known range of *P. townsendii* in Sonora approximately 250 miles south.

The bat (adult female, specimen no. 2683 in the University of Arizona collection) was taken by hand 50 feet interior from the mine entrance where it was hanging from the tunnel roof. In a lateral gallery approximately 150 feet from the site of collection, a Vampire bat (*Desmodus rotundus murinus* Wagner) was taken.

Minas Nuevas, elevation 1600 feet, is located in the arid tropical thornforest region with vegetation consisting of woody plants 15 to 20 feet tall. The tunnel in which the *P. townsendii* was taken has openings at both ends, one the mine entrance, the other a large shaft or cave-in. In November, the tunnel is quite cool and the bat was in a semi-torpid condition when captured.

The occurrence of *P. townsendii* in this environment, arid tropical thornforest, appears to be unique. It is commonly known from the Sierra Madres and central plateau to the east where it is found in the regions of mesquite-grassland; pine-oak forest; and at higher elevations, boreal forest; while avoiding the truely arid desert regions. —Ross E. Dingman, *University of Arizona, Tucson.*

CLARIFICATION OF THE FAMILY THALAMOPORELLIDAE (ECTOPROCTA)

Dorothy F. Soule[1] and John D. Soule[2]
Allan Hancock Foundation, University of Southern California, Los Angeles

The recent acquisition of a large quantity of *Thalamoporella* sp. from the island of St. Helena in the South Atlantic, sent by Dr. Arthur Loveridge to the American Museum of Natural History, and to the Hancock Foundation, of the University of Southern California, has emphasized the need for clarification of the bryozoan family Thalamoporellidae as described by Levinsen (1902).

When Hincks established the genus *Thalamoporella* in 1887, he placed it in the family Steganoporellidae, and the distinguishing features he enumerated served only to separate it from the other genera of that family. Thus the characteristics which concerned him were the presence of a dividing wall in the lower compartment, external bilobate ooecia, and an orifice partly closed by an operculum with a large foramen on each side. In the new genus *Thalamoporella* he placed *Flustra rozieri*, Audouin 1826, which Hincks had previously renamed *Steganoporella rozieri*, in 1880.

The family Thalamoporellidae was erected by Levinsen in 1902. He characterized it as being "distinguished by the possession of epistomal ooecia, vicarious avicularia, and free calcareous spicules in the form of bows and compasses." Apparently Levinsen was the first to note the presence of these peculiar spicules and to appreciate their taxonomic significance, since they are not known to occur in any other family.

Levinsen's monograph of 1909 again cited the family Thalamoporellidae, indicating it as being a new family. This has led a number of authors to date the family from 1909, rather than 1902 when Levinsen actually proposed it. He elaborated the family characteristics, emphasizing the unique spicules and the zooecial characteristics, and stating that the avicularia also generally offer good specific characteristics. Levinsen reported on ten species, but named five different varieties of what he called *Thalamoporella rozieri* Audouin. Subsequent authors have assigned species rank to some of

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[2] Research Associate; also American Museum of Natural History, New York.

these varieties. Harmer (1926) doubts that Levinsen's (1909) *T. rozieri* is actually the same as *Flustra rozieri* Audouin 1826.

In keying out the families of his division, now super family, (Soule and Soule, 1964) Coilostega, Levinsen united three families, Thalamoporellidae, Steganoporellidae, and Aspidostomidae, under the title Group Tubifera, all of which contain some sort of polypide tube. He then offered a key in which the first choice was the presence of spicules (Thalamoporellidae), or their absence; the second choice for those lacking spicules was the presence of avicularia (Aspidostomidae), or their absence (Steganoporella). It would seem then that while Levinsen did not base his initial key to the families on the presence of avicularia, he clearly indicated that all members of the family possessed vicarious avicularia, and his descriptions of the species bears this out.

Harmer (1926) further emphasized the presence of the interzooecial avicularia by indicating that these structures quite commonly were the initial zooecium in a series, often standing beside a zooecium which is modified by being smaller than usual. Thus new rows would originate by having an unlike pair (a small normal zooecium beside an avicularium) formed immediately distal to a full size single normal zooecium. In those colonies which form prismatic branches of fairly uniform diameter, new rows would not then be as frequent as they would be in the colonies which form bilaminar leafy folds with consequent increase in the number of rows occurring. Harmer's key to the family Thalamoporellidae is based upon the nature of the avicularian mandible as the first choice to be made. Harmer also used the nature of the spicules in further differentiating the species; some having both compass and caliper shapes and others having only compasses.

Large, cabbage-shaped colonies were collected by Dr. Arthur Loveridge on a buoy cable at St. Helena Island and were presented to the authors by Mr. Fred Zeissenhenne of the Hancock Foundation. Smaller colonies from the same locality, also collected by Dr. Loveridge, were forwarded from the Department of Living Invertebrates of the American Museum of Natural History, courtesy of Dr. W. K. Emerson. The St. Helena material differs from all previously mentioned *Thalamoporella* in possessing no avicularia whatsoever. While small fragments of *Thalamoporella* sp. have been found occasionally which lack both ovicells and avicularia, larger fragments have possessed at least a few avicularia. In the location at which the avicularia would be expected to occur, at the beginning of new row, the zooecia of the St. Helena material appear to be simply large chambers covered by the ectocyst but having no cryptocyst, operculum, or polypide tube. Numerous ovicells occur which are large, erect and bilobate in formation, so the colony can be considered mature. In colony fragments crushed in distilled water and spread for examining, only compasses were seen in the first material examined.

Marcus (1938a:204) mentioned briefly and figured in his paper on the Bryozoa of St. Helena a small specimen which appears to be similar to the new material. His illustration, however, shows an approximately equal number of compasses and bows or calipers. Marcus did not name the species at the time but indicated that he considered it to be new. His specimen lacked both ovicells and avicularia. ("Deshalb muss sie unbenannt bleiben, obgleich sie fast sicher neu ist.")

In 1939, Marcus described at length a new species which he named *Thalamoporella evelinae*, collected at Bahia de Santos in Brazil. The description appears to be identical to the St. Helena fragment he had previously mentioned, and similar to our present material, except that his figures now show compasses only and he remarks that the calipers are extremely rare. A considerable amount of the new St. Helena material was crushed, and finally a single caliper was revealed thus confirming that they are indeed rare, and that the 1938 illustration is highly misleading. It is fortunate that a good quantity of material made possible the sacrificing of a large enough portion to make that determination. The question also arises as to whether other species which have been stated to possess compasses only might not have a few calipers hidden away if only a sufficient quantity were available for sacrifice.

The obvious absence of avicularia in *Thalamoporella evelinae* necessitates that the criteria for identifying members of the family Thalamoporellidae be revised, although Marcus made no mention of establishing a key to the species which would include this characteristic. Harmer (1926), Buge (1957), and Osborn (1950) have all based their method of identification on the nature of the avicularia.

The family Thalamoporellidae as presently constructed contains only the single genus *Thalamoporella*. This is also the only group which shows the peculiar compasses and calipers, and as such is undoubtedly the correct genus for this Brazilian material and for the colonies from St. Helena. Marcus (1937) reported that 38.7% of the species in Dr. Mortensen's collections from St. Helena were represented in his Brazilian collections. This is not an unexpected situation since both are in the tropical latitudes of the South Atlantic, with both the South Equatorial current and the Southeast Trade Winds flowing in a direction toward the Brazilian coast from the general area of St. Helena.

Two types of *Thalamoporella* commonly occur in the Eastern Pacific, *Thalamoporella gothica* (Busk), 1856, and *Thalamoporella californica* (Levinsen), 1909. *T. gothica*, first described as *Membranipora gothica* by Busk in 1856 has been synonymized with Levinsen's *T. rozieri*, var. *D.* (*gothica*), 1909, according to Osburn, 1950.

Thalamoporella gothica is distinguished as being erect, branching, or encrusting. Zooecia are large (1.0 mm.) and the perforated cryptocyst covers most of the frontal, descending to the dorsal wall at the opesiules. There are two unequally sized foramina lying on either side of the polypide tube through which the muscles to the transparent ectocyst pass. The aperture is closed by a thin, chitinous operculum which is continuous proximally with the ectocyst and is reinforced with a heavier chitinous rim and a narrow sclerite. The aperture is sinuate on the proximal border with occasional adoral tubercles. The inter-zooecial avicularia are large, with the rostrum elevated and shaped like a gothic arch. The sclerites are straight, joining in a triangle near the tip of the beak. Both caliper and compass-shaped spicules are abundant.

T. californica was renamed by Hastings (1930) from another of Levinsen's varieties of *T. rozieri*, variety *californica*, 1909. The colony may be encrusting or rise in erect, jointed stems. Zooecia are smaller than those of *T. gothica*, usually about 0.5 to 0.65 mm. The perforate crytocyst extends forward over most of the length of the frontal. Two unequal opesiules lie one on either side of the polypide tube, with one wall descending to the dorsal surface. The aperture is rounded with a curved proximal border, not sinuate. The operculum is thin with a broad chitinized border and incomplete sclerites proximally. Adoral tuburcles may be short or tall, blunt or thin, or lacking.

Large interzooecial avicularia are located at the beginning of a series of zooecia with the mandible elongate, variable in form. Spic-

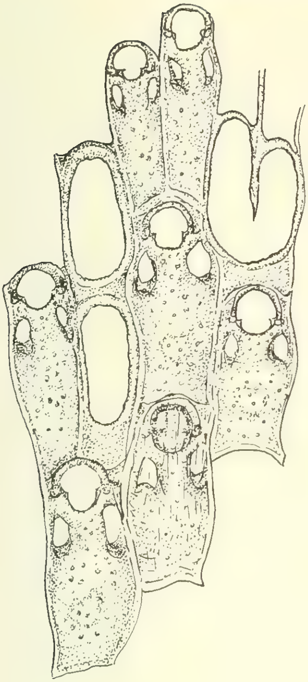

FIG. 1

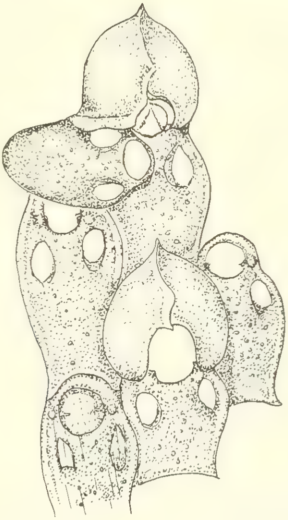

FIG. 2

Figure 1. Thalamoporella evelinae, part of a colony showing undeveloped zooecia at the beginning of new rows.

Figure 2. Thalamoporella evelinae, zooecia with typical ovicells. Note the ancestrula that has settled partly within the hood of one of the ovicells.

ules are all curved calipers. Ooecia are typical of Thalamoporellidae; large, bilobate, prominent.

These two species may be compared with the descriptions of *Thalamoporella evelinae* Marcus 1939. *Thalamoporella evelinae* may encrust on algae and shells, or form erect layers. The zooecia are arranged in straight series. The frontal is flat and covered with a cuticle, with small tubercles in the adoral areas. The granular frontal cryptocyst has pores in the central region. The two opesiules are asymetrical, with both inserted on the basal wall in most cases, thus forming a complete polypide tube. (Os zóecios dispostos em series longitudinaes. . . . . Olado frontal é plano e se acha coberto pela cuticula . . . os tuberculos pequenos olas areas adoraes. . . . As duas opesiules são asymetricas, attingindo, na maioria dos casos ambas a pareda basal. . . . D'este modo, forma se tubo completo em redor da bainha tentacular.)

The aperture is almost round, with the operculum reinforced on the sides and base. Marcus indicates that the basal sclerites at times completely or almost unite in the center (. . . a escleritos basaes muitos vezes completa ou approximadamente unidos no centro.) The basal sclerites are not generally this large in our St. Helena material. The internal spicules are almost exclusively "compasses," with "calipers" being rare. Avicularia are lacking and in the interzooecial spaces where a longitudinal series divides are zooecia that are frequently aberrent, lacking in operculum, polypide and crytocyst.

The size of the St. Helena zooecia is about 575 μ long and 230 μ wide. The ovicells on the present St. Helena material are typical of Thalamoporellidae in being large, shiny, bilobate structures, with the operculum shaped like a Moorish arch and reinforced by double sclerites. At the median suture of the imperforate hood, keels may arise as though the two halves had overgrown upon meeting (See Fig. 2). A few of these showed that an ancestrula had apparently attached while still only partially extruded from the chamber. Ovicells measure about 570 μ in length and about 450 μ in width at the widest part of the hood.

On the basis of Marcus' work (1937, 1938, 1939) it would appear that the species which occurs at St. Helena in quantity is probably *Thalamoporella evelinae*, although certain minor differences are seen. The opercular sclerites are smaller, and the cryptocyst bears pores evenly distributed instead of being limited to the central area as indicated by Marcus in *T. evelinae.*

Marcus (1937:53,54; 1938) identified as *Thalamoporella gothica* (Busk) var. *prominens* (Levinsen), specimens collected at Bahia de Santos which lacked avicularia and possessed similar aberrent zooecia. However, he indicated approximately equal proportions of calipers and compasses, as he did in his first mention of his new species from St. Helena. It is difficult then to determine upon what basis he identified *T. gothica* var. *prominens* since its most definitive characteristic is its large, rounded avicularia.

It seems obvious then that Thalamoporellidae exist which have not developed the specialized avicularia in the usual position at the beginning of a bifurcating row. This would indicate that the family and generic descriptions should be so modified, and this situation taken into consideration in developing keys to the species.

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A NEW SNAKEFLY FROM SOUTHERN CALIFORNIA (NEUROPTERA: RAPHIDIIDAE)

R. S. Woglum
705 Arden Road
Pasadena, California

and

E. A. McGregor
128 South Washington Avenue
Whittier, California

Information previously gained by the study of two species of snakeflies (Woglum and McGregor, 1958, 1959) led to a continuing interest in this group. The study of some specimens collected by P. H. Timberlake on May 1, 1959, near the Chuchupate Ranger Station, Ventura County, California stimulated further collecting in this area. On June 26, 1962, Woglum collected several specimens at Mill Potrero, Kern County, near the north base of Mt. Pinos. On July 1, 1963, while collecting with Dr. Thomas S. Acker, snakeflies were found to occur commonly in this Mill Potrero area. One species was especially numerous on buckthorn (*Rhamnus* sp.) and on mountain lilac (*Ceanothus* sp.). On examination, this species proved to be new, and its description follows.

Agulla nigrinotum, new species

Figure 1

Male: Length of forewing 8.5-9.5 mm.; width 3.0-3.5 mm.; pterostigma four times as long as wide, length 1.4-1.6 mm., color brown. Wing veins dark brown to black. Head black, its markings usually indistinct as in *bicolor* and *astuta*; clypeus dark red-brown posteriorly, yellowish-brown anteriorly. First antennal segment black, darker than second segment. Pronotum bicolored, black except for the narrow, light reddish-brown anterior, collar-like area, usually less than 0.50 mm. wide, and not exceeding 1/10 the length of the notum, at times reduced to merely a small marginal border. The rest of the thorax and abdomen dark brown to black; some sclerites margined with yellow. The sternites with posterior margin narrowly yellow. Legs with femora black.

Previous students of the Neuroptera found the male terminalia to be of special importance in the taxonomic study of these insects. In the species here discussed the epiproct (f) is hood-shaped, and of

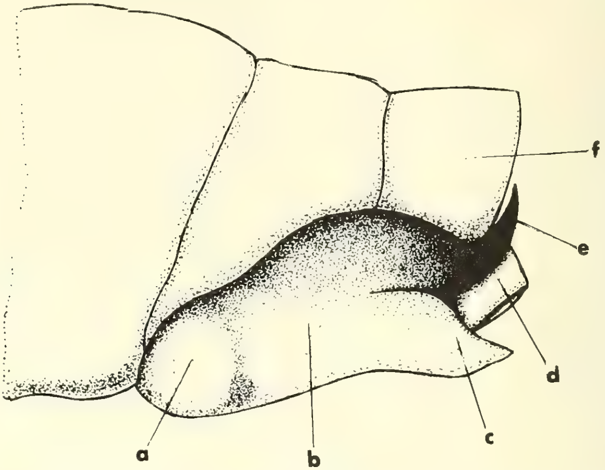

Figure 1. Caudal portion of abdomen of male, viewed laterally, containing the genital chamber. (a) anterior bulbous swelling of harpogon; (b) harpogon; (c) posterio-ventral toe-like lobe; (d) aedeagus; (e) style; (f) epiproct.

light brown color posteriorly. The harpogones (b) are somewhat foot-shaped, with a bulbous heel-like (a) anterior, and with the posterior projecting as a pointed toe-like process (c), occupying the usual position of the style (e) which, in the present species, lies proximad to the "toe." The style is black. The aedeagus (d) usually extends beyond the tip of the harpogones, and is exposed medially by their wide separation. The species is unique in that the parameres are entirely absent.

Female: Forewing 9.0-10 mm. in length, its color and structure simulate that of the male.

Holotype: (male): Mill Potrero, Kern County, California, July 1, 1963 (R. S. Woglum). In California Academy of Sciences, San Francisco.

Allotype: (female): Collecting data same as for holotype. In California Academy of Sciences, San Francisco.

Paratypes: (20 males and 20 females): Collecting data same as for holotype. In the collection of R. S. Woglum.

Two males and one female collected at Chuchupate Ranger Station, Ventura County, California, May 1, 1959 (P. H. Timberlake).

Two males and two females collected at Victorville, San Bernardino County, California, April 21, 1935 (P. H. Timberlake). In University of California, Riverside.

Two females collected at Walker Pass, Kern County, California, May 26, 1946 (E. C. Van Dyke). In California Academy of Sciences, San Francisco.

Two males and two females collected San Francisquito Canyon, Los Angeles County, March 28, 1959 (Menke and Stange). In Los Angeles County Museum.

Agulla nigrinotum is readily distinguished from other species of the genus. The notum is uniformly black except for the very narrow reddish-brown anterior margin. The black posterior of the bicolored pronotum extends much further toward the front than usual. *Agulla distincta* is the only other species in the genus having a very narrow anterior collar, but it differs conspicuously by its very different type of stigma and epiproct.

A. nigrinotum is entirely lacking in parameres. The only other known *Agulla*, usually lacking parameres, is *unicolor* in which, according to Carpenter, parameres are present in about five per cent of the males. However, the notum in *unicolor* is uniformly reddish-brown—very different from the black notum of *nigrinotum*.

The present species has been collected commonly in association with *A. bicolor*. Specimens of *nigrinotum* have been collected from late March to mid-July.

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RESIGNATION OF DR. WILLIAM DWIGHT PIERCE

The resignation of Dr. W. Dwight Pierce from the Treasurership of the Southern California Academy of Sciences after long years of efficient service leads us to a recording of the debt which the Academy owes for his multiple activities in its behalf.

Dr. Pierce was appointed Curator of Entomology at the Los Angeles County Museum in 1937, and in the same year joined the Academy.

He was elected to the Advisory Board in 1940, and to the Board of Directors in 1941.

He served as President from 1943 to 1945, was made a Fellow in 1946, and became Treasurer in 1948. At that time the assets of the Academy were just under $25,000.00. During his years in office they have nearly quadrupled, due in no small measure to his financial sagacity.

Dr. Pierce will be missed in active Academy affairs, but he will continue to remain active at the Museum in Paleoentomology and available for frequent consultation in matters related to the Academy.

JOHN ADAMS COMSTOCK

THREE SCARABAEID GENERA FOUND IN NESTS OF *FORMICA OBSCURIPES* FOREL IN COLORADO

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INTRODUCTION

While collecting myrmecophiles in recent months, this author has experienced one of the great thrills in entomology today. Myrmecophily is the fascinating study of symbiosis between ants and their guests. Excitement comes from the experience of finding many species of organisms in a variety of symbiotic relationships with ant hosts. The collections reported here were made in El Paso, Park and Teller Counties of Colorado in the following biotic communities: short-grass prairie, Spruce-fir forest and Ponderosa pine forest respectively.

Myrmecophily has been devoid of a major monographic work, but the phenomenon has been recorded since 1818. The first work of real significance was by E. Wasmann (1894), while the most substantial recent work showing the scope of the subject was by W. M. Wheeler (1960). Other workers have contributed to the field in papers on the family, the genus, or a few species they have studied. The record is still a scattered one from the standpoint of life history, mimicry, degree of symbiosis and geographic distribution of most myrmecophiles. Some host life histories and distributions are unknown and difficult to work out (Gregg, 1963).

The purpose of this paper is to report one family of myrmecophiles, the Scarabaeidae, found inside the nests of one host ant, *Formica obscuripes* Forel in Colorado. The Scarabaeidae are known to most collectors in ecological niches other than that of an ant nest.

OBSERVATIONS

The thatch ant, *Formica obscuripes* Forel, is a conspicuous part of the Colorado ant fauna. Nests can be found with ease, from the plains to the high altitude Spruce-fir forest, by looking for piles of thatch covering the main galleries and entrances. This species uses pine needles, dry grass, and small twigs. Usually many seeds of *Yucca* are included in the thatch and in the food refuse piles. The workers have paths, free of obstructing vegetation, leading from the nest to nearby food collection sites.

When the nest is located, the problem is to collect symbionts without being irritated or distracted by hundreds of angry ants. Chemical efforts to immobilize the host ants have not been successful. I decided that if ant lions (Neuroptera- Myrmeleonidae) were successful using a pit, then it might work for excavation of ant colonies for myrmecophiles. A steep sided moat-like pit was maintained between the ant colony and the collector.

Three Scarabaeid beetles were found with *Formica obscuripes* Forel in Colorado. *Cremastocheilus wheeleri* LeConte was found as expected according to Wheeler (1960) and Cazier (1961). This guest, I would say, was typical in nests of this host ant, but not abundant in any nest. Both larvae and adults were encountered alive in thatch ant nests.

Euphoria inda Linnaeus was an unexpected find in some respects. This is a new record with *F. obscuripes*. Another facet of this record is the high density of this species in certain nests. Only the grubs were found. This species of scarab was not as common in nests as was *Cremastocheilus*.

Euphoriaspis hirtipes (Horn) was the third scarab genus found with thatch ants. Both grubs and adults were collected in the nests. Dr. O. L. Cartwright (In Litt.) claims this is a new record geographically. Previously, *Euphoriaspis hirtipes* was recorded east of Colorado in Dodge County, Nebraska.

Discussion

The genus *Euphoria* was claimed by Wheeler to be a "neutral synoekete" in a very controversial classification scheme of Wasmann's. These beetles do not mimic their host, but they get along without being preyed upon by *Formica* by possessing a tough integument (as adults at least). These beetles are neutral because they pay no attention to the host. *Euphoria* is interested in the refuse pile in the nest.

The genus *Euphoriaspis* has no previous record with ants. I would guess, from my field study, that these beetles are neutral and live on refuse piles. *Euphoriaspis* shows no obvious mimicry of their host.

Cremastocheilus has quite a reputation as a symbiont with various ants. Wheeler classifies this genus as a "true symphile." An observer notices immediate morphological mimicry which sets this genus aside from other scarab beetles. The beetles in the genus *Cremastocheilus* may exhibit tufts of hair (termed trichomes), modified an-

TABLE I. Guests of *F. obscuripes* Forel

Sample #	*Locality*	*Guests*
6307223	Chestnut-Greenridge site, Colo. Spgs, Colo. El Paso County.	none
6307262	Garden of the Gods Rd., El Paso Co., Colo.	1. *Euphoria inda* L. (32 grubs—3rd. stage) 2. *Euphoriaspis hirtipes* (Horn) (5 adults)
6307263	Garden of the Gods Rd.	1. *Anthicus* sp. adult 2. Silverfish (Thysanura) 3. Tenebrionid larvae (3) 4. Tenebrionid adults—1 sp. 5. Carabid adult—1 sp.
6307271	Garden of the Gods Rd.	1. Asilid adult flew on the excavated mound 2. Ant lion adults flying over the mound area 3. *Euphoria inda* L. (7 grubs—3rd. stage) 4. *Cremastocheilus wheeleri* LeConte adult 5. *Euphoriaspis hirtipes* (Horn) 8 adults
6406261	E. Constitution at C.R.I.&P.R.R. tracks, E. Colo Spgs., Colo. El Paso Co.	1. *Cremastocheilus wheeleri* LeConte adult 2. *Euphoriaspis hirtipes* (Horn) 4 dead adults 3. Tenebrionid larva 4. Beetle pupa
6406282	Eleven Mile Can., Park Co., Colo.	1. Carabid beetles 2. Phorid larva (Diptea: Phoridae)
6407083	Garden of the Gods Rd.	none
6407112	Garden of the Gods Rd.	none
6407112	Manitou Park, Manitou Exp. For. Pike N.F., Teller Co., Colo.	1. small gray spiders 2. small Staphylinids 3. Carabid beetles
6407113	Manitou Park, Teller Co., Colo.	1. *Cremastocheilus wheeleri* LeConte grubs 2. Beetle larvae—2 sp.
6407114	Manitou Park, Teller Co., Colo.	1. *Cremastocheilus wheeleri* LeConte adult

tennae and/or modified mouthparts. Wheeler claimed these features are indicative of the close symbiotic relationship these beetles share with their ant host.

Dr. Mont A. Cazier has contributed the most to the present knowledge of the genus *Cremastocheilus*. He has made valuable field observations of the beetles entering and leaving the nest, the host ants urging beetles in and out of the nest from some distance, and has compiled the only list of host ants that associate with species of *Cremastocheilus* (Cazier and Statham 1962). No hostility of the host was shown in my field work. Larvae were, however, seized by the ants when the nest was disturbed. This may not be an act of hostility, since there are records of guests being protected by the host during times of stress. The guest larvae, in some cases, are carried to safety with the ant larvae. No dead larvae or adults of *Cremastocheilus* were found in my work. Cazier (1961) is unwilling to make the generalizations that Wheeler makes in regards to the relationships between these beetles and their host; I prefer to take the same cautious view until far more is known.

Euphoria and *Euphoriaspis* were found only in short-grass prairie area nests while *Cremastocheilus* was found in nests from the upper altitude range (Spruce-fir community) nests down to the low altitude nests. This may suggest a difference in ecological amplitude among the guests of a single host species of ant.

Acknowledgments

Gratitude is expressed to F. Martin Brown of Fountain Valley School, Colorado Springs, Colorado, for inspiration and direction of this project. The adult Scarab beetles were identified by O. L. Cartwright of the U.S. National Museum. The larvae of the scarabaeid specimens were worked out by Paul O. Ritcher, head of Entomology at Oregon State University.

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The Southern California Academy of Sciences met nine times during the fiscal year 1963-64. Eight of these meetings were at the Los Angeles County Museum, and the Annual Meeting was held at San Fernando Valley State College, Northridge. The Section on Earth Sciences held several meetings at different schools in the area.

The following talks were presented at the monthly meetings: The Earth Sciences Section, on September 20, 1963, presented Mr. Raymond M. Alf of the Webb School, Claremont, who spoke on "Precambrian Life." The Botany Section, on October 18, 1963, heard Dr. Takashi Hoshizaki, Aerospace Center, U.C.L.A., talk about "Space, Gravity and Plants." On November 15, 1963, Dr. Philip A. Adams, of California State College at Fullerton, discussed "The Biology of Warm-blooded Insects," sponsored by the Intervebrate Zoology Section. The Section on Experimental Biology presented Dr. Bernard O. Phinney, of U.C.L.A., who gave the talk "The Hormonal Regulation of Growth," on January 17, 1964. Dr. Bayard H. Brattstrom, California State College at Fullerton, discussed "Barcena Volcano, 1952; A Ten Year Report on the Repopulation of San Benedicto Island, Mexico," on February 21, 1964, to the Section on Vertebrate Zoology. The Section on Anthropology met March 20, 1964, and heard a talk by Dr. James Moriarity, of Scripps Institute of Oceanography, on "Underwater Archaeology." The Section of the Junior Academy met on April 17, 1964, and four students, Judith Goldman, James Jengo, Terrance Davidson and Peter Walstrom, presented short talks on their research.

The Board of Directors and Advisory Board met on May 1, 1964, to hear reports and elect officers for 1964-1965.

The Fourth Annual Meeting was held at San Fernando Valley State College, Northridge, on May 16, 1964. More than 150 people attended the scientific sessions, including the general session with 21 papers and three symposia with 14 papers presented. Twelve of those presenting papers were students.

The papers presented were:

GENERAL SESSIONS (*Student papers)

"Ecological Studies on a Deep Reef in Santa Monica Bay." Robert R. Given (speaker), Charles H. Turner, and Earl E. Ebert (State of Calif. Dept. of Fish and Game).

*"Some Observations on *Gigantocypris in the Antarctic*." John Tibbs (Univ. So. Calif., Allan Hancock Foundation).

"Seasonal Shift in the Geographical Location of the Pelagic Polychaete *Tomopteris septentrionalis*." Stephen R. Geiger (Univ. So. Calif.).

"Observations on Marine Algal Depauperation in the Tropical Eastern Pacific," E. Yale Dawson (Natural History Museum, San Diego, Calif.).

"Survey of Myocardial Proteins in Dogs of Various Ages." Harry Sobel (speaker), H. Thomas and R. Masserman (Veterans Administration Hospital, Sepulveda and St. Joseph Hospital, Burbank, Calif.).

"Specific Genetic Control of Life Span." H. Everett Hrubant (Calif. State College at Long Beach).

*"Investigation of a Putative Polygenic System Modifying the Expression of a Mutant at the *Dumpy* Locus in *Drosophila melanogaster*." J. H. Asher, Jr. (speaker) and R. A. Kroman (Calif. State College at Long Beach).

*"A Histological and Cytological Study on the Digestive Tract of *Limnoria tripunctata* Menzies." Dean Bok (Calif. State College at Long Beach).

*"Electrophoretic Polymorphism of Hemoglobin of the Bluefin Tuna, *Thunnus thynnus*." William Burton (Calif. State College at Long Beach).

"Pacific Gray Whale Census, 1961-64." Robert L. Eberhardt (speaker) and William Kielhorn (Lockheed-Calif. Co., Ocean Systems Staff, Burbank, Calif.).

"The Ear of the Elephant as a Heat Exchange Device." Bayard H. Brattstrom (Calif. State College at Fullerton).

"Rate of Thermal Acclimation in the Mexican Salamander *Chiropterotriton*." Phil Regal (Univ. Calif., Los Angeles) and Bayard H. Brattstrom (speaker) (Calif. State College at Fullerton).

"Bioluminescent Behavior in the Midshipman *Porichthys notatus*." Jules Crane (Cerritos College, Norwalk).

*"Social Behavior in Mollies: *Mollienisia latipinna*." James R. Des Lauriers (Calif. State College at Fullerton).

*"The Albacore Pineal as a Possible Photoreceptor Complex: A Microscopic Study." Thomas R. Anderson (Calif. State College at Long Beach).

"A Tremarctine Bear from the Pleistocene of the Western Colorado Desert, California." Theodore Downs (Los Angeles County Museum).

"Fossil Hammerhead Sharks' Teeth from California." Shelton P. Applegate (Los Angeles County Museum).

*"A New Miocene Mammal Fauna from Boron, California." David P. Whistler (Riverside, Calif.).

*"Late Pleistocene History of West Anacapa Island, California." Jere H. Lipps (Univ. Calif. at Los Angeles).

*"Geology and Paleontology of a Portion of the Manix Basin Deposits, San Bernardino County, California." George T. Jefferson (Riverside, Calif.).

*"Stratigraphy of the Cambrian Carrara Formation of the Death Valley Region." Edmond E. Bates, Jr. (Univ. Calif. at Los Angeles).

SYMPOSIA

REPETITIVE COLLECTING AND LONG-TERM SAMPLING IN DESERT ECOLOGICAL STUDIES

"Comparative Results of Repetitive Sampling of Reptiles in California and Colorado." Benjamin H. Banta (Colorado College, Colorado Springs, Colorado).

"Can Trap Studies at the Nevada Nuclear Test Site." Dorald M. Allred (Brigham Young University, Provo, Utah).

"Analysis of Chigger-Lizard Relationships Utilizing Long-term Sampling Methods." Richard B. Loomis (Calif. State College at Long Beach).

"The Sampling of Terrestrial Invertebrates by Means of Pitfalls and Other Traps." Elbert L. Sleeper (Calif. State College at Long Beach).

"Long-term Study of *Uta stansburiana* in Joshua Tree National Monument, Utilizing Can Traps." Robert C. Stephens (El Camino College).

*"An Ecological Study of *Cnemidophorus tigris* in the Mojave Desert." W. Leon Hunter (Barstow, California).

*"Homing and Home Range in Desert Reptiles." Peter Spoecker (San Fernando Valley State College).

THE BIOLOGY OF *SCHIZOTRYPANUM (TRYPANOSOMA) CRUZI*, THE CHAGAS DISEASE ORGANISM

Sponsored by the Southern California Society of Parasitologists

"Chagas' Trypanosome: The California Zoonosis in Arthropods and Chordates." Sherwin F. Wood (Los Angeles City College).

"Physiological Experiments with *Schizotrypanum cruzi*." Yost U. Amrein (Pomona College).

"What Kissing Bug Bites Beget." Robert L. Swezey (Los Angeles).

THE USE OF THE OPOSSUM AS A RESEARCH ANIMAL

"Utilization of the Opossum Embryo for Research." Milo B. Brooks (Child Amputee Prosthetis Project, UCLA Medical Center).

"Hematological Aspects of Opossum Embryo." Mathew Block (University of Colorado Medical School).

"EEG During Feigned Sleep in the Opossum." Allen C. Norton (speaker). A. V. Beren and G. A. Misrahy (Childrens Hospital of Los Angeles).

"Research on Living Marsupial Embryos." Dale Carpenter (Bioastronautics Department, Marquart Corporation).

Ninety-seven members and guests attended the Annual Dinner Meeting which was held in the Banquet Room of the College Cafeteria at San Fernando Valley State College. Dr. Reid Macdonald, of the Los Angeles County Museum, gave a talk on "The History and Exploration of the Big Badlands of South Dakota."

The following members were elected Fellows of the Academy: Mr. Raymond M. Alf, Webb School, Claremont; Dr. Malcolm C. McKenna, American Museum of Natural History, New York; Dr. Charles A. McLaughlin, Los Angeles County Museum; and Dr. Richard H. Tedford, University of California at Riverside.

Winners of the Student Awards were: first prize of $35.00 to Mr. Jere Lipps and second prize ($15.00) to Mr. James R. Des Lauriers.

Two grants provided by AAAS were awarded to Mr. Jules Crane and Mr. David P. Whistler.

Thanks are extended to Dr. James A. Peters, chairman of the local committee and to other faculty members and students of the Department of Biology at San Fernando State College for their help in making this meeting so successful.

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Vol. 64 JANUARY-MARCH, 1965 PART 1

A NEW MIOCENE TORTOISE FROM SOUTHERN CALIFORNIA

JAMES R. DES LAURIERS
California State College at Fullerton
Fullerton, California

In 1940 eight specimens of a Miocene tortoise were found in Barstovian aged deposits of Cajon Pass, San Bernardino County, California. This material has remained unexamined in the collection of the Los Angeles County Museum (LACM) until now.

I wish to thank Dr. Theodore Downs, Los Angeles County Museum, for the use of these specimens; and Dr. Bayard H. Brattstrom, California State College at Fullerton, for his guidance and criticism.

Gopherus dehiscus, new species

Figures 1-3

Holotype.—LACM 400(26)/5178 consists of the internal cast of an entire shell except for the anterior lip of the carapace. The bones of the plastron are present as well as most of the peripherals.

Type locality and age—LACM 400(26) Cajon Pass, W. end of Cajon Valley, NW¼ Sec. 1, NE¼ Sec. 2, T3N, R7W, SBB&M. San Antonio quad. ½ mile SW of the hwy. to Big Pines recreation area, San Bernardino Co., Calif.

Diagnosis.—A *Gopherus* closely resembling *G. mohavetus* (Merriam), (see footnote, Table 4) but differing from it in: nuchal scute not much wider than long; the length of the pectoral scute 1/6-1/8 as long as the abdominal along the midline; third vertebral sulcus crossing the fifth neural bone; epiplastral lip protruding very little if at all beyond the anterior edge of the carapace; proneural deeply notched by the first neural; inguinal scute large, so that the abdominal scute does not closely approach the inguinal notch; entoplastron at least as wide as long.

Description of the type.—(Fig. 1) The holotype consists of a small, high domed internal cast with most of the peripherals and the whole

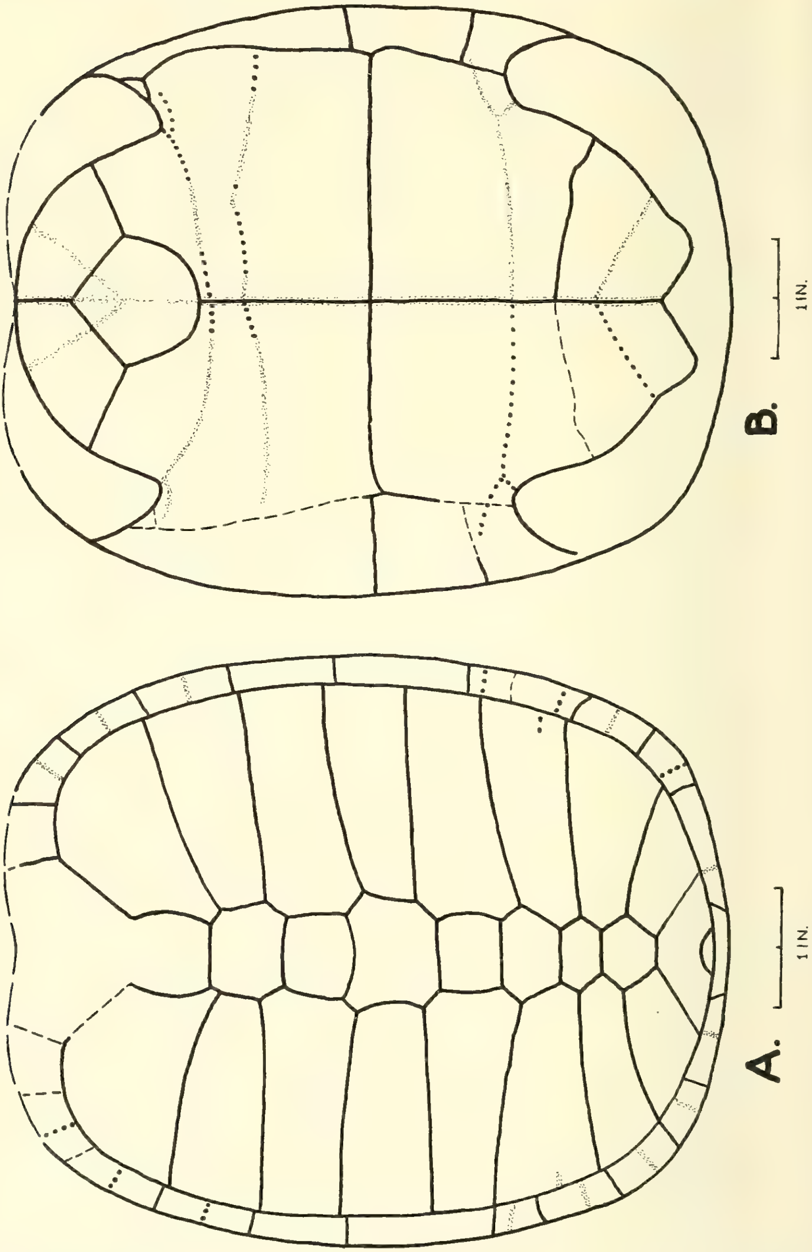

Figure 1A. Dorsal view of carapace of the holotype of *Gopherus dehiscus*, LACM 400(26)/5178. Solid lines: sutures; stippled lines: sulci; broken lines: reconstructed parts; dotted lines: extrapolated sulci. *B.* Ventral view of plastron of the holotype of *Gopherus dehiscus*, LACM 400(26)/5178. Note the abnormal bone in the axillary notch.

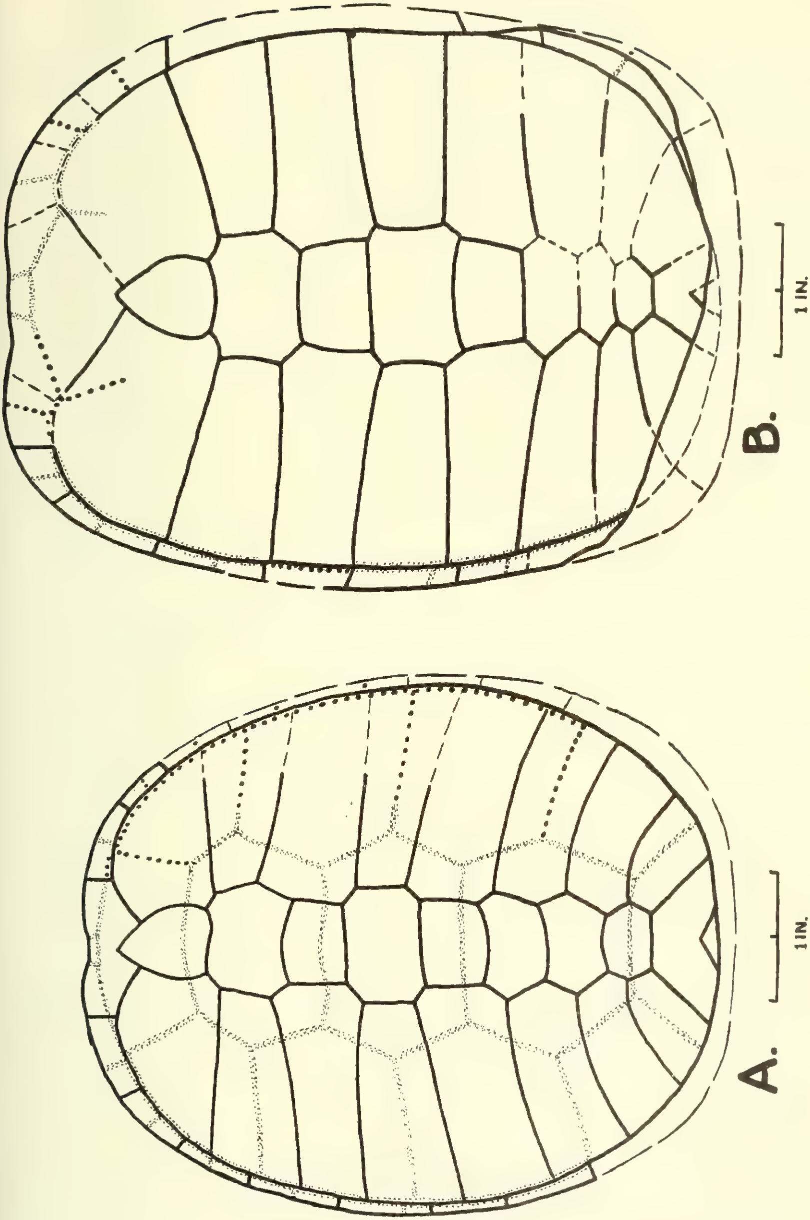

Figure 2A. Dorsal view of carapace of *Gopherus dehiscus*, LACM 400(25)/5182. The position of the peripherals and lateral margins of the shell are reconstructed. *B*. Dorsal view of the carapace of *Gopherus dehiscus*, LACM 400(45B)/5181. Posterior portion of the carapace badly eroded and position of posterior peripherals reconstructed.

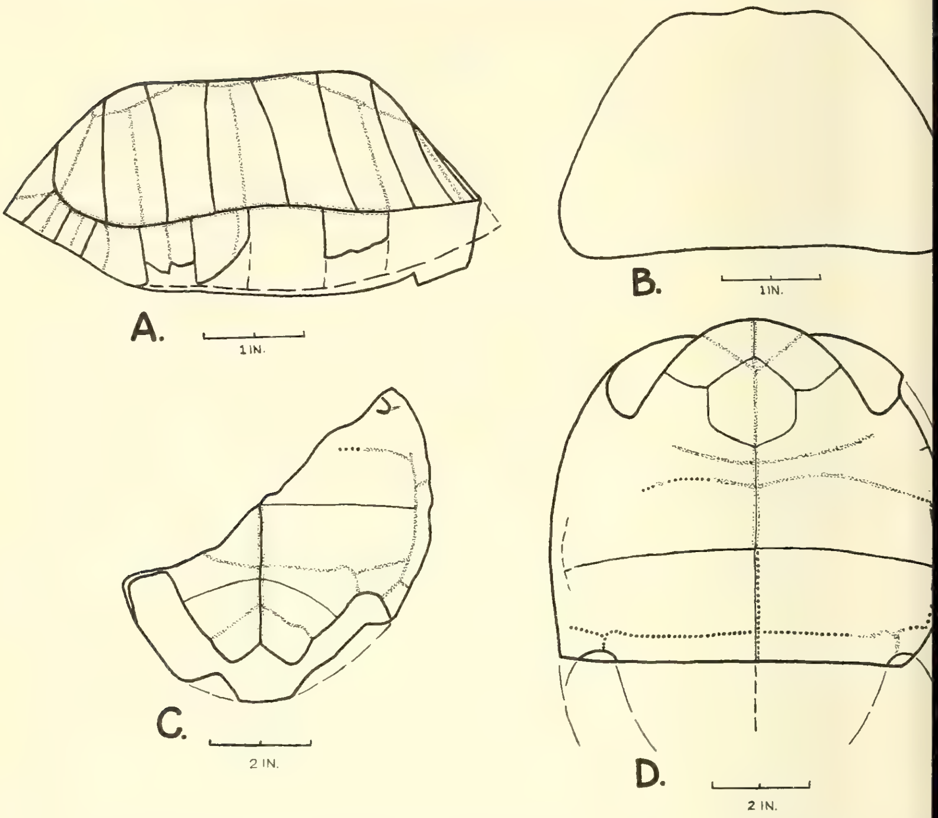

Figure 3A. Left side view of the shell of *Gopherus dehiscus,* LACM 400(25)/5182. *B.* Schematic cross section of *Gopherus dehiscus. C.* Ventral view of the plastron of *Gopherus dehiscus,* LACM 400(26)/5179. *D.* Ventral view of the plastron of *Gopherus dehiscus,* LACM 400(26)/5180.

plastron still present. The fossil is not distorted and the carapace has three dorsal longitudinal ridges (Fig. 3B).

The epiplastral lip does not project beyond the reconstructed carapace, and very little beyond the broken edge of the carapace. The gulo-humeral sulci meet at the midline on the entoplastron; the humeropectoral sulci probably do not touch the entoplastron. The pectoral scute narrows markedly toward the midline. The length of the pectoral scute along the midline is 1/8 that of the abdominal scute. The pectoral scute does not touch the axillary notch due to the presence of a narrow axillary scute. The inguinal scute prevents the abdominal scute from reaching the inguinal notch by contacting the femoral scute. The femoral scute narrows toward the midline.

TABLE 1

Carapace measurements of *G. dehiscus* and *G. mohavetus* (5131) in millimeters

	5178	5182	5181	5183	5184	5185	5131
carapace length*	?153.0	?140.0	?124.0	?216.8	?176.2	—	—
carapace width	127.0	?113.0	?104.0	—	161.5	—	—
central scute one length	—	—	27.5	—	—	—	92.2
central scute one width	—	28.5	?39.0	—	—	—	102.4
proneural length (greatest)	32.7	28.0	24.0	?44.2	—	—	?77.5
proneural length	—	18.0	?21.2	—	—	—	?71.5
proneural width	39.0	37.3	33.8	—	44.8	—	?85.0
neural one length	—	19.6	20.1	30.0	23.8	30.0	—
neural one width	16.6	13.8	14.0	?26.2	19.6	26.5	—
neural two length	18.0	17.7	15.8	25.0	20.0	23.2	—
neural two width	19.5	24.2	21.8	38.2	31.4	38.2	—
neural three length	15.1	14.0	12.0	23.2	20.4	24.0	—
neural three width	17.9	21.9	16.2	?34.5	31.0	32.0	—
nuchal scute length	—	8.0	6.5	—	—	—	?22.2
nuchal scute width	—	8.0	6.8	—	—	—	28.0
pleural one prox. length	22.0	18.5	19.5	27.8	25.5	24.0	—
pleural one distal length	34.5	27.5	?32.0	53.0	35.8	51.5	—
pleural two prox. length	15.2	10.2	6.4	?19.0	12.2	17.0	—
pleural two distal length	21.0	?16.8	20.5	33.8	37.0	33.7	—
pleural three prox. length	21.0	19.4	20.5	18.0	23.0	36.0	—
pleural three distal length	17.0	12.7	15.5	27.2	7.5	25.2	—

*Lengths are measured along the midline unless otherwise indicated.

The anterior edge of the plastral lobe is a smooth curve, without any notch. The entoplastron is slightly wider than long, angular in front and round behind; greatest width 29.0 mm., length on the midline 27.8 mm. The posterior plastral lobe is deeply notched on the midline, there is also a small notch where the femoro-anal sulcus reaches the margin.

The first neural is obviously elongate, even though its anterior portion has been destroyed. The second neural is octagonal; the third, tetragonal; and the fourth, octagonal. The first suprapygal is bifurcate and encloses the second suprapygal laterally. The pygal bone narrows toward the margin and is intermediate in width between the first and second suprapygals as measured along the peripheral suture. Alternate pleurals do not differ much in distal width.

There appears to be an abnormality in this specimen. In the axillary notch there is a small triangular extra bone. Its base is on the margin of the notch and its apex contacts the periphero-hyoplastral suture (Fig. 1B). Measurements of the holotype are presented in Tables 1 and 2.

TABLE 2

Plastron measurements of *G. dehiscus* and *G. mohavetus* (5131, 473) in millimeters

	5178	5182	5181	5183	5184	5185	5131	473**
plastron length*	138.5	122.5	—	—	173.5	—	—	—
plastron length (greatest)	145.0	129.9	—	—	180.9	—	—	—
gular scute length	22.0	?27.0	—	—	—	—	?24.0	—
humeral scute length	?19.9	—	—	—	—	—	—	—
pectoral scute length	?6.9	—	—	45.5	—	14.0	—	—
abdominal scute length	57.8	—	—	42.0	—	74.0	—	—
femoral scute length	17.3	16.3	14.0	12.0	30.7	—	—	—
anal scute length	14.4	12.2	—	15.8	20.0	—	—	—
entoplastron length	27.8	—	—	?42.5	27.2	42.7	78.3	45.5
entoplastron width	29.0	25.3	—	46.2	33.7	46.8	96.9	50.0
epiplastron length	11.6	—	—	—	20.5	7.4	—	—
hyoplastron length	36.8	—	—	—	46.5	51.2	—	—
hypoplastron length	40.8	33.7	—	—	40.0	57.0	—	—
xiphiplastron length	22.9	21.0	—	—	38.7	—	—	—
bridge length	72.0	?55.0	71.8	—	90.5	—	—	—

*Lengths are measured along the midline unless otherwise indicated.

**U.S.G.S. catalogue number.

TABLE 3

Shape of suture between neural one and the proneural.

	straight	slightly curved	pointed
G. dehiscus	—	—	6
G. mohavetus	—	2	—
T. milleri	1	1	1

Auffenberg (pers. comm.) indicates that "distal pleural widths are important in fossil tortoises." Further, the holotype of *G. dehiscus* displays the primitive condition. That is, alternate pleurals do not differ greatly in width. The referred material shows a similar condition with the exception of LACM 400(26)/5184 which shows alternately wide and narrow pleurals.

G. mohavetus shows the advanced condition in regard to this particular character with alternate bones differing greatly in distal width (Merriam 1919: Fig. 4A).

Referred material.—LACM 400(25)/5182, (Fig. 2A) from the same locality as the holotype is a nearly complete carapace. The posterior and all but two right peripherals are missing. Portions of the right pleurals are missing, but the sutures show clearly on the internal cast. Only one small fragment of the plastron remains. The plastral cast is so badly eroded that nothing can be said about the plastron. The complete scute pattern of the carapace is easily discernible. The left front and right rear quarters of the carapace are somewhat pushed toward the center of the shell. The proneural is deeply notched by the first neural. See Tables 1 and 2 for measurements.

LACM 400(45B)/5181, (Fig. 2B) from the same locality as the two preceding specimens. It consists of the complete cast of a small high domed shell. The posterior peripherals are missing. The anterior and left peripherals, and portions of the plastron are present. The carapace has three dorsal longitudinal ridges. The proneural is slightly notched by the first neural. There is no evident distortion in the fossil.

LACM 400(26)/5179, (Fig. 3C); LACM 400(26)/5180, (Fig. 3D) are from the same locality as the holotype and are referred to the same species. LACM 400(26)/5179 measurements: femoral scute, 19.7 mm. long; anal scute length, 21.0 mm.; hypoplas-

TABLE 4

Summary of Barstovian Tortoises of Southern California

Cajon Valley, San Bernardino Co.	Barstow Syncline area, San Bernardino Co.	Tejon Hills, Kern Co.	Cache Peak, Kern Co.
T. milleri	*T. milleri*	*G. mohavetus*	*G. depressus*
LACM 400/7450	UC 21574 (type)[1]	LACM 303/5132	LACM 498/5133 (type)
G. dehiscus	LACM 494/5129		
LACM 400(26)/5178 (type)	LACM 495/5130		
LACM 400(26)/5179	*G. mohavetus**[1]		
LACM 400(26)/5180	UC 21575 (type)		
LACM 400(45B)/5181	LACM 494/5131		
LACM 400(25)/5182	U.S.G.S. 473		
LACM 400(26)/5183	*Stylemys sp*[2]		
LACM 400(26)/5184	LACM 1751/4857		
LACM 400(26)/5185			

*The name *mohavense* does not agree grammatically with *Gopherus*. Herein the name is changed to *Gopherus mohavetus*.

[1] Merriam (1919) based his description of *Testudo mohavense* on specimens UC 21575 (type) and UC 21574. Brattstrom (1961) put *T. mohavense* in *Gopherus* but used UC 21574 as the type of his *Testudo milleri*.

[2] This specimen (A1420, now catalogued LACM 1751/4857) referred to *G. mohavense* by Brattstrom (1961:547) appears, on re-examination by Brattstrom and Des Lauriers, to be incorrectly placed and should be in *Stylemys*.

TABLE 5

Comparison of some characteristics of *G. dehiscus* and *G. mohavetus*

G. dehiscus	*G. mohavetus*
Nuchal scute little wider than long.	Nuchal scute much wider than long.
Pectoral scute 1/6-1/8 as long as abdominal along midline.	Pectoral scute ½-⅓ as long as the abdominal along midline.
Bridge length more than ½ the length of the plastron along midline.	Bridge length less than ½ the plastron length along midline.
Third vertebral sulcus crosses the fifth neural.	Third vertebral sulcus crosses the sixth neural.
Proneural deeply notched by neural one.	Proneural not notched by neural one.
Inguinal scute large.	Inguinal scute small or absent.
Entoplastron wider than long.	Entoplastron longer than wide.
Pleurals do not differ much in distal width.	Pleurals differ markedly in distal width.

tron length, 45.9 mm.; xiphiplastron length 32.8 mm.; bridge length, 99.8 mm. LACM 400(26)/5180 measurements: entoplastron length, 45.1 mm., width, 45.1 mm.; pleural two distal width, 30.8 mm.; pleural three distal width, 27.7 mm.; bridge length, 127.0 mm.(?). Where applicable the above dimensions are taken along the midline.

LACM 400 (26)/5183, 400(26)/5184, 400(26)/5185 all consist of casts from the same locality that are too badly crushed or eroded to be figured, although they all show enough characters to be placed tentatively with *G. dehiscus*. The specfic name, *dehiscus*, is given as a descriptive reference to the peculiar notched shape of the proneural bone.

Relationships.—With *G. dehiscus* and *G. mohavetus* occurring in the same age deposits and within 60 miles of each other, it is appropriate to point out the characters that are used to distinguish the two species, (Tables 3, 5).

Generic assignment of fossil tortoises is made with no evaluation of and with generally poor, often ambiguous characters. This is well borne out by the changes of generic and subgeneric assignment many species have experienced. *G. dehiscus* has been assigned to the genus *Gopherus* on the basis of characters used by Ernest Williams as they appear in Oelrich (1957). Characters in *G. dehiscus* that indicate the genus *Gopherus* are:

a. The high, flattened dome is produced by three longitudinal ridges, (Fig. 3A).
b. The fourth vertebral scute is much wider than long.
c. The vertebral scutes are broader than the length of the lateral scutes.

Discussion.—From the same site a single, tentatively identified, fragmentary specimen of *Testudo milleri* Brattstrom was collected.

Since the Barstovian tortoises of Southern California have been variously renamed and recatalogued, Table 4 is presented in an attempt to clarify any confusion.

SUMMARY

a. A new species of Miocene tortoise, *Gopherus dehiscus*, is described.
b. *G. dehiscus* occurred sympatrically with *Testudo milleri*.
c. The new species resembles *G. mohavetus* of the Barstow syncline area, but differs from it in several characteristics.
d. A summary of Barstovian aged tortoises of Southern California is given.

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THE NESTING STARLING POPULATION IN SAN DIEGO COUNTY, CALIFORNIA

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Since its introduction into New York in 1890, the European Starling, *Sturnus vulgaris*, has been spreading westward. Ornithological journals are liberally sprinkled with reports that the species had reached new areas, and a number of papers have appeared summarizing these scattered references; the most recent is that by Kessel (1953). Despite this, there is little information available on the population buildup in any given locality; a notable exception is the work of Myres (1958) in British Columbia. In most parts of the United States and Canada it is too late for studies of the increase of local Starling populations, as their numbers are already great. In a few areas, however, where the species has but recently begun to nest, enough information is available to document the beginning of the population boom. One such area is San Diego County, California.

This report primarily summarizes the nesting records of the Starling in San Diego County through the season of 1964. Kessel (1953:-63) suggested that the extension of the breeding range of the Starling has been accomplished by colonization by migrant and wandering first-year and non-breeding second-year birds. In view of this suggestion, I have included what information is available concerning winter records for the county. All localities are indicated in Figure 1.

Acknowledgments

I am deeply indebted to many persons for much of the information presented here. Mr. Joseph Dion, of the San Diego County Department of Agriculture, kindly gave me all the records available to him as the result of work by personnel of that department, and permitted me to report on specimens in the department's collection. Mr. Dale T. Wood gathered information from the northern part of the county, and relayed this to me. Mr. R. Guy McCaskie reported freely on his observations from 1962 to 1964. Others who reported to me about nesting Starlings include Dr. Carl Hubbs, Curtis Croulet, and Allan J. Sloan. Some records were taken from the minutes of the Fellows of the San Diego Society of Natural History. The accompanying map was prepared by Wesley M. Farmer.

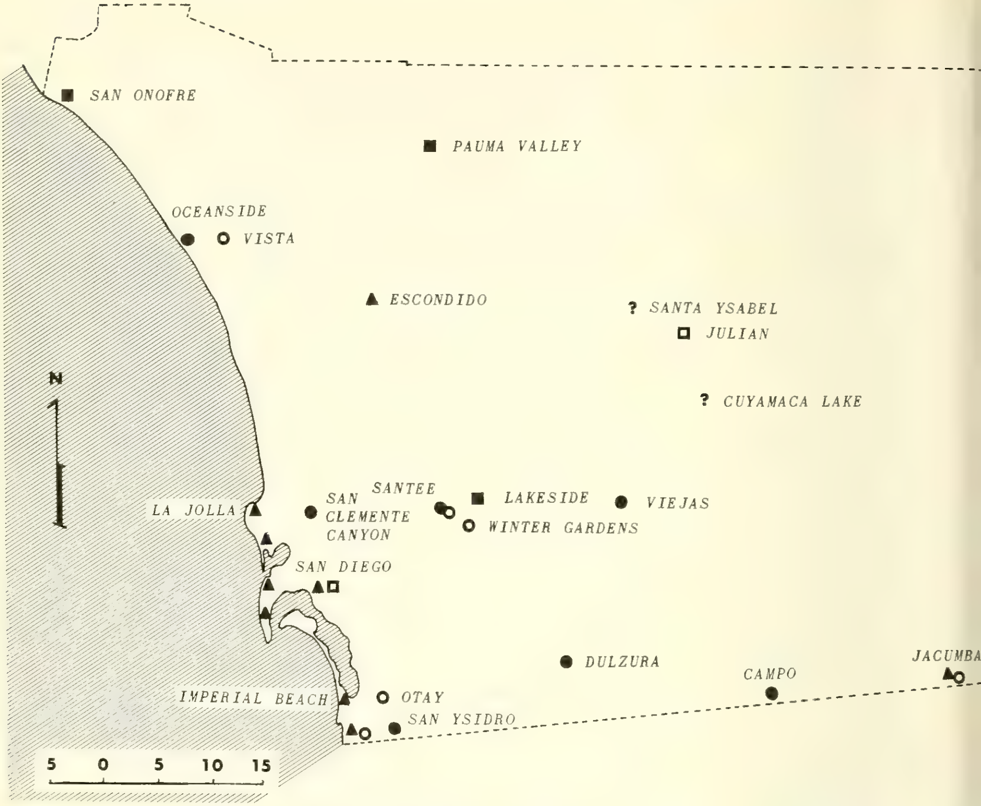

Figure 1. Map of San Diego County, California, showing localities from which Starlings have been reported. Squares represent first records prior to 1962; circles are records reported first in 1962; triangles are localities newly reported in 1963 and 1964. Open symbols represent winter records, and solid ones are breeding records.

WINTER POPULATIONS

The earliest reports of Starlings in the county are, unfortunately, undocumented. Mr. Wood (in litt.) informed me that Morris Burns saw a flock of about 25 Starlings at Julian in the winter of 1948 or 1949. The first published record for the county (Small and Pyle, 1952) was also for the vicinity of Julian, for early October, 1951. No further details are available for either of these reports, and there is a gap of several years before the next recorded occurrence. Two Starlings were seen in downtown San Diego on February 4, 1959 (Stott, 1959).

Records of the County Department of Agriculture show that two specimens were collected at Jacumba in September, 1962. In October, 1962, Mr. Dion's notes indicate that about 125 were seen at Winter Gardens, 35 were observed at Santee, and 250 to 300 were found in the Tia Juana River bed near Imperial Beach. The Department banded 600 or more Starlings that year approximately three miles east of Otay. In the winter season of 1963-64, approximately 300 birds were banded by the Department of Agriculture in the vicinity of Otay.

The species was first reported on an Audubon Christmas Bird Count in 1962, when one was seen in the Oceanside-Vista area (*Aud. Field Notes*, 17:280, 1963). The following year, 128 Starlings were reported on the Christmas Bird Count in that area (*Aud. Field Notes*, 18:311, 1964), and 153 were counted in the San Diego area (*ibid.*, 18:317).

The available data for wintering populations of Starlings indicate a rather sudden appearance, in considerable numbers, in 1962. These figures, however, almost certainly do not reflect the situation accurately. The earlier records, although few and without detail, and the fact that Starlings were already nesting in the county in 1959, suggest that there were large wintering populations in the mid-1950's which were overlooked or not recorded.

Nesting Populations

1959-1961.—Nesting of the Starling is first known from the northwestern corner of the county, at San Onofre. Mr. Kirby Wolfe collected young from a nest there on May 14, 1959, and deposited one specimen in the San Diego Natural History Museum. This bird was apparently only a few days from fledging. Mr. Ken Anderson reported that Starlings were nesting in a cottonwood tree in Lakeside in 1960; three or four birds were present that year. On May 18, 1961, a male and a female were collected near the Pauma Valley Post Office by K. Franklin and T. Escher; these specimens are in the collection of the San Diego County Department of Agriculture.

1962.—There is a large number of records available for this year, mainly due to the efforts of Mr. Dion and his associates. Nesting was noted in the Dulzura area in April; 25 to 30 pairs were sighted, and two specimens were collected. In the same month, eight to ten pairs were observed nesting in the vicinity of Santee. In April and in May, adult birds were seen in both the San Ysidro and Viejas areas.

An adult bird was taken at San Onofre on May 2, 1962; this bird is in the collection of the Department of Agriculture, where there is a record of another specimen, a bird approximately 23 days old, taken at that locality in the same month. Mr. Wood informed me that Morris Burns collected a set of four Starling eggs in Pauma Valley on May 9, 1962. This egg set is currently housed with the J. B. Dixon egg collection at Palomar College.

One specimen was taken and 20 to 25 birds were seen in the Campo area in June. Three immatures were taken as specimens near Santee on June 16. R. Guy McCaskie reported that Starlings were nesting in sycamore trees in San Clemente Canyon, some 10 miles north of San Diego. Mr. Wood saw birds carrying nesting material to a tall fan palm in Oceanside. The population in Lakeside had grown from the original three or four birds to between 30 and 50 birds, according to Mr. Anderson.

1963-1964.—There are three additional records available for 1963. On June 8 of that year I observed at least four Starlings apparently nesting in palm trees in downtown San Diego. A telephone call to the Natural History Museum reported the species in the eastern part of San Diego. McCaskie found them nesting in palms in the Fort Rosecrans National Cemetery on Point Loma, San Diego. The species was also present at the latter locality in 1964, and had perhaps colonized a second nesting site a short distance from the original one.

A number of nesting areas were reported for the first time in 1964. Starlings nested in palms in the Tia Juana River valley near the Baja California border, according to McCaskie, who also saw them entering a hole in a sign board in Imperial Beach. McCaskie further reported them in Ocean Beach, and I saw several carrying food to a group of palms in Pacific Beach on May 7; both localities are in San Diego. The species nested in at least two localities in La Jolla, including the grounds of the Scripps Institution of Oceanography. Mr. Wood reported that two or three pairs apparently nested in Escondido. McCaskie saw them throughout the summer at Jacumba, where they undoubtedly nested.

Starlings were also observed in 1964 in the vicinity of Cuyamaca Lake and at Santa Ysabel, but nesting in those areas was not observed. Reports for the latter locality and for Flinn Springs, east of San Diego, were late in the summer and may have been of postbreeding wanderers.

Despite the records reported here, the timing of nesting in San

Diego County is not well documented. Breeding is probably under way by mid-April, and nesting activity must be nearly concluded by mid-July. A bird found dead in La Jolla on July 30, 1964, is a post-breeding individual with a black bill, molting into the winter plumage. The seventh primary is about half-grown; the eighth has not yet been dropped. Judging from this one individual, the timing of the molt in San Diego County is the same as reported for New York by Kessel (1957:311).

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STUDIES ON CALIFORNIA ANTS.
1. *LEPTOTHORAX HIRTICORNIS* EMERY, A NEW HOST AND DESCRIPTIONS OF THE FEMALE AND ERGATOID MALE (HYMENOPTERA: FORMICIDAE)

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Leptothorax hirticornis is a rare and little known ant not previously recorded from California. When Emery (1895) described this species he had available to him a few workers from Hill City, South Dakota, presumably collected by Titus Ulke in 1890. Wheeler (1915) subsequently redescribed this ant as *L. (Mycothorax) hirticornis formidolosus*, based upon a small series collected on Flagstaff Mt., near Boulder, Colorado; Smith (1939) rightly synonymized this variant with the nominate form. Smith redescribed the worker, described for the first time the worker-like ergatoid female and the queen-like ergatoid female, provided a few additional collection records and recorded *Formica obscuripes* Forel as a host. Described as new was *L. diversipilosus*, a closely related species from Washington, also taken from nests of *F. obscuripes*.

Recently, while examining a collection of miscellaneous ants from California, I discovered a small series of *L. hirticornis* collected at a site 6 miles north of Castle Lake, 4000′, Siskiyou County, California by Dr. J. A. Powell, "from mound of wood ants." Dr. Powell responded to a query by sending a sample of the "wood ants" which proved to be *Formica integroides integroides* Emery.

Specimens of the *Leptothorax* were sent to Dr. Smith who very kindly compared them with original material in the collections of the United States National Museum. Unfortunately, the series there consisted only of ergatoid females not included in my sample. Nevertheless, Dr. Smith concluded my material represented the same species. Specimens from the Wheeler Collection were made available by Dr. E. O. Wilson, and Dr. G. C. Wheeler sent a fine series for comparison. I am very happy to acknowledge the assistance of these gentlemen and of Dr. Smith. Comparison of the two samples with my California specimens indicates that there is no doubt but that they are conspecific. The very slight differences in color and sculpturation are insignificant and can be expected to be fully bridged when more material of this interesting species becomes available.

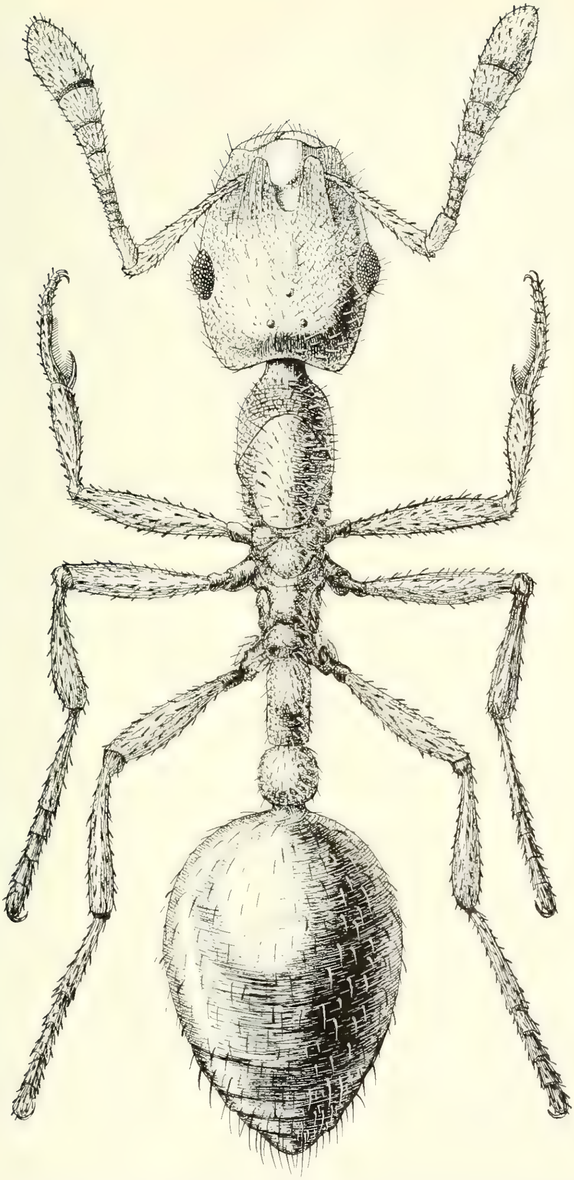

Figure 1. Leptothorax (Mycothorax) hirticornis Emery, deälate female, dorsal view. Drawing by Mrs. Evie Templeton.

Since neither the typical deälate female nor the ergatoid male have been previously described, these are described below.

Deälate female (Fig. 1).—Length 2.9–3.2 mm.

Similar to the worker as redescribed by Smith (1939) but larger, stouter. Similiarly colored. Eyes larger, more convex. Thoracic sclerites normal for female; humeral angles rounded, thorax slightly compressed anterior to wing bases.

Head 0.73 times as wide as long, greatest width at about level of antennal sockets; eyes slightly longer than wide, removed from mandibular base by about 1.6 times their length. Antennal scapes failing to reach occipital margin by a distance about equal to one-fifth their length; first funicular segment slightly longer than following three combined; last three segments forming a moderately well-defined club. Clypeus prominent, convex; anterior border rounded, extending forward beyond the mandibular bases; posterior border extending well above level of antennal insertions; laterally with well-developed carinae, those of disc convergent anteriorly, median area ecarinate. Mandible with well-developed apical and preapical teeth with three smaller, rather widely spaced basal teeth on masticatory border. Epinotum with a pair of blunt, well defined teeth at summit of declivity. Petiole with prominent, blunt basal tooth; postpetiole more convex dorsally than that of worker. Gaster similar to that of worker, when viewed from above first segment occupying almost all of visible surface.

Hairs moderately abundant, whitish, suberect to erect; hairs of scapes mostly subspatulate; hairs of frons, occiput, and outer surfaces of femora and tibiae mostly spatulate; elsewhere simple, except that a few somewhat thickened hairs occur on thoracic dorsum; a few scattered, erect hairs on the eyes.

Head, except clypeus and supraclypeal area, thorax, petiole, postpetiole densely punctate, opaque; scape very finely punctate, opaque; femur and tibia finely punctate, but slightly shining. Clypeal disc and supraclypeal area very obscurely punctate, shining; median frontal line shining, impunctate. Gaster smooth and shining. Sides of head finely carinate, the carinae obsolescent above the eyes; a few faint carinulae on front, ending below level of anterior ocellus. Pronotum with a few fine, irregular, transverse carinae; two or three indistinct carinae on lower, lateral portion of epinotum; petiole and postpetiole without carinae.

The queen closely resembles that of *L. diversipilosus*, but apparently averages slightly smaller; the integument is more densely

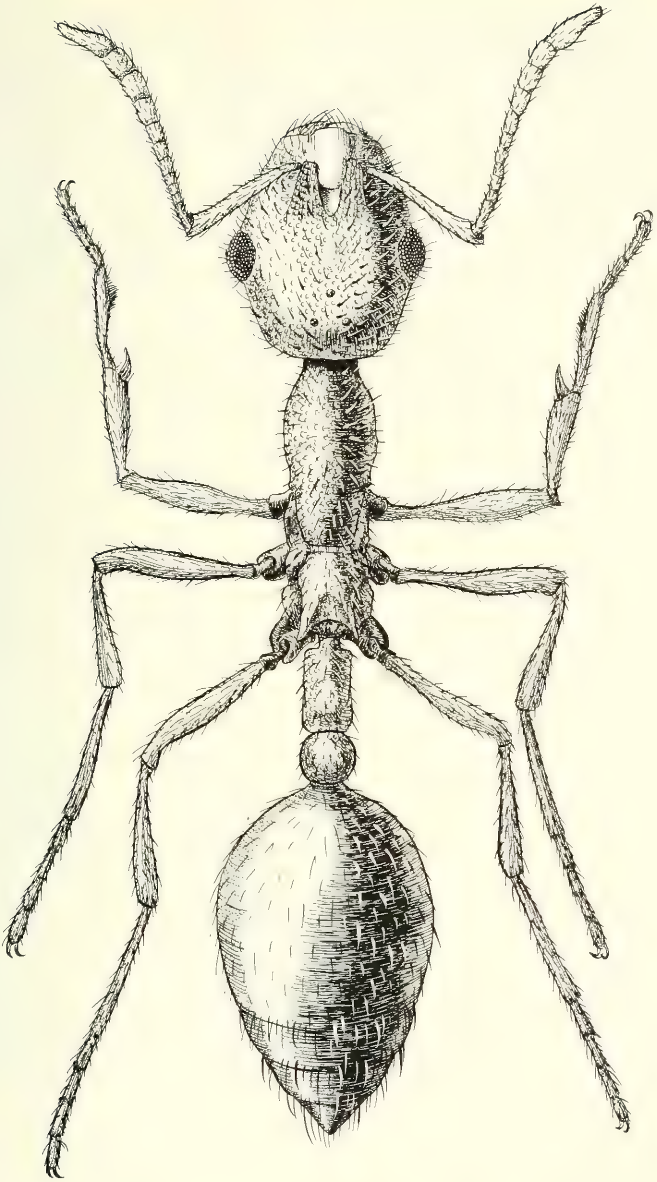

Figure 2. Leptothorax (Mycothorax) hirticornis Emery, ergatoid male, dorsal view. Drawing by Mrs. Evie Templeton.

punctate, hence less shining; fine transverse carinae are present on the pronotum (absent in the one queen of *L. diversipilosus* before me); the longer epinotal spines are directed upward rather than posteriorly; the erect body hairs are sparser, shorter, with a greater percentage of spatulate hairs on the head and appendages.

Ergatoid male (Fig. 2).—Length 2.4—2.7 mm.

Very similar to ergatoid male of *L. diversipilosus* as described by Smith (1956), but differs as follows: sides of head a little more convergent above; first funicular segment about as long as following two combined (Smith's figure of *L. diversipilosus* shows the first somewhat shorter); integument a little duller, more densely punctate; hairs of antennal scapes more reclinate; epinotal spines longer; gaster light brown.

Described from two deälate, two alate females and three ergatoid males. In addition, the series includes four workers.

Smith (1956) has discussed the similarities between the European inquilinous ant, *Formicoxenus nitidulus* (Nylander) and his *L. diversipilosus*. These two species, plus *L. hirticornis* appear to form a closely related complex characterized by a basic similarity of habitus, structure and biology. Smith has pointed out the features of color, sculpture and structure which separate the forms. The first two are of no great importance, and the structural features do not seem so great as to warrant generic separation. According to Smith, *M. nitidulus* possesses a lamellate process beneath the petiole; the distinction between this and the rather large, thin petiolar projection of *L. diversipilosus* and *L. hirticornis* would seem to be merely a matter of degree. The European species does possess a distinct spine beneath the postpetiole, no indication of which occurs in the two American species. It would appear then, that the European species is merely a more highly specialized form of *Leptothorax* closely allied to our American species. No doubt a critical comparison of these forms will result in the synonymy of *Formicoxenus* under *Leptothorax (Mycothorax)*. There certainly would be no justification for separating the American species from their present generic placement.

The two figures were prepared by Mrs. Evie Templeton of the Exhibitions staff of the Los Angeles County Museum, and it is with pleasure that I acknowledge her talented assistance.

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A NEW SPECIES OF SEARSIID FISH, *NORMICHTHYS CAMPBELLI*, FROM THE EASTERN NORTH PACIFIC OCEAN

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The searsiid genus *Normichthys* Parr (1951) previously has been known only from the eastern Atlantic Ocean. Parr (1960) refers four specimens from the tropical east Atlantic to *N. operosa operosa* Parr and described a new subspecies, *N. o. islandica,* based on three specimens from the region between southeast Greenland and Iceland.

In August, 1963, a moderate-sized searsiid fish was collected in the Santa Catalina Basin, southern California. The specimen was readily identified as a member of the genus *Normichthys,* since it lacked body photophores and had three open dermal pits over the top of the shoulder girdle. The single example differs so strikingly from the only other known species, *N. operosa,* that it is described as new. The holotype has been deposited in the fish collections of the Los Angeles County Museum (LACM).

Normichthys campbelli, new species

Figure 1

Holotype: LACM 7068; 98 mm. in standard length (SL); outer Santa Barbara Passage (Santa Catalina Basin), California (approximately 33° 18′ N, 118° 39′ W); R/V *Velero IV* station 8882; 10-foot Isaacs-Kidd midwater trawl; maximum depth of trawl 900 m., between 0825 and 1207 hours; 22 August 1963.

Diagnosis: A *Normichthys* differing from *N. operosa* in the shorter length of the maxillary, the maxillary extends only to a vertical through the pupil of the eye rather than extending behind the pupil; in having 6 or 7 rather than 8 branchiostegal rays; in having fewer gill rakers, 5-6+1+12-14 rather than 7+20-21; in having 8 rather than 6 ventral rays; in having 15 rather than 17 anal rays; and in having fewer transverse, 18-23 rather than 28-29, and longitudinal scale rows, 65-71, rather than 80-90.

Description: Body moderately compressed, tapering only slightly to caudal peduncle; greatest depth immediately anterior to ventral fins, depth tapers gradually from a vertical in front of ventrals to caudal peduncle, caudal peduncle deep; greatest width behind eye on head. Dorsal and anal fins slightly elevated, ventral fins not ele-

Figure 1. Holotype of *Normichthys campbelli*, new species, LACM 7068, 98 mm.standard length.

vated; procurrent rays elevated. Shoulder organ with a well developed base but papillar fleshy tube short and stubby. Three dermal pits present directly over angle of preopercle. Head blunt; a slight muscular hump behind nape; flattened above region of opercular flap and interorbital region, dorsal profile descends in a gentle slope from nape to a vertical in front of eye, descends in an oblique moderately steep slope from anterior margin of orbit to tip of snout; ventral profile rises gently in branchiostegal region and moderately to lower jaw; snout bluntly rounded. Snout length less than interorbital width, both less than eye diameter. Nares flapless. Jaws of moderate length, rounded; two supramaxillaries present; upper jaw shorter than lower jaw; posterior edge of maxillary extends no further than through a vertical from center of orbit; teeth on premaxillary very small and uniserially arranged; no teeth visible on maxillary although there are some scattered small lateral projections; no tusks present on either jaw; no mid-dentary teeth present; dentary with a dentitional pattern like the premaxillary; one pair of teeth on the vomer; palatines toothless; tongue without teeth but strongly papillate. Teeth of lower jaw insert inside upper jaw series when mouth is closed.

Scales cycloid, thin and oval in shape; heavily marked by primary and secondary annuli, and no radii; completely covering body. No scales on head. Scales arranged in longitudinal rows; extent of overlap between scale rows less than 50 per cent. Region where scales fail to completely overlap giving rise to narrow longitudinal stripes. Stripes run through center of each scale. Along these narrow stripes are remains of brown epidermal tissue that contain one pore under each scale.

Gill rakers moderately long. Gill filaments about same length as rakers. Small pseudobranch present. Lateral line indistinct.

Origin of dorsal nearer caudal than snout, first ray anterior to base of anal but closer to origin of anal than ventral fins; dorsal and anal fins about opposite; ventral fins nearer to snout than to caudal fin; shoulder organ directly over pectoral fin; pectoral fin base inserted about one-fourth of way up side of body, its position oblique on body. Pectoral fins appear short and delicate, length of rays about equal to length of base; ventral fins more than twice as long as pectoral fins.

Inner surface of peritoneum heavily pigmented appearing nearly solid black. A thin-walled stomach present. Four large pyloric caeca present, two caeca branched.

Counts and measurements: Dorsal rays 18, anal rays 15, pectoral rays 19-20, ventral rays 8, branchiostegal rays 6, gill rakers 6+12, and vertebrae 44.

Measurements in millimeters followed by percent of SL in parentheses. Greatest body depth 22.5 (23.0); head 27.2 (27.8); snout 5.5 (5.6); eye 9.3 (9.5); interorbital width 7.4 (7.5); length of upper jaw 9.8 (10.0); length of lower jaw 12.8 (13.1); predorsal length 63.2 (64.8); dorsal base 19.4 (19.8); preanal length 63.9 (65.5); anal base 16.9 (17.3); prepectoral length 30.0 (30.7): pectoral base 4.0 (4.1); preventral length 46.3 (47.4); ventral base 3.7 (3.8); preshoulder organ length 30.0 (30.7); least depth of caudal peduncle 10.9 (11.1); length of caudal peduncle 18.6 (19.0).

Color in alcohol: Ground color deep yellow-brown; scales on body have a shiny, light blue-grey appearance; abdominal region a deep blue-brown; shoulder organ, operculum, and branchiostegal region black; head region with scattered patches of shiny blue iridescence; top of head semi-transparent with dark brown pores; fins light grey-brown.

Remarks: N. campbelli agrees well with the generic description given by Parr (1960). Photophores are absent; the number of dermal pits fall within the range of three to seven; small pores are present on the body associated with each scale; dorsal and anal fins are subequal and about opposite; the ventral abdominal wall is quite thickened anterior of the ventral fins; and the absence or indistinct lateral line are characters diagnostic of the genus *Normichthys*.

In addition to the features mentioned in the diagnosis *N. campbelli* differs from *N. operosa* in the position of the dermal pits on the body. In the Atlantic species the dermal pits lie equidistant between the top of the gill slit and the shoulder organ but in the Pacific form the pits are found a short distance anterior to the top of the gill slit. *N. campbelli* appears to represent a specific population with smaller proportions than the genotype. The length of the head, snout, upper and lower jaws, and the width of the interorbital are relatively shortest in the new species. In addition, the caudal peduncle is heavier and the pectoral and ventral fins are nearer the head in *N. campbelli*. Campbell's slickhead has fewer dorsal and anal rays, gill rakers, transverse and longitudinal scale rows, and branchiostegal rays, but it has more ventral rays than does *N. operosa*. The two species are similar in the proportion of eye size, the presence of an elongate anal papilla, and in the position of the dorsal and anal fins.

The last three upper branchiostegal rays of *N. campbelli* are broad and flattened, while the first three are elongate ray-like structures. In *N. operosa* the upper branchiostegals are only moderately widened.

Four pyloric caeca are present in Campbell's slickhead, fewer than in either Atlantic subspecies. The middle two caeca are deeply branched so that there are six terminal diverticula. The first and fourth caeca are simple.

This species is named for Mr. Alex Campbell, Chief Engineer of the R/V *Velero IV*, who has unhesitatingly given his time for thirty years to aid scientific work aboard the vessel and her predecessors.

Distribution: The genus *Normichthys* occurs in the eastern Atlantic and Pacific Oceans. *N. campbelli* represents the first record of the genus in the Pacific Ocean and as far as is known, *campbelli* occurs only off southern California and Baja California.

Acknowledgments: I am grateful to David K. Caldwell, Fred S. Truxal, and Jay M. Savage for their critical review of the manuscript. The material was collected with the aid of Richard C. Anderson, Gary J. Brusca, and Michael H. Coffy. The photograph was taken by the Museum staff photographer, Armando Solis. The work was financed in part by a National Science Foundation Research Grant (G-23647).

Since this paper was accepted for publication four additional specimens of *Normichthys campbelli*, from the north eastern Pacific Ocean, were sent on loan by Richard H. Rosenblatt of Scripps Institution of Oceanography (SIO). These specimens (SIO56-79-82, one spec.; SIO57-46, two spec.; SIO56-76, one spec.) are here designated as paratypes. They range in standard length from 86 to 125 mm. The diagnosis has been corrected to include the data from these additional specimens. The SIO paratypes have 17-19 dorsal rays, 15 anal rays, 18-20 pectoral and 42-44 vertebrae.

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OBSERVATIONS ON THE DISTRIBUTION AND ECOLOGY OF THE WHITE-THROATED WOOD RAT IN CALIFORNIA[1]

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Introduction

Ecological studies of the White-throated Wood Rat, *Neotoma albigula* Hartley, have been made in southern Arizona by Vorhies and Taylor (1940) and by Finley (1958) in southern Colorado. Published accounts of the ecology of this species in California are lacking.

On 1-2 March 1958, a field trip was made to the Carrizo Creek area of western San Diego County (5 miles S, 9 miles E, Agua Caliente Hot Springs) to collect specimens of the only subspecies, *N. a. venusta* True, known to occur in California. This site is located in the Colorado Desert subdivision of the extensive Sonoran Desert (Jaeger, 1957:85-103). The type locality for this subspecies was reported merely as Carrizo Creek, California (True, 1894:354). These specimens were obtained perhaps at or near the Carrizo Creek Stage Station (El. 423), which no longer exists. It was located in Imperial County just a few yards east of the present San Diego-Imperial County line.

Nine *albigula* were taken with kill traps the night of 1 March 1958, 2.7 miles west of the former stage station site. Observations at this time indicated a large population of wood rats in the area, and I decided to undertake a limited live trapping program in order to acquire some ecological information about this species in California. Field trips for this purpose were made 15-16 November 1958, 1-3 January 1959, 20-22 March 1959, 18-19 April 1959, 20-22 January 1960, and 28-30 March 1961.

Distribution

Perusal of the literature indicates that *N. albigula* is one of the least known small mammals in California, at least ecologically. Published distribution records are both meager and old. The range of *albigula* in California was reported by Grinnell (1933:178) as being the "Bed of Colorado Desert, from the Mexican line northwest

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[1] A portion of this paper was read at the annual meeting of the Southern California Academy of Sciences in May, 1961.

at least to Mecca, Riverside County, west to Carrizo Creek, in extreme eastern San Diego County, and north along the Colorado River at least to near Riverside Mountain, northeastern Riverside County." Grinnell (*loc. cit.*) also pointed out that this rodent was closely associated with mesquite, *Prosopsis juliflora* var. *torreyana* L. Benson.

Owing to growth of agriculture and concomitant destruction of the natural habitat of most small mammals in the Coachella and Imperial Valleys and along the Colorado River in the general region of the city of Blythe, I decided to make two reconnaissance trips to cover as much as possible the range as outlined by Grinnell. As trapping time was limited, I relied mostly on carefully inspecting patches of mesquite for wood rat sign. The first trip was made 14-16 March 1958 along the Colorado River in the Blythe region. Inland areas and the Colorado River in the vicinity of Winterhaven, Imperial County, were visited 2-4 May 1958.

On 14 March 1958, numerous localities were investigated along the Colorado River from Blythe (Riverside County) north to a point 9 miles S, 4 miles W Vidal, San Bernardino County, which is approximately one mile from Riverside Mountain. Mesquite was found to be mostly confined to within 25 to 150 yards from the river bank, and evidence of burning was present at *each* site inspected. Many trees, however, had survived the fire, but the ground beneath them was barren and wood rat sign was not present. The Desert Wood Rat, *Neotoma lepida lepida* Thomas, inhabited adjacent rocky hillsides. Attempts to learn the explanation for burning the mesquite were unsuccessful. Officials of the Riverside County and California State Departments of Agriculture were not able to supply an answer (personal communication). Residents of a fishing camp indicated that the river "bottom" is burned periodically to force out cattle, and the mesquite "may" be burned at this time even though it does not occur in the river bottom flora. Seemingly, the trees were deliberately burned.

On 15 March 1958, a small concentration of unburned mesquite was located 30 miles south of Blythe on the Colorado River. One adult female and one juvenile male *albigula* were taken at this site. Owing to inaccessibility, localities immediately south of this locality were not investigated.

The following inland localities were inspected 2-3 May 1958, but wood rat sign was not observed within the clumps of mesquite: *Riverside County:* 2 miles NW Mecca; 6.5 miles SE Mecca; 11.2

miles SE Mecca; 17 miles SE Mecca; 4.7 miles NW Hot Mineral. *Imperial County:* 3 miles N, 2 miles W Calipatria; 13.6 miles NW Glamis; 2.5 miles E Ogilby; 1.6 miles N Bard. Various sites were investigated 3 May 1958 along the Colorado River from Winterhaven, Imperial County, to a point 16 miles northeast of that town. Trapping one night did not yield any *albigula.*

More recently, a single specimen of *albigula* was obtained by Stevan Logsdon in Long Canyon (Riverside County) within Joshua Tree National Monument. The site is 29 miles north, 19.5 miles west of Mecca and represents a northwestward extension of range. It was trapped in a patch of mesquite found in the canyon.

Although trapping was not done at most localities on these investigative trips to confirm the presence or absence of this species, sign (fecal pellets, food remains, collections of sticks, burrows, etc.) ordinarily is a trustworthy means of detecting the past or current presence of any member of the genus. An extensive study of the current distribution of *albigula* throughout California is needed. Destruction of the mesquite habitat, notably along the Colorado River, seems to have resulted in discontinuities in much of its range.

ECOLOGY

Habitat at Carrizo Creek.—The site selected for study is at the junction of Vallecito and Carrizo Creeks at an elevation of approximately 495 feet. Except during rare heavy rains, these creeks are dry washes of alluvial gravel, fine sand, and lacustrine clays. Vallecito Creek drains the Laguna Mountains; Carrizo Creek drains the Inkopah and Jacumba Mountains. The Vallecito Badlands lie to the northwest and Fish Creek Mountains to the northeast. In this general area, discontinuous patches of dense mesquite are found over an area of approximately 2500 acres. Live trapping was restricted to an area of approximately 12 acres.

The vegetation is a mesquite-creosote, *Larrea tridentata* (Sessé and Moc. ex DC.) Coville, association. Mesquite trees grow on the tops of low banks of loose sand bordering the washes. Owing to accumulation of drifting sand, usually little of the main trunk is exposed; as a result, branches often extend down the sides of the banks in actual contact with the substrate (Fig. 1). Creosote is found at the margins of the mesquite, in the washes proper, and in more "upland" situations away from washes. Nearby hillsides are nearly barren of vegetation. Other prominent plants are: Tamarix, *Tamarix* sp.; Smoke Tree, *Dalea spinosa* A. Gray; Allscale, *Atriplex polycar-*

Figure 1. A characteristic "patch" of mesquite at the Carrizo Creek study area, which typifies the growth form discussed in the text. *Neotoma albigula* was found chiefly in this habitat.

pa (Torr.) Wats.; Rabbitbush, *Chrysothamnus paniculatus* (A. Gray) Hall; and Alkali Goldenbush, *Haplopappus acradenius* S. F. Blake. Screwbean, *Prosopsis pubescens* Benth., is present but uncommon. Most of the mesquite is parasitized by Desert Mistletoe, *Phoradendron californicum* Nutt.

Climate.—This area, one of the most arid in the entire Southwest, is characterized by low rainfall and extremely high summer temperatures. The annual average rainfall at Crawford's Ranch (7.6 miles west of the study area) for an eight year period (1951-1958) was only 3.57 inches. In this period there were 45 months without any precipitation. A total of 6.54 inches fell in 1951 (3.19 inches in August!), but only .64 inches fell in 1956. It did not rain in the month of June during this eight year period. While I was in the area on the afternoon of 16 November 1958, following a severe dust storm, it rained lightly most of the night and the temperature fell to freezing. On the following day, nearby mountains were covered with a thin layer of snow down to the 2000-foot level.

The nearest temperature records are for Borrego Valley, which is 27 miles N, 14.5 miles W of the study site. Borrego Valley is approximately the same elevation, and trends probably are similar to those at Carrizo Creek, although the latter is probably slightly warmer. July is the hottest month, and the mean maximum temperature for an eight year period (1945-1952) was 107.8 F. The maximum temperature recorded during this period was 121 F, and temperatures in excess of 110 F were common. January is the coldest month, and the mean minimum for the above period was 34.5 F. The lowest recorded was 15 F. The mean annual temperature for the eight year period was 70 F.

Den Sites.—Most, if not all, species of this genus construct more or less elaborate above-ground stick houses or dens. Vorhies and Taylor (1940:477-484) reported *albigula* building substantial houses in southern Arizona, although in certain situations (rock crevices, etc.) the rat collected no more than a few sticks. At Carrizo Creek, the species dwelled exclusively in underground burrows, and the house-building instinct was not expressed. The harsh summer climate, low humidity, adequate overhead protection by dense mesquite in most instances, ease of burrowing in loose sand, and general scarcity of building materials are probably responsible for lack of stick houses.

A typical burrow system would be located at the base of the main trunk of a mesquite. As many as eight openings to the system would be present, and most have the overhead protection of large limbs branching from the main trunk, which was multiple in some instances. More exposed openings often had a few small twigs loosely arranged over them. Typically, many droppings and empty mesquite bean pods expelled from the subterranean system were in the immediate vicinity of the openings. Prominent well-worn trails cleared of all debris radiated from the burrow system.

This species lived also in burrow systems in banks cut by water erosion (Fig. 2) but to a lesser extent that at the base of mesquites. Not all cut-banks were used, as those lower than approximately three feet seldom were excavated. Most of those banks that harbored wood rats were 6 to 15 feet high, and burrows occurred at any height from the bottom. It is possible that kangaroo rats originally formed the burrows and wood rats later invaded them. Seemingly, water and wind erosion helped increase the size of many openings. Interestingly, there was always at least one mesquite tree in the immediate vicinity of these burrows, usually in the wash proper, but they did not have burrow systems at their bases. Frequently, obvious trails led from the cut-bank to the mesquite trees.

Figure 2. The cut-bank habitat of *Neotoma albigula* at Carrizo Creek showing numerous entrances to burrows, many of which interconnect.

A typical six-foot stretch of bank had 12 entrance holes. The bank was seven feet high, and the entrance holes were two feet from the top. The diameter of the holes ranged from 3.5 to 7 inchs. There were approximately 200 fecal pellets at one opening. A mesquite grew in the wash 20 feet from this system and a trail led to its base. Empty mesquite bean pods often were noted at entrance holes in the cut-bank habitat.

Burrow Microclimate.—A continuous record of the temperature 24 inches within an underground burrow was obtained 20-23 March 1959 (Fig. 3). A Bendix-Friez distance thermograph was used to measure burrow temperatures, and simultaneous outside air temperature was recorded with a Bendix-Friez thermograph housed in a portable weather shelter. A wood rat occupied this burrow system, which was excavated in a two foot high eroded bank along the edge of Carrizo Creek wash. The main entrance burrow was beneath the trunk of a dying mesquite that had fallen into the wash because of erosion around its base. The soil above the system was

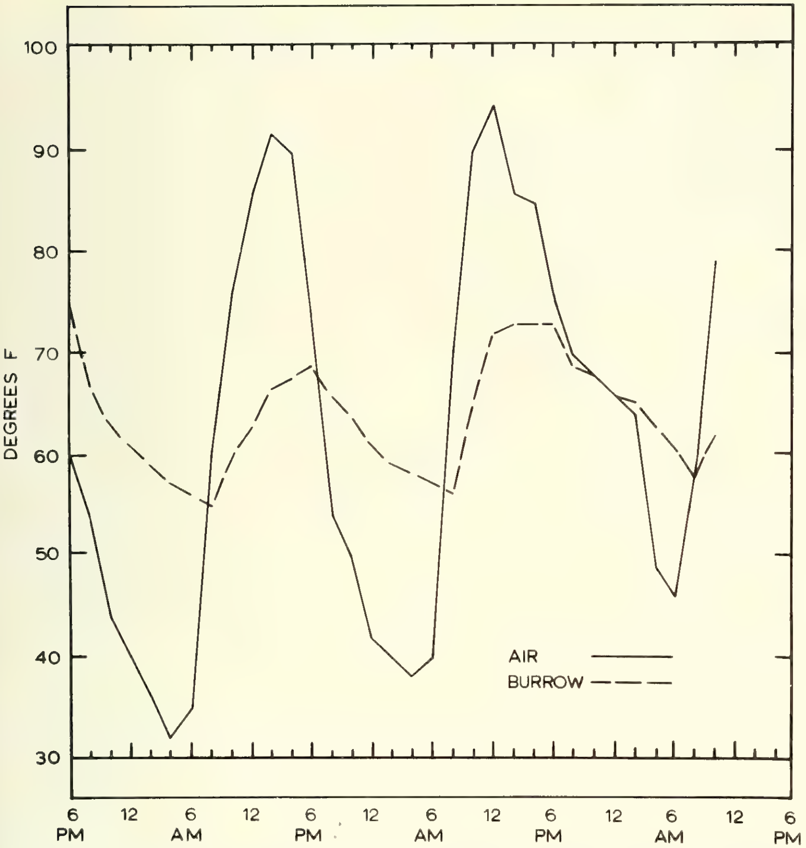

Figure 3. Graph of thermograph recordings within a wood rat burrow compared to the air temperature outside the burrow. The period is from 6:00 PM, 20 March 1959, to 10:00 AM, 23 March 1959.

exposed fully to solar radiation. All temperatures in the following discussion are degrees Fahrenheit.

During the night of 20 March, the burrow temperature was 25 degrees warmer than air temperature at 4:00 AM. During the 10 hours previous to this, the burrow temperature had declined only 18 degrees while the outside air fell 28 degrees. Between 4:00 PM and 8:00 PM 21 March, the air temperature fell 34 degrees, but the burrow temperature declined only 2 degrees and was 12 degrees warmer than outside at 8:00 PM. During the remainder of this night, the burrow was considerably warmer than outside, and when the minimum (38 at 4:00 AM) outside was reached, the burrow was 20 degrees warmer. The burrow was 15 degrees warmer the night of 22 March when the outside minimum of 46 was attained at 6:00 AM.

The burrow temperature during the day was considerably cooler than outside atmosphere. At 2:00 PM on 21 March when the maximum air temperature of 92 was attained, the burrow was 25 degrees cooler. On 22 March, the burrow was 25 degrees cooler at 10:00 AM, but it warmed 7 degrees in the next two hours when the maximum air temperature of 95 occurred. Then, the burrow remained remarkably stable for the following six hours, as it increased only 1 degree. The burrow was only 8 degrees cooler than the ambient temperature when recordings were discontinued at 10:00 AM on 23 March. However, a definite warming trend followed the night of 20 March, and the minimum of 46 degrees at 6:00 AM on the 23rd was 14 degrees higher than the minimum of 32 degrees on the 20th.

Although continuous records are lacking, "spot" readings with a thermistor telethermometer at a depth of 24 inches in a burrow at the base of a large living mesquite suggest a somewhat lower differential between air and burrow temperatures. Even though the tree had only scattered dead leaves, the density of limbs and twigs furnished abundant filtered shade. On 21 January 1960, the air temperature in the shade of the tree was 56 at 11:00 AM and the burrow temperature was 44. At 1:30 PM the same day, the air temperature was 65 and the burrow 58.

These limited observations illustrate the adaptive features of dwelling underground in an extremely harsh environment. The surface of the soil absorbs incoming solar radiation and transfers heat inwardly at a slow rate. When incoming radiation begins to decline in late afternoon, the burrow temperature will continue to increase slowly at least for a short time. Air temperature then declines rapidly and usually reaches its low shortly before sunrise, but the burrow temperature lags behind. As wood rats tend toward crepuscular habits, they may retire to the warmth of the burrow system well before early morning minima.

During the day, the burrow remains cooler than the outside, but the magnitude of the difference appears to depend upon the overall trend in ambient conditions. If a warming trend is in progress, especially increasing daily minima, the difference between burrow and air temperature should be less than during a period of falling temperatures. It would seem that in summer, the difference at mid-day would be considerably less than in cooler weather, and an occupant would be subjected perhaps to occasionally quite warm temperatures. Vorhies (1945:504) reported that *N. albigula albigula* dwelling in above-ground dens in southern Arizona had to endure higher temperatures during the day than did *Dipodomys spectabilis* Merriam, which lived in extensive underground burrows. He concluded (*loc. cit.*) that *Neotoma* was much more vulnerable to evaporative water loss than *Dipodomys* owing to scarcely unimpeded air circulation through the den. Later, the Schmidt-Nielsens (1950:82) demonstrated the water content was two to five times greater than outside atmosphere in a *D. spectabilis* burrow in the same area where Vorhies did his study. The burrow of *albigula* in the Carrizo Creek area probably furnishes similar protection from loss of body water even though its system may be less extensive.

Trapping Records.—The live traps used to obtain wood rats were constructed from hardware cloth and patterned after those of Fitch (1950). These wood rats were marked for future identification by excising one toe each from two feet according to a predetermined formula. Toe formulae were not duplicated. In addition, the top portion of the right ear was clipped. Each animal was weighed, inspected for parasites, condition of pelage, wounds, condition of external genitalia, and then released at site of capture. Observations were recorded on the animal's behavior following release.

Nine rats (4 males, 5 females) were kill trapped 2 March 1958 and 13 (6 males, 7 females) were obtained in a like manner 16 November 1958. These specimens were not obtained in the immediate vicinity of the area where live trapping was done. Live trapping began 15 November 1958, and 152 trap nights ensued through 30 March 1961 at intervals previously mentioned.

In order to position the live traps in places most likely to catch a rat, it was necessary in most instances to cut a narrow trail to the base of the mesquite trees with heavy pruning shears. Thirty one sites were so prepared, but all sites were not trapped each trip. The traps were baited with a mixture of commercial "pigeon" food, sunflower seeds, and some raisins. A large piece of cotton was placed in the rear of each trap for protection from the cold.

The average last-capture weight of six females was 185 g and 221 g for seven males. The average measurements in mm (from study skins) were 339-156-36-31 for 10 females and 345-159-36-31 for 10 males.

Twenty-five rats (10 males and 15 females) were captured 64 times. Captures according to sex were as follows: *Males.* one captured 7 times; one, 5 times; three, 4 times; three, 2 times; and, two captured once. *Females.* one captured 5 times; three, 4 times; one, 3 times; two, 2 times, and, eight captured once. The sex ratio from these and those kill trapped combined was 42.6 per cent males to 57.4 per cent females. Based on a much larger number of specimens, Vorhies and Taylor (1940:473) found the sex ratio in Arizona *albigula* to be almost exactly 1:1. In the present study, males were caught also 32 times (initial capture and recaptures) and females were caught also 32 times even though a larger number of females were marked.

Survival and Movements. – The span of records for those live trapped is given in Table 1. Records exceeded 100 days for nine rats, and 300 days for eight. Four survived for more than one year and two for 451 days. However, 40 per cent were captured only once and presumably were taken by natural enemies, disease, or migrated out of the trapping area. It should be noted that I did not observe any external sign of disease, and all those captured appeared to be in excellent health. In another study, Fitch and Rainey (1956:-516-517) reported limited home ranges and a strong tendency not to wander extensive distances from home base in *N. floridana* (Ord) in Kansas.

TABLE 1

Number of days between first and last captures according to sex. Those caught only one time are considered herein as surviving only one day.

Number of days	Number of wood rats	
	Males	Females
1	3	9
29	2	2
106	0	1
305	1	1
307	1	0
385	1	0
432	0	1
433	0	1
451	2	0
Totals	10	15

These records indicate greater potential survival for males than females. Seventy per cent of the males captured survived longer than the initial capture; 50 per cent survived more than 300 days. Among females, only 40 per cent were caught more than once; only 20 per cent survived more than 300 days. In my study of *N. floridana* in eastern Kansas, males survived, on the average, longer than females but the difference was not significant statistically (unpublished data). However, males of *N. floridana* tended to move more than females especially during the reproductive period (Fitch and Rainey, 1956:518). The length of movements seemed to be directly correlated with population size, *i.e.*, low numbers require longer moves by males in search of females. In the Carrizo area, the population was large, and males seemingly would not have to travel long distances in search of females. The trapping records appear to substantiate this assumption. For those individuals whose records extend more than one capture, 62 per cent were caught the first and last times at the same site. The longest move, by a male, was less than 100 yards and his span of records covered 451 days. All other movements were less than 75 feet and all within the same mesquite patch. Females are probably subjected to increased hazards when they have young and may actually have a potentially shorter life span when compared to males within a large population. Lengthy longevity periods, up to 991 days, were reported for *N. floridana* in eastern Kansas (Fitch and Rainey, 1956:530).

Food.—My observations indicate that these rats rely heavily on mesquite for food. Discarded bean pods were noted often around burrow systems. Vohies and Taylor (1940:530) found mesquite and cactus to be complementary, according to time of year, in the diet *of albigula* in Arizona. They found that mesquite constituted 30.2 per cent of the annual total of food. Cactus did not occur in the immediate vicinity of the Carrizo Creek study site, so this population lacked this food source.

Green mesquite leaves also are collected, and young green terminal twigs of the mesquite were utilized to a considerable degree, at least during the growing season. Although I did not observe wood rats in the process of collecting these twigs, height from the ground of many of those removed would prevent nonclimbing mammals such as lagomorphs from taking them. Creosote leaves were recorded one time at a burrow entrance.

Water.—Wood rats do not have the capacity to utilize metabolic water as do many heteromyid rodents (Lee, 1963:57-96). They derive water from their food and utilize succulents whenever possible. As there was a general lack of succulents in the Carrizo Creek area, the wood rats almost certainly derive most of their water from the mesquite tree. This is in the form of new twig growth, green leaves, green pods, new beans, and gnawing bark from larger limbs to obtain sap. There was always much bark gnawed from larger limbs and the main trunks. Some of this closer to the ground may have been done by Lagomorpha, but numerous gnawings were as much as six to eight feet from the ground. When a large limb is cut with a pocket knife, sap exudes in considerable amounts. I feel that the close association of *albigula* with mesquite throughout its range in California is due to ease of obtaining food and water along with the shelter it furnishes. However, not all mesquite is suitable for wood rats. Numerous trees extended intermittently for several miles directly west of the Carrizo Creek area, but wood rats were not found associated with these. They did not have the accumulation of sand around their bases and were much more "tree-like," mostly with the main trunks 3 to 5 feet high before it branched resulting in little overhead protection.

Reproduction.—Breeding was in progress in March in 1958, 1959, and 1961. Five females kill trapped 16 March 1958 were all pregnant. Embryos ranged from 6 mm crown-rump to near term. Two females had two embryos each and three had three each. Four females live trapped had perforate vaginas in March 1959, and two were noted with the same condition in March 1961. There was some indication of at least preparation for breeding in January 1959 and 1960. Juveniles were not captured during this study indicating their appearance at dates other than those when live trapping was conducted. Vorhies and Taylor (1940:474) found the highest per cent of reproductive activity in March in southern Arizona.

Evidence from males also indicated that mating occurs perhaps as soon as late February and continuing into early March. The testes of all males live trapped in March were abdominal in position but often enlarged. Only one had enlarged caudal epididymides when the testes were palpatated into the scrotum. Furthermore, a dermal abdominal stain was observed only three times in males (March 1959). It was reported that this stain intensifies during breeding season in *N. fuscipes* Baird (Linsdale and Tevis, 1951:

243). This suggests that males had passed their peak of sexual activity in late March. It is not known if more than one litter is born each year by this race.

Molt.—Since observations on molt were noted only in adults, the sequence in all age groups is not known. Annual molt in adults is similar if not identical to the pattern reported for both this and other species (Linsdale and Tevis, 1951:457; Finley, 1958:484, 498, and 533; Rainey, 1956:623). Old hair is lost in small patches commencing on the hips and back, and a molt "line" is not evident. Most records of the annual molt in progress were in April 1959.

Wounds.—Most males and some females had healed tears of the pinnae, probably acquired in the main from intraspecific conflicts. One male had two large wounds on the back and one on the stomach. Both hind feet of this rat had been severely injured with one swollen to twice its normal size. These wounds may have resulted from an encounter with a predator.

Behavior Following Release.—A female when released ran three feet, paused and began stamping the hind feet and vibrating the tip of the tail. This peculiar behaviorism has been observed in other species and seems to be a fear reaction.

Dependence upon established and probably memorized trails leading to the burrow system was observed numerous times following release. If a rat was released near but not on a trail, it usually paused momentarily to get its bearings and then dashed rapidly directly to shelter via the trail. On a few occasions when released, a rat would dash in obvious confusion for several feet in the "wrong" direction, pause and study its surroundings, and then proceed slowly to some nearby temporary shelter. After several minutes it would seek its way back to home base.

External Parasites.—A single species of flea, *Orchopeas sexdentatus* (Baker), was the only external parasite found on this wood rat; however, a high percentage of rats had fleas at every trapping date. Chigger mites, common on most species of wood rat, were not observed although both living and dead specimens were carefully searched to locate them. Flesh fly larvae were reported by Vorhies and Taylor (1940:508) parasitizing *albigula* in southern Arizona.

Perhaps those of Carrizo Creek are parasitized at times other than when I visited the area. Internal parasites were not studied.

Vertebrate Associates.—The following vertebrate species were recorded from the study site in the course of field work.

Reptiles: Banded Gecko, *Coleonyx variegatus* Baird; Zebra-tailed Lizard, *Callisaurus draconoides* Blainville; Side-blotched Lizard, *Uta stansburiana* Baird and Girard; Sidewinder, *Crotalus cerastes* Hallowell.

Birds: Cooper's Hawk, *Accipiter cooperii* (Bonaparte); Red-tailed Hawk, *Buteo jamaicensis* (Gmelin); Mourning Dove, *Zenaidura macroura* (Linnaeus); White-throated Swift, *Aeronautes saxatalis* (Woodhouse); Costa's Hummingbird, *Calypte costae* (Bourcier); Western Kingbird, *Tyrannus verticalis* Say; Ashthroated Flycatcher, *Myiarchus cinerascens* (Lawrence); Flycatcher, *Empidonax* sp.; Common Raven, *Corvus corax* Linnaeus; Verdin, *Auriparus flaviceps* (Sundevall); Phainopepla, *Phainopepla nitens* (Swainson); Yellow Warbler, *Dendroica petechia* (Linnaeus); Audubon's Warbler, *Dendroica auduboni* (Townsend); Wilson's Warbler, *Wilsonia pusilla* (Wilson); Black-throated Gray Warbler, *Dendroica nigrescens* (Townsend); Hooded Oriole, *Icterus cucullatus* Swainson; Bullock's Oriole, *Icterus bullockii* (Swainson); Lazuli Bunting, *Passerina amoena* (Say).

Mammals: Audubon's Cottontail, *Sylvilagus auduboni* (Baird); Black-tailed Jack-rabbit, *Lepus californicus* Grey; White-tailed Antelope Squirrel, *Citellus leucurus* (Merriam); Southern Pocket Gopher, *Thomomys umbrinus* (Richardson); Desert Pocket Mouse, *Perognathus penicillatus* Woodhouse; Merriam's Kangaroo Rat, *Dipodomys merriami* Mearns; Cactus Mouse, *Peromyscus eremicus* (Baird); Coyote, *Canis latrans* Say; Kit Fox, *Vulpes macrotis* Merriam; Badger, *Taxidea taxus* (Schreber); Bobcat, *Lynx rufus*, (Schreber). All carnivores were identified by tracks, calls, and other sign.

SUMMARY

Two field trips were made in southeastern California along the Colorado River and to several inland localities in search of the White-throated Wood Rat. These trips revealed much destruction of the natural mesquite habitat of this wood rat, and has resulted in discontinuities in its range. A northwestward extension of the range is reported.

A small-scale capture-release study was conducted in 1958, 1959, 1960, and 1961 in the Carrizo Creek area of western San Diego County near the type locality of the only race, *Neotoma albigula venusta* True, occurring in California. Twenty-five wood rats (10 males, 15 females) were captured 64 times (152 trap nights) and information is presented on habitat, longevity, movements, food, water requirements, reproduction, molt, wounds, behavior, external parasites, and vertebrate associates.

Acknowledgments

I wish to express my gratitude to Dr. Richard B. Loomis, Dr. Elbert Sleeper, and Mr. S. G. Van Hoose, Jr., for their valuable assistance during certain of the field trips. My wife, Bettye, also provided field assistance. Dr. William L. Jellison kindly identified the fleas obtained from the wood rats.

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ASPECTS OF REPRODUCTIVE BIOLOGY IN THE STRIPED SHORE CRAB *PACHYGRAPSUS CRASSIPES*[1]

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Since reproductive cycles of marine organisms are usually timed in order to be of greatest advantage to the larvae which are produced, it is of interest to discover the exogenous and endogenous factors which are responsible for the consistent timing of reproductive events. The conditions which seem to be of benefit to the larvae often do not affect the adult at all. For example, some mollusca, annelida, and arthropoda of the intertidal zone produce planktonic larvae which have to contend with environmental conditions that the adults never experience. There must, therefore, be some signal or signals for the onset of the breeding season other than the presence of factors which benefit the young.

This paper presents information on a single population of *Pachygrapsus crassipes* Randall, the common striped shore crab of the California coast.

Decapods are convenient animals for reproductive studies since they can be readily sexed externally and females carry eggs on the pleopods or swimmerettes during the incubation period. Systematic examination of females throughout the year should yield information on the natural reproductive cycle in the field. The work here presented was undertaken to determine: (1) the reproductive cycle over an eighteen month period, (2) the distribution of males and females in three arbitrarily defined areas in the intertidal zone, and (3) whether future laboratory studies were feasible to determine the effects of light, temperature, and food on the timing of reproductive events.

Seventeen hundred and fifty-four specimens of *Pachygrapsus crassipes* were collected and examined over an eighteen month period from March 1960 to July 1961. The specimens came from the intertidal population at Flat Rock, Palos Verdes, California (Fig. 1). In order to estimate the percent of females in the population carry-

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[2] Department of Zoology.

ing eggs, at least thirty females were collected each month and examined. A total of sixty animals was taken each month, and the number of males was also recorded, along with the data on the females.

During the first few months of work it became apparent that the proportion of males to females varied at different levels of the intertidal range of these crabs. Three arbitrarily defined zones were established to determine whether the two sexes occupied different levels of the intertidal area, as follows:

Zone A—the lower mid-tide region, uncovered by most tides. This region includes many tide pools regularly interchanging water with the ocean.

Zone B—the region of the intertidal area having permanent tide pools at low water.

Zone C—the high tide region. This area is covered only at high water.

Refer to Figure 1.

In addition to the numbers of males and females, the percent of ovigerous females was noted in each zone.

Crabs were kept in our closed circulating sea-water system tanks for fourteen months in the laboratory. During the period several females reproduced and released larvae on two occasions, but only at a time when animals in the field were reproducing. No significant data can be presented for the laboratory animals, but it seems certain that the laboratory system is satisfactory for experimental work designed to show the effects of light, temperature, and food on the timing of reproductive events.

The data from the 1960 Flat Rock population shows the reproductive season beginning in March, with 3 percent of the females carrying eggs. The percent of ovigerous females reached a peak of 54 percent in June, followed by a sharp drop to 10 percent in July. There is no explanation for the tremendous drop, except that a shipwrecked cargo vessel emitted a dark oily substance in the area. Female crabs were much more difficult to find at that time, as compared with any occasion previous to or since July 1960. The percent of ovigerous females climbed from 10 percent to 67 percent in August, and then fell to zero percent by November 1. This represents a three month extension of the breeding season observed at Flat Rock as compared with the data recorded by Boolootian, *et al.* (1959) on a population of Monterey Bay.

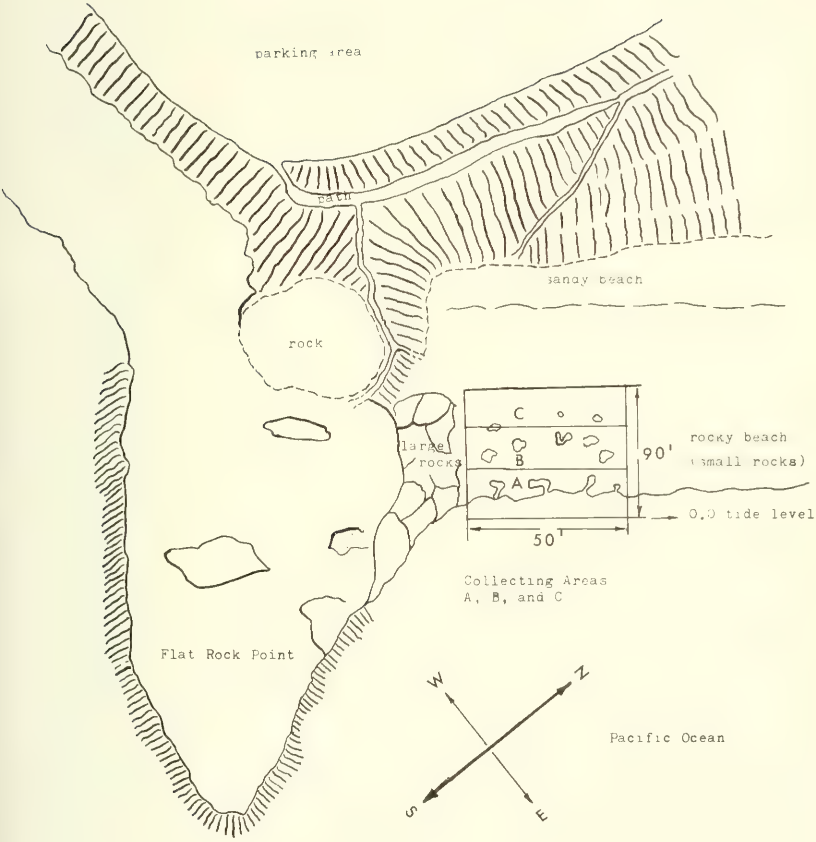

Figure 1. Map of Flat Rock Point, Palos Verdes, California. 33° 47.8′ N, 118° 24.4′ W; showing location of the study site.

Figure 2

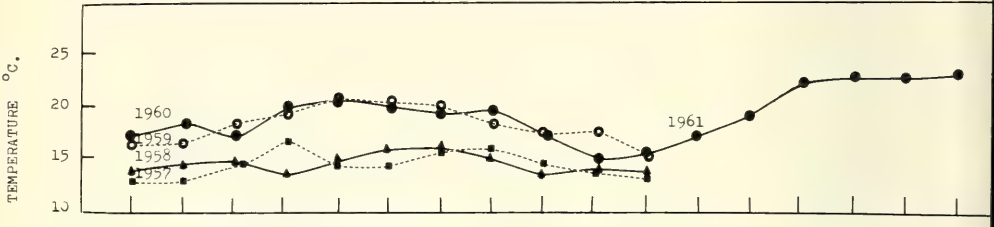

Figure 3

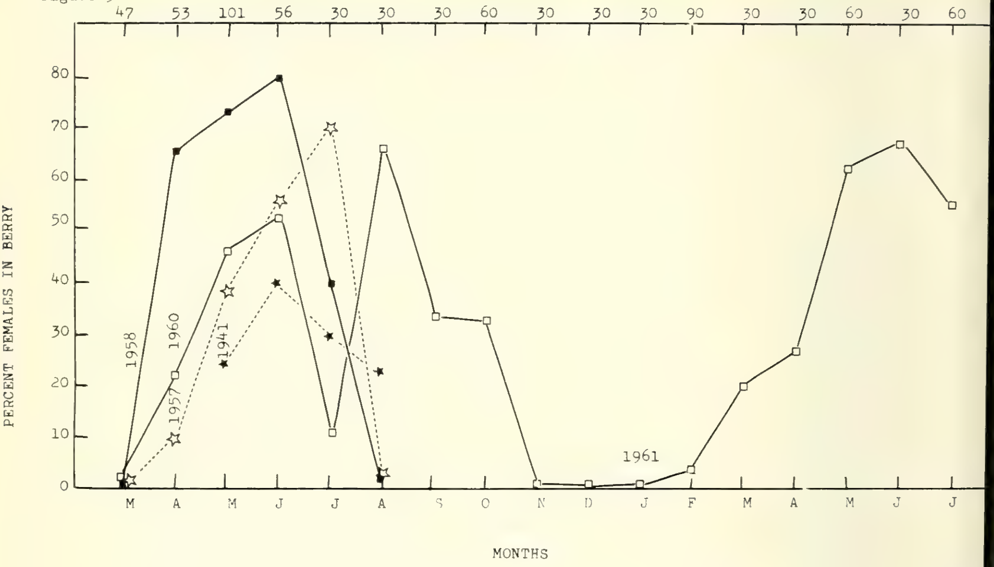

Figure 2. Monthly mean surface water temperatures for 1) Flat Rock Point for the years 1959, open circles connected by dotted line; 1960-61, closed circles connected by solid line; and 2) Monterey Bay, California for the years 1957, squares connected by dotted line; 1958, triangles connected by solid line. These data obtained in part from Boolootian (1960) and from readings taken during this study.

Figure 3. Reproductive cycle of *Pachygrapsus crassipes* as indicated by the percent females in berry for the years 1941, closed stars connected by dotted line, (Hiatt, 1948); 1957, open stars connected by dotted line; and 1958, closed squares connected by solid line, (Boolootian *et al.*, 1959); 1960-61, open squares connected by solid line (this paper).

Figure 4

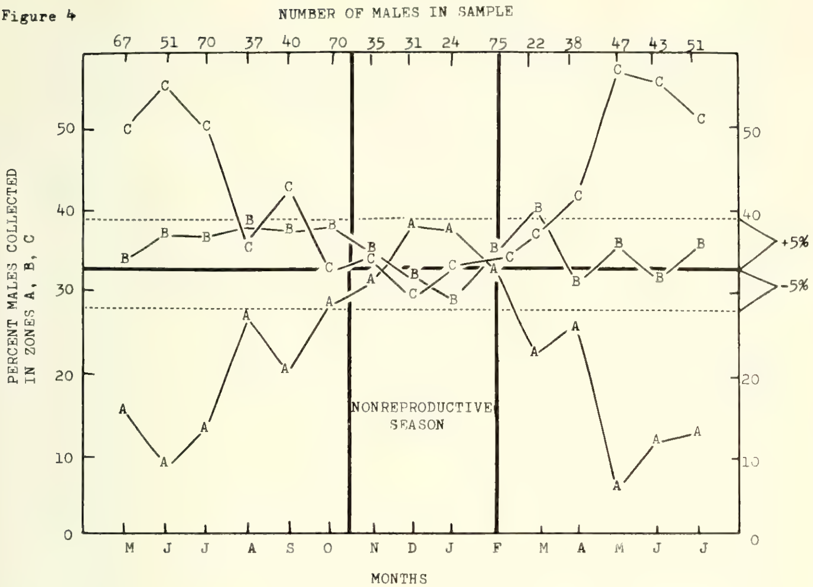

Figure 5

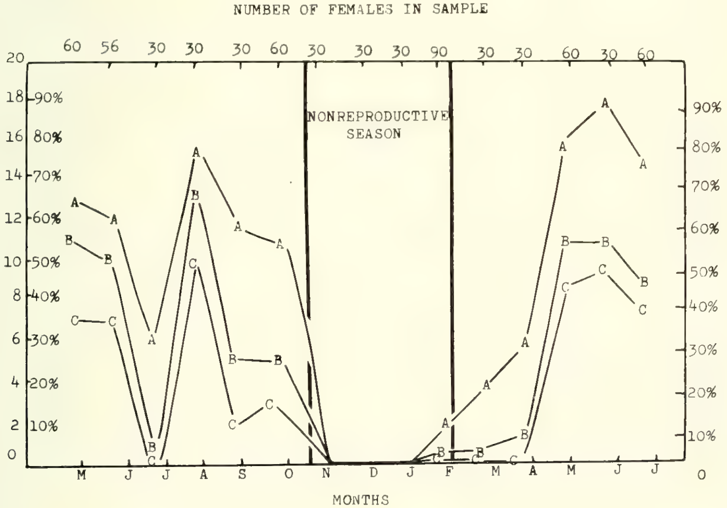

Figure 4. Percent males found in zones A, B, and C, throughout the reproductive cycle of *Pachygrapsus crassipes.*

Figure 5. Percent females found in zones A, B, and C, throughout the reproductive cycle of *Pachygrapsus crassipes.*

Hiatt (1948) presents data for only four months during the breeding season of 1941 in Monterey Bay. He reports that about 25 percent of the females collected in August of that year were ovigerous. This 1941 data, when compared with Boolootian's 1957-1958 data, shows no similarities of peak percentages or length of breeding season (Fig. 3).

In 1961, the Flat Rock population reproductive season began in February. There was no drop in the percent of ovigerous females during July, which casts doubt on the bimodal pattern of 1960.

The temperature data recorded in Figure 2 shows the normal seasonal fluctuations. In 1961 the temperature did not rise earlier than it had in 1960.

Figures 4 and 5 show the distribution of males and ovigerous females in the three intertidal zones described above. Figure 4 shows that during the reproductive seasons males are rarely found in Zone A, and more numerous in Zone C, although the ratio of males to females in the three zones is generally 1:1. During the non-reproductive period (October to February) the males and females were equally distributed throughout the three zones. Figure 5 shows that during the reproductive season there is a significantly greater percent of ovigerous females in Zone A and correspondingly few in Zone C.

From these data one might conclude that the ovigerous females migrate toward the water, where the developing larvae on the pleopods may be more easily kept moist and aerated until they hatch.

This migration of reproducing and ovigerous females may account for the discrepancy between the 1941 data reported by Hiatt and the much higher percentages of ovigerous females from the same area reported by Boolootian, *et al.* (1959). For if one examines Figure 5, it becomes clear that a sample taken in Zone A at the peak of the reproductive season would indicate that 80 to 90 percent of the females were carrying eggs, while a sample taken in Zone C at the same time would show only 40 to 50 percent ovigerous females. In the same manner, if the sampling area were restricted to Zone C, the breeding season in 1961 would have seemed to begin in May, whereas actually, ovigerous females were found in Zone A in February.

In view of this horizontal distribution and change in sex ratios accompanying the reproductive season, sampling methods must be conceived which take this into account.

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A NEW SPECIES OF CORMORANT FROM THE PLIOCENE OF MEXICO

Hildegarde Howard[1]
Los Angeles County Museum

The occurrence of vertebrate fossils in deposits south of the small town of La Goleta, near Morelia, Michoacan, Mexico, was first discussed by Arellano and Azcon (1949) at the El Paso, Texas, meeting of the Geological Society of America. In 1950, the California Institute of Technology (CIT) collected in the La Goleta area, followed, five years later, by the Los Angeles County Museum (LACM). The material collected on both of these expeditions is now in the collections of the latter institution.

A brief discussion of the Michoacan beds, based on an unpublished report of the field party from California Institute of Technology is presented by Repenning (1962:554), who records the occurrence of the giant ground squirrel, *Paenemarmota*, in the Goleta fauna. Except for *Paenemarmota*, the only other generic or specific identifications from the fauna have been of horses assigned to *Nannipus* cf. *montezuma* and *Pliohippus osborni* (Arellano and Azcon, 1949). On the basis of the horses, the Goleta fauna has been placed in the Pliocene. A difference of opinion exists, however, as to whether it should be considered of Hemphillian (middle Pliocene) or early Blancan (late Pliocene) age (Repenning, 1962:554-555; and October, 1964, correspondence with the present writer from R. H. Tedford who takes the latter view).

Undescribed mammalian specimens representing mastodon, hyaenid, peccary, tapir, rabbit, rodent, antelope and camel are included in the fauna (Repenning, 1962:554-555). Only two avian bones occur, both representing a small cormorant of lesser size than the Recent *Phalacrocorax olivaceus*, known in the area today. Fortunately an almost complete coracoid is present, an element that is particularly diagnostic in the cormorants. More significant than the size difference from *P. olivaceus* are physical characters of the coracoid that serve to distinguish the fossil. The Goleta species is, therefore, here described as new to science:

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[1] Research Associate.

Figure 1. Phalacrocorax goletensis—new species, type coracoid, LACM 4632. A. Anterior view, B. Internal view, C. External view, D. Posterior view. Natural size. Photo by George Brauer, retouched by Pearl Hanback.

Phalacrocorax goletensis, new species

Figure 1

Type: Nearly complete right coracoid, lacking only the sternocoracoidal process; LACM 4632, collected by R. H. Tedford and R. L. Shultz (CIT field party), summer, 1950.

Locality and age: CIT locality no. 505 (equivalent of LACM locality no. 1136); Morelia lacustrine basin, near La Goleta, and east of Morelia, state of Michoacan, Mexico; Goleta formation, in slightly consolidated sandstone approximately 10 feet below diatomite stratum; middle or late Pliocene (Hemphillian or early Blancan).

Diagnosis: Compared with coracoids of Recent cormorants, closest to *Phalacrocorax olivaceus*, but smaller (5 per cent shorter than minimum of four specimens of the Recent species, 13 per cent shorter than maximum); and further distinguished by (1) area from top of glenoid facet to tip of head relatively, as well as actually shorter, (2) posterior contour of head more abruptly rotated medianly (see Fig. 1 D), with brachial tuberosity projected so as to produce an even more angular contour of the area as seen in external view (Fig. 1 C), (3) depression of neck equal in depth, but more circumscribed (pitlike), (4) anterior intermuscular line more lateral (external) in position (Fig. 1 A). See Table 1 for measurements and proportions.

Referred material: Distal end of left humerus, LACM 3166, from type locality; collected by L. C. Bessom (with LACM field party),

TABLE 1

Measurements of coracoid and humerus of *P. goletensis* and *P. olivaceus*

	P. goletensis	*P. olivaceus* (4 specimens)
Coracoid		
a. Length from head to internal sternal angle	47.7 mm.	50.0mm. -53.7mm.
b. Distance from head to scapular facet (calipers placed under facet)	15.4	17.1 -18.0
c. Distance from top of glenoid facet to tip of head	8.1	9.1 - 9.9
d. Anteroposterior breadth immediately above procoracoid	7.1	7.3 - 7.5
e. Distance from anterior intermuscular line to internal sternal angle (measured along upper level of sternal facet)	9.5	7.5 - 8.3
Ratio of measurement *c* to measurement *a* above	16.9%	17.8% -18.8%
Ratio of measurement *e* to measurement *a* above	20.0%	14.5% -15.4%
Humerus		
a. Greatest breadth distal end	10.6 mm.	11.0mm. -12.0mm.
b. Distal breadth across condyles only	8.9	9.4 -10.0
c. External depth distal end	7.4	8.1 - 8.8
d. Internal depth distal end	8.8	9.2 -10.0
Ratio of external to internal depth of distal end	84.0%	87.0% -89.3%

May 6, 1955. Resembling humerus of *P. olivaceus* as distinguished from that of *P. pelagicus* in more rounded and more deeply depressed distal terminus of impression of brachialis anticus muscle; distinguished from *P. olivaceus* by relatively less depth of distal end, externally, and generally smaller size (4 to 13 per cent smaller in distal width). See Table 1.

Discussion: The five Recent North American cormorants that were compared with the Pliocene fossil fall into two groups on the basis of shape of the neck and head area of the coracoid, and position of the anterior intermuscular line (with minor variations within each group). In group 1, *P. olivaceus*, *P. auritus*, and *P. carbo*, the lower edge of the furcular facet terminates posteriorly well above the glenoid facet and projects in the area of the brachial tuberosity so as to produce an angular posterior contour of the neck and head area as viewed externally; in group 2, *P. pelagicus* and *P. penicillatus*, the furcular facet terminates lower (nearer the glenoid facet) and there is little (*P. penicillatus*) or no (*P. pelagicus*) angularity of posterior contour. The anterior intermuscular line is more medially placed in group 1 than in group 2. The fossil, *P. goletensis*, is closer to group 1 in the characters of the head and neck, but closer to group 2 in the position of the intermuscular line.

Nineteen fossil cormorants have beeen previously described from tertiary and quaternary deposits of various geographic areas (see Brodkorb, 1963:250-254). Thirteen of these were notably larger than *P. goletensis*. From four of the smaller species (*P. miocaenus* and *P. littoralis* from the Miocene of France, *P. destefani* from the Pliocene of Italy, and *P. vetustus* from the Pleistocene of South Australia), *P. goletensis* is distinguished by the medial curvature of the anterior intermuscular line as it meets the sternal facet. In the four above-named species, the line is either straighter or more externally directed (see Lambrecht, 1933:290-298).

Through the courtesy of Dr. J. A. Shotwell of the Museum of Natural History, University of Oregon, I have been able to examine the type tarsometatarsus and referred lower end of coracoid of *P. leptopus* Brodkorb (1961:170-172) and the middle and lower Pliocene (respectively) of Oregon. These bones, though representing a relatively small cormorant, are larger than comparable elements of *P. olivaceus*. Calipered measurements are difficult to make on the Oregon coracoid; not only is the upper end lacking, but the bone is broken through the sternocoracoidal process and sternal facet so that the point of distal termination of the anterior intermuscular line cannot be determined. Bone-to-bone comparisons indicate close size agreement with large individuals of *P. pelagicus* that are 20 per cent longer than the type of *P. goletensis*. Shaft dimensions at the narrowest part preserved in the coracoid of *P. leptopus* are 4.4 x 5.8 mm. At an estimated similar location on the type of *P. goletensis* (point of greatest anteroposterior bend), the dimensions are 3.5 x 4.6 mm. More significant than the size difference is the character of the internal angle of the sternal end and the development of the upper lip of the sternal facet. In *P. leptopus* the sternal angle is blunt, and the lip of the facet is large, both in lateral and posterior extent. In *P. goletensis* the sternal angle is sharper, and the lip of the facet is relatively, as well as actually smaller. In this latter character, the Mexican fossil resembles *P. olivaceus*, whereas *P. leptopus* is closer to *P. pelagicus*.

P. pampeanus, from the Pleistocene (Pampean formation) of Argentina, may be within the size range of *P. goletensis*. It is known only from the type, a proximal end of humerus described (Moreno and Mercerat, 1891: 35) as being slightly smaller than this element of "*P. brasilianus*" (= *P. olivaceus*). No measurements are given, and the two views of the bone that are illustrated (*Ibid.*: pl. xviii, figs. 8-8a) do not agree in size. Neither view, however, shows the specimen to be of lesser dimensions than the minimum humerus of *P. olivaceus* now available for comparison (Univ. Calif. Mus. Vert. Zool. no 126084, a femal from Mexico). The description of the type of *P. pampeanus* specifies slight distinctions from *P. olivaceus*, which are difficult to evaluate. In several instances, the four specimens of *P. olivaceus* now at hand show a variability that seems to include the characters referred to *P. pampeanus*. No direct comparison can be made between the humeri of *P. pampeanus* and *P. goletensis*; the type of the former is a proximal end, the referred specimen of the latter is a distal end. In view of the fact that the South American Pampean formation is considered to be of latest Pleistocene (Rancholabrean) age (Stirton, 1953: 606), whereas the Goleta formation is, at most, late Pliocene (an age difference of at least a million years), I believe it wiser to name the Mexican fossil as a separate species rather than to allocate it, even tentatively, to *P. pampeanus*. It seems likely that *P. pampeanus* bore closer relationship to the living *P. olivaceus* (geologically separated by some 15,000-30,000 years) than to the earlier *P. goletensis*. Either, or both of the fossils may have been in the ancestral line to *P. olivaceus*.

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A MIOCENE DUGONGID FROM BAJA CALIFORNIA, MEXICO

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INTRODUCTION

Dugongs, commonly referred to as sea cows, are interesting and comparatively little-known aquatic mammals which live today in coastal waters of the Indian Ocean, Red Sea and the southwestern Pacific Ocean. The fossil record reveals, however, that during the Cenozoic Era dugongids lived in many other parts of the world including the eastern Pacific bordering North and Central America. In 1957, fragments of the jaw of an adult dugongid were collected from the Ysidro Formation exposed near La Purisima, a principal community located 180 miles northwest of La Paz near the Pacific Coast of southern Baja California. This discovery marked the fourth dugongid from Cenozoic beds of the Pacific Coast of North and Central America including the second from Baja California. Although the relative ages of the four dugongids is not clearly understood, present evidence suggests that the La Purisima dugongid may be the oldest of the group. The Ysidro marine invertebrate fauna with which the jaw was associated appears to be no younger than the Temblor fauna (middle Miocene) or older than the Vaqueros fauna (early Miocene) of the California megafaunal sequence.

ACKNOWLEDGMENTS

The jaw was collected by E. C. Allison and the writer during a reconnaissance of Baja California in 1957 sponsored by the Museum of Paleontology and the Associates of Tropical Biogeography, University of California, Berkeley. I am grateful to Dr. R. H. Reinhart, Dr.

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[1] Department of Physical Science.

D. E. Savage and Dr. R. A. Stirton for helpful discussion of the present paper. Mr. Howard E. Hamman prepared the illustrations.

Order Sirenia

Family Dugongidae

Halianassa(?) allisoni, new species

Figures 1 and 2

Holotype:—Right lower jaw: Horizontal ramus broken off at the mandibular canal foramen, most of symphyseal region missing, M_3 complete, alveoli for M_2, M_1, P_4, and P_3 present, ascending ramus represented by massateric fossa only. *Left lower jaw:* Includes portion of horizontal ramus dorsal to mandibular canal, incomplete M_3, alveolus for M_2 and lingual portion of alveolus for M_1. *Left coronoid process:* fragment with segments of anterior and posterior margins preserved. University of California, Berkeley, Museum of Paleontology No. 47250. The new species is named in honor of its discoverer, Dr. Edwin C. Allison, Department of Geology, San Diego State College, San Diego, California.

Type Locality:—Approximately ¾ mile NNE of the town of La Purisima near base of cliff which forms north bank of major stream in the Arroyo Purisima. This site is about 100 yards downstream from end of side road which branches off the main La Purisima-San Ysidro road about 0.4 miles east of La Purisima and ends at stream. Cliff is composed of gently-folded light-gray and yellowish-brown calcareous sandstone and siltstones totaling about 75 feet in thickness. Near the base of this section is a fine grained, gray sandstone bed about 10 feet thick which forms a prominent overhanging ledge about 150 long ranging from 6 to 25 feet above ground level. The dugongid fossils were collected from the basal part of this sandstone about 8 feet above ground level at the east end of the ledgeforming sandstone.

Formation:—Ysidro.

Age:—Early-middle Miocene.

Diagnosis:—Mandible short, deep, heavily built; medial surface of mandible below M_3 slightly concave, lateral surface slightly convex; M_3 distinctly bilophid, two subcircular roots, metaconid and entoconid of nearly equal size as are hypoconid and protoconid, anteromedially-directed process extends from hypoconid into transverse valley, hypoconulid area includes four tightly-packed cusps partially encircling a fifth cusp which adjoins hypolophid, hypoco-

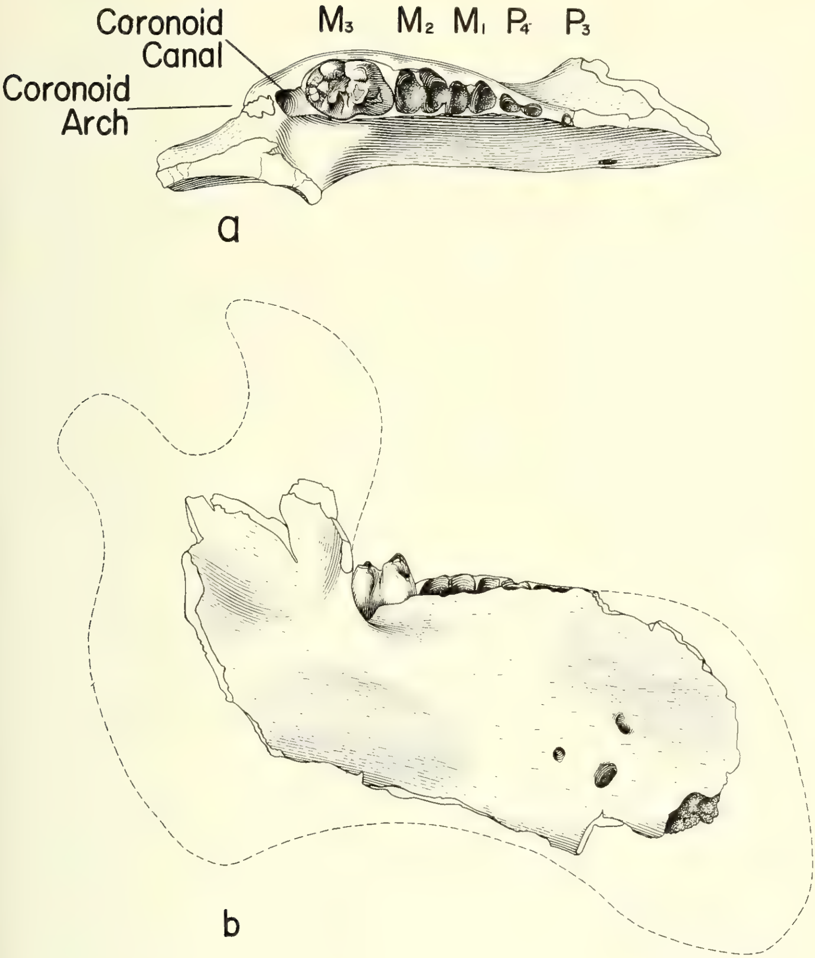

Figure 1. Halianassa (?) *allisoni*, new species, UCMP 47250, Ysidro Formation, La Purisima, Baja California, Mexico. a, right mandible, occlusal view; b, right mandible, lateral view.

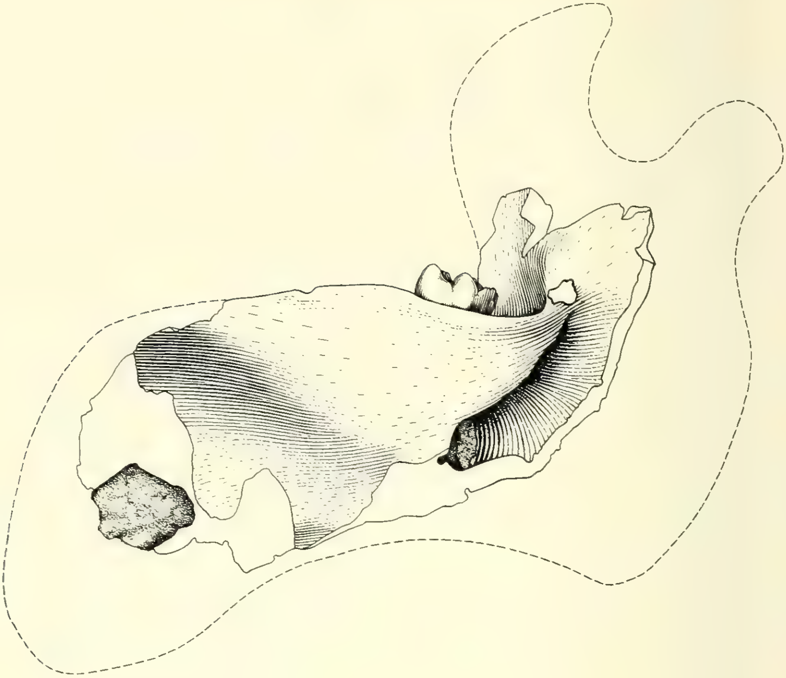

Figure 2. Halianassa (?) *allisoni*, new species, UCMP 47250, Ysidro Formation, La Purisima, Baja California, Mexico. Right mandible, medial view.

nulid area partially concealed from lateral view by anterior margin of ascending ramus; margin of coronoid crest rather thick, rounded and flanged laterally.

Mandible. The horizontal ramus resembles *Dugong* with respect to size and shape but is more stoutly constructed. The ventral margin is not well preserved but the curvature of laminated bone in this region suggests a broader ventral arch in the horizontal ramus than in *Dugong*. The anterior lateral surface is curved outward less strongly than *Dugong* but the posterior curvature of the symphysis is like *Dugong* and the manatee *Trichechus*. The downward deflection of the symphysis is comparable to *Dugong*. The medial and lateral surfaces below M_2 alveolus are slightly concave and convex, respectively. A large, shallow depression, broken off ventrally, is present on the posterior lateral surface of the horizontal ramus extending from the area below the coronoid crest anteriorly to a location ventral to M_2 alveolus.

The mandibular canal is large and elliptical in cross section with the long axis vertical. It increases in area anteriorly and opposite the symphysis is deflected moderately downward. Three small mental foramina, spaced as on the corners of a right triangle are located on the anterolateral surface, posterior to the mandibular foramen, and appear to lead directly into the mandibular canal.

The masseteric fossa forms a slightly deeper depression than in *Dugong* and possesses faint grooves and pits which may be attaching points of the masseter muscle. The preserved basal part of the coronoid crest is vertical, thick (5mm.) and rounded. It is turned out sharply in an anterolateral direction. The coronoid crest is joined to the horizontal ramus by a strongly-developed curved ridge which merges with the ramus below M_3.

The medial wall of the ascending ramus, opposite the masseteric fossa, consists of an anterior vertical surface which faces anteromedially from a position posterolateral to M_3 and a posterior vertical surface which faces posteromedially. These two vertical surfaces intersect to form a prominent, vertical ridge which is joined to the medial margin of the alveolar row by a small arch.

The coronoid process is represented by a fragment which closely resembles the lower part of the coronoid process in *Dugong*. The anterior and posterior margins are thick and rounded but the anterior one is sharper and is flanged strongly outward.

The tooth row is complete including M_3 and anterior alveoli sufficient for M_2, M_1, P_4 and P_3. The alveolar borders converge anteriorly from a maximum width at M_3 until they join to form a narrow diastem. In profile, the dorsal alveolar margins arch slightly upward. The medial alveolar borders are higher than the lateral borders especially opposite M_3. The sockets for M_2 and M_1 indicate double-rooted teeth with roots located anteriorly and posteriorly. In M_2 the alveoli for the anterior and posterior roots appear to slant steeply anteriorly and posteriorly whereas the root alveoli in M_1 are essentially vertical. The M_2 socket indicates a subquadrate tooth about ⅔ the occlusal area of M_3 while the M_1 socket suggests a similar outline about one-half the occlusal area of M_3.

Anterior to M_1 are two small alveoli for P_4. The size of the alveoli indicate a tooth of essentially the same length as M_1 but only about one-third the width. A small circular pit, interpreted as the alveolus for a single-rooted P_3, lies anterior to P_4 within the narrow diastem.

Posterior to M_3 the dental groove narrows sharply and is roofed by a small arch of bone which connects the ascending ramus and the medial margin of the tooth row. Similar arches are found in *Dugong*, *Trichechus* and in many other mammals. In *Trichechus* the archway is large enough for the forward passage of cheek teeth which apparently are produced in a single dental capsule located posterior and ventral to the archway. In *Dugong*, and in the specimen from La Purisima, the archway is much too small to allow passage of teeth and may served in these forms only as a strengthening feature between the horizontal and ascending rami. The arch and archway are designated herein as the *coronoid arch* and *coronoid canal*, respectively (Fig. 1).

M_3 in the right mandible is complete and only slightly worn. It is of moderate size, subquadrate in outline and may be regarded as a bilophid-bunodont tooth with well-developed protoconid, hypoconid, entoconid and metaconid cusps and hypoconulid area. The roots are two in number and subcircular. The enamel extends only slightly below the alveolar border. Both protolophid and hypolophid are distinct, transverse ridges. The protoconid and hypoconid are transversely elongate prominences of comparable size and shape. The protoconid is the most heavily worn cusp and is represented by a triangularly-shaped, near-flat surface composed of an outer layer of grayish-brown enamel and an inner area of yellowish-brown dentine. The enamel of the hypoconid has been slightly worn on the anterior side of the cuspid so that a small ovate surface has been formed which declines anteriorly. Near the center of the tooth a spur from the hypoconid curves anteromedially down over the anterior surface of the hypolophid and partially obstructs the transverse valley. A very low ridge follows the bottom of the transverse valley extending from the base of the spur to the lateral margin of the tooth. The metaconid and entoconid are semi-circular cusps similar to each other in size and shape and are about one-third the size of the protoconid and hypoconid by shallow notches located about one-third the distance from the medial to the lateral margins of the lophs. The metaconid and entoconid are worn slightly and the surfaces of wear decline posterolaterally.

The hypoconulid area is lower than the hypolophid and is composed of four, closely-compressed cusps which form the semi-circular posterior margin of the tooth. Another cusp is centrally located and obstructs the posterior valley formed between the four posterior cusps and the hypolophid. No cingulum is present but a small V-shaped, indentation is located on the anterolateral surface of the tooth about halfway between the crest of the protoconid and the base of the enamel.

In the fragment of the left mandible, a large, bowl-shaped pit lies immediately posterior to M_3 and ventral to the coronoid arch. This pit appears to be the remains of a tooth capsule but no dental materials are now evident. The significance of this structure is not clear but it may represent an aberrant development of a fourth molar. No similar structure is present in the right mandible and the corresponding region is somewhat smaller and composed of dense bone.

Most of the mandible is composed of dense, laminated bone except near the posterior margin of the ascending ramus. The relatively high proportion of dense bone suggests that the jaw represents an adult individual.

COMPARISONS

Recent Sirenia

The mandible is similar to that of *Dugong* with respect to shape and length but is more heavily constructed. The deflection angle of the partially-preserved symphysis in *Halianassa* (?) *allisoni* appears nearly equivalent to *Dugong*. The double-rooted, bilophodont M_3 of *H.* (?) *allisoni* differs sharply from the corresponding, small, cylindrical teeth in *Dugong* which possess very small, pointed cuspules arranged in anterior and posterior clumps. Tome (1914) considers the teeth in *Dugong* to be of semi-persistent growth and degenerating. Such degeneration explains the gross dissimilarity between teeth of *Dugong* and *H.* (?) *allisoni*.

The mandible of the extinct Recent genus, *Hydrodamalis*, is about four times larger than that of *H.* (?) *allisoni*, lacks teeth altogether and the ventral margin of the horizontal ramus is nearly straight and more like that found in the Trichechidae. The medial side of the edentulous dorsal ridge sharply overhangs the medial region, a character only faintly represented in *H.* (?) *allisoni*.

The mandible of *Trichechus* possesses a relatively long, slender horizontal ramus which differs sharply from the deeper and more strongly-built, horizontal ramus of *H.* (?) *allisoni*. The M_3 of *H.* (?) *allisoni* is somewhat similar to the smaller homodont, bilophid teeth of *Trichechus* differing principally in being about four times larger, lacking a cingulum and in that the hypoconulid area is relatively lower. Aside from these differences the cheek teeth of *Trichechus* are somewhat comparable to M_3 of *H.* (?) *allisoni* with respect to the arrangement, shape and relative sizes of the cusps and the obstructed transverse valley. The general resemblance of teeth representing the Trichechidae and Dugongidae may be the result of similar adaptations to environment.

Cenozoic Dugongidae from the Pacific Coast of North America

Halianassa vanderhoofi is from beds assigned to the Santa Margarita Formation near Santa Cruz, California. VanderHoof (1941) and Reinhart (1959) regard this species as of Tortonian age (early late Miocene) based on a comparison with European dugongids. Mitchell and Repenning (1963) indicate that marine invertebrate fossils found in the same Santa Margarita beds are "suggestive of a very late Miocene age (Neroly Stage)." *H. vanderhoofi* consists of a skull, mandible and post-cranial elements. The jaw is approximately 1.75 times larger than that of *H.* (?) *allisoni*. The medial margin of the alveolar wall markedly overhangs the medial region reminiscent of *Hydrodamalis* but much more pronounced than in *H.* (?) *allisoni*. The protolophid is lost in M_3 of *H. vanderhoofi*. The hypolophid measures 22.50mm. in width compared to 19.8mm. in *H.* (?) *allisoni* and is composed of relatively loosely-packed cuspules which do not coalesce to form a distinct transverse loph as in the La Purisima specimen. The hypoconulid area is composed of 3 cuspules separated from the entoconid and hypoconid by a hexagonal lake while in *H.* (?) *allisoni* there are four, tightly-packed cuspules partially encircling a fifth which adjoins the hypolophid. No anteriorly-directed process extends from the hypoconid into the transverse valley in M_3 of *H. vanderhoofi* as it does in *H.* (?) *allisoni*. There is no evidence of P_3 in *H. vanderhoofi* although it appears to have been present in *H.* (?) *allisoni*. The coronoid crest is not sharply turned out or rounded and in this respect *H. vanderhoofi* is similar to *Halianassa* sp. indet. from Punta Pequena, southern Baja California (Reinhart, 1959).

The skull of *Halianassa* (=*Metaxytherium*) *jordani* was described by Kellogg (1928) from diatomaceous deposits near Lompoc, California which have been mapped as the Sisquoc Formation by Dibblee (1950). Kellogg regarded the sirenian to be "Sarmatian, or Upper Miocene" in age although it was apparently collected from a Sisquoc horizon which may be early Pliocene or even middle Pliocene in age according to Dibblee. The skull is virtually the same size as *H. vanderhoofi* and differs from the latter species only in minor differences in the sizes of the frontals and parietals. Reinhart

(1959) interprets *H. vanderhoofi* and *H.* (=*Metaxytherium*) *jordani* as being closely related species. Although no mandibular elements were apparently recovered with the skull of *H.* (=*Metaxytherium*) *jordani* the size of the mandible would be expected to be nearly equal to that of *H. vanderhoofi* and considerably larger than the adult mandible of *H.* (?) *allisoni.*

Cenozoic Dugongidae from the Pacific Coast of Central America

Halianassa sp. indet. from the Ysidro Formation at Punta Pequena, Baja California includes cranial and post-cranial elements and a mandible which are interpreted by Reinhart (1959) as those of an adolescent individual. The mandible lacks the tooth row dorsal to the mandibular canal but otherwise is complete. It is of nearly the same length as the adult mandible of *H.* (?) *allisoni* but due to its youthful stage is much more delicately formed. The ascending ramus is remarkably similar to that of *H. vanderhoofi* with respect to outline and the relative sizes and positions of the masseteric fossa and the two large fossae of the medial surface. The ventral margin of the horizontal ramus appears to be more strongly arched than in *H.* (?) *allisoni.* The coronoid crest of *Halianassa* sp. indet. is directed in an anterior-posterior direction unlike that of *H.* (?) *allisoni* which is sharply turned out laterally. Along the dorsal medial edge of the symphysis there is an elongate fossa which is not apparent in *H.* (?) *allisoni.* Cranial elements of the adolescent *Halianassa* sp. indet. are nearly as large as corresponding bones in adult *Felsinotherium serresi* from France and somewhat larger than those of a mature *Dugong.* Reinhart (1959) considers that *Halianassa* sp. indet. in the adult stage would be large and referable to either *H. vanderhoofi* or *H.* (=*Metaxytherium*) *jordani.* In any case, *Halianassa* sp. indet. when fully grown would be expected to be considerably larger than an adult *H.* (?) *allisoni.*

Cenozoic Dugongidae from the Atlantic Coast of North America

Dugongid fossils, mainly skull and post-cranial elements, are known from Cenozoic deposits in Maryland, South Carolina, New Jersey and Virginia. Many of the fossils are fragmentary and of doubtful provenance. No mandibles have been reported and only one lower tooth has been described. This tooth was recovered from the Ashley Creek beds, South Carolina, and described by Leidy (1873) under the name *Manatus inornatus.* It is a small, rectangular, molar(?) with well-developed bicuspid lophs and a simple hypoconulid area. The tooth is distinct from M_3 of *H.* (?) *allisoni* because of its much smaller size and less complex hypoconulid area. The occlusal outline appears to be more elongate than would be expected for either M_2 or M_1 of the La Purisima specimen. Simpson (1932) considers this tooth to be generically indeterminate.

Cenozoic Dugongidae from Florida

Although numerous dugongid remains have been collected from Cenozoic deposits in Florida no mandibles have been reported and only a single, lower tooth has been described. Hay (1922) provisionally referred a tooth, believed to be the right hindermost molar (M_3) of a sea cow, to *Metaxytherium floridanum.* This tooth is nearly identical in occlusal outline and dimensions to that of M_3 of *H.* (?) *allisoni* but is heavily worn and few details of the cusp morphology are evident. It was collected as beach drift in Manatee County, Florida associated with mammal and fish debris believed by Hay to have been derived from Miocene, Pliocene and Pleistocene beds of the region. This tooth is of doubtful value in a comparison to M_3 of *H.* (?) *allisoni* although it may represent a similar stage of evolution.

Hesperosiren crategensis Simpson (1932) from the Hawthorn Formation (Miocene) is based upon a skull and post-cranial elements. The length of the upper tooth row is nearly identical to the lower tooth row in *H.* (?) *allisoni* but the rostral deflection as reconstructed by Simpson is considerably less than that which would be expected to accommodate the mandible of *H.* (?) *allisoni.* Simpson (1932) suggests that *H. craetegensis* is close in actual affinity to *Metaxytherium* but is slightly more aberrant in specialization.

Cenozoic Dugongidae from the Caribbean region

Caribosiren turneri was recovered from the San Sebastian Formation (Oligocene) of Puerto Rico and consists of a skull and post-cranial elements (Reinhart, 1959). The rostral deflection of the skull corresponds roughly to the deflection angle of the preserved symphyseal region in *H.* (?) *allisoni.* The upper tooth row in *C. turneri* is slightly shorter than that of the lower jaw of *H.* (?) *allisoni* but it includes an equivalent number of molars (M_1, M_2 and M_3) and premolars (P_3 and P_4). These similarities suggest that *C. turneri* represents a stage of evolution near to that of *H.* (?) *allisoni.* Reinhart (1959) considers *C. turneri* to be assignable to the Haliannasidae.

(?) *Halitherium antillense*, described by Matthew (1915) from middle Oligocene(?) shales near Juana Diaz, Puerto Rico, is based upon a left, lower jaw with M_1, M_2 and M_3 preserved. The alveoli anterior to M_1 are interpreted by Matthew as representing three premolars, a condition more primitive than that found in *H.* (?) *allisoni*. The shape of the posterior part of the jaw is suggestive of *Halitherium* but the molars are heavily worn and damaged and reveal few details of comparative value. Matthew considered the Puerto Rican jaw to be that of a halithere possessing characters reminiscent of two European species, *Halitherium schinzi* (Oligocene) and *Halitherium christoli* (lower Miocene).

Cenozoic Dugongidae of Europe

Of the European dugongids, *H.* (?) *allisoni* appears nearest to *Metaxytherium cuvieri* de Christol from the middle Miocene (Vindobonian) of France. The length of the mandible is essentially the same and the shape is similar except that the ventral arch of the horizontal ramus appears more sharply rounded in the French species. The number of molars is the same as in *H.* (?) *allisoni* but only a single premolar (P_4) compared to two premolars (P_3 and P_4) for the Mexican species. The right M_3 of *M. cuvieri* is a bunobilophodont tooth of virtually the same size as M_3 in *H.* (?) *allisoni* and the cusps are comparable with respect to size and position. Although the figure of this tooth in Deperet and Roman (1920) is not clear, a narrow spur appears to extend from the hypoconid anteromedially into the transverse valley as in *H.* (?) *allisoni*. In *M. cuvieri*, however, all the remaining cheek teeth are larger than those which would be expected to occupy the corresponding alveoli in *H.* (?) *allisoni*. In fact, M_2 is longer than M_3 in *M. cuvieri* whereas in *H.* (?) *allisoni* the M_2 alveoli indicate a smaller tooth than M_3. The mandibular foramen in *M. cuvieri* occupies a somewhat different position as that in *H.* (?) *allisoni* being located directly below P_4 while in the La Purisima jaw it is below the anteriormost part of the diastem.

The mandible of *Felsinotherium serresi* Deperet and Roman (1920) from the Pliocene of France closely resembles *H.* (?) *allisoni* although it is slightly smaller and possesses a more strongly produced ventral arch of the horizontal ramus. The right M_3 figured by Deperet and Roman (1920) is a bilophodont tooth similar in size, occlusal outline and cusp pattern. A cluster of small cuspules between the entoconid and hypoconid obstructs the transverse valley in M_3 of *F. serresi* differing from M_3 in *H.* (?) *allisoni* in which the transverse valley is partially obstructed by a narrow spur. The cheek teeth include three molars (M_1, M_2 and M_3) and a single premolar (P_4) with no evidence of P_3 having been present. P_4 appears to be proportionately much more reduced than in *H.* (?) *allisoni.*

In *Thallatosiren petersi* from the middle Miocene (Vindobonian) of Austria, the M_3 (M_4 in Abel, 1904) is a subrectangular to oval-shaped tooth sharply constricted the transverse valley. Between the protoconid and metaconid and also between the hypoconid and entoconid are clumps of from two to three additional cusps which do not occur in *H.* (?) *allisoni.*

The mandible of *Felsinotherium forestii* from the Pliocene of Italy (Capellini, 1872) is larger than that of *H.* (?) *allisoni* and possesses a more sharply rounded ventral arch of the horizontal ramus. The rectangular M_3 is larger and the bilophodonty less distinctly developed. The anterior part of the tooth consists of a single, moderately worn prominence while the posterior two-thirds is composed of a series of irregularly arranged cusps, a condition not found in *H.* (?) *allisoni.*

The M_3 of *Felsinotherium gervasi* from the Pliocene of Italy (Bruno, 1839) differs sharply from M_3 of *H.* (?) *allisoni* in that the anterior and posterior lophs are composed of nine and seven cusps, respectively, compared to bicuspate lophs in the Mexican species. The hypoconulid area of *F. gervasi* is more complex and more strongly produced than in *H.* (?) *allisoni.*

The mandible of *Halitherium schinzi* from the Oligocene of France (Lepsius, 1882) is similar in length to that of *H.* (?) *allisoni* but is much slenderer and less strongly constructed. The larger number of teeth in *H. schinzi* is decidedly more primitive than the condition in *H.* (?) *allisoni*, the former possessing seven cheek teeth compared to five for the latter. The right posterior molar (M_4 according to Lepsius, 1882) is slightly larger than M_3 of *H.* (?) *allisoni.* It consists of seven, large, cone-shaped cusps located along the margins of the tooth which produce a winding, longitudinal valley. This condition is sharply different from the well-developed transverse lophs and valley of *H.* (?) *allisoni.*

The mandible of *Halitherium christoli* from the lower Miocene of Austria (Abel, 1904) is slightly larger than that of *H. schinzi* but is of similar shape. M_3 of *H. christoli* differs from M_3 of *H.* (?) *allisoni* in that the occlusal outline is more oval and the transverse valley is sharply bent, a condition not found in the Mexican species.

The left posterior molar (M_4 of Abel, 1904) of *Metaxytherium* *krahuletzi* from the early Miocene (Burdigalian) is a bilophid, subquadrate tooth slightly larger than M_3 of *H.* (?) *allisoni*. The anterior loph is nearly twice the width of the posterior loph. The disproportion in loph width is not found in the La Purisima specimen in which the lophs have essentially the same width.

Other European species including *Miosiren kocki*, *Metaxytherium beaumonti* and *Halitherium bellunense* do not appear sufficiently comparable to *H.* (?) *allisoni* to warrant comment here.

Affinities

The classifications of the Sirenia proposed by Simpson (1934; 1945) and by Reinhart (1959) are based upon cranial and post-cranial elements. Because of this circumstance the isolated mandible of *H.* (?) *allisoni*, while that of an adult dugongid, cannot be referred to any of the established genera except on a questionable basis. The relatively short, deep horizontal ramus and well-developed, buno-bilophodont M_3 with partially obstructed transverse valley stamp the La Purisima jaw as decidedly closer to *Halianassa* (=*Metaxytherium*) and *Felsinotherium* than to *Halitherium* or any other Cenozoic genus. That all previous dugongid remains recovered from Cenozoic deposits of the Pacific Coast of North and Central America have also been assigned to either *Halianassa* or its synonym *Metaxytherium* lends additional although by no means conclusive support to the present referral to *Halianassa*. The difficulty of satisfactorily separating *Halianassa* and *Felsinotherium* is well known. Capellini (1872) considered the two genera synonymous and Simpson (1934) and Gregory (1941) both have pointed out that the differences proposed to separate these genera are rather slight and inconstant.

On the basis of current evidence of Old and New World dugongids, *H.* (?) *allisoni* appears morphologically nearest to *Metaxytherium cuvieri* from France. The rather marked similarity existing between M_3 of *M. cuvieri*, *F. serresi*, and *H.* (?) *allisoni* suggests that these species may represent a particular line of dugongid development. *H. vanderhoofi* differs significantly from *H.* (?) *allisoni* and seems unlikely to be on the main line of descent from the latter species. The phyletic relationship between the juvenile *Halianassa* sp. indet. from Punta Pequena, Baja California, and the adult *H.* (?) *allisoni* is uncertain. In the adult stage, Reinhart (1959) suggests that *Halianassa* sp. indet. would be expected to grow to a large size and would be referable to either *H. vanderhoofi* or *H. jordani*. It may, therefore, be considered to express a more advanced stage of evolution than *H.* (?) *allisoni.*

The present evidence of dugongid mandibles or lower dentition from Cenozoic deposits of the Atlanti Coast of North America, Florida and the Caribbean region is exceedingly meagre and any inferences concerning phyletic relationship between species of these regions and *H.* (?) *allisoni* must be highly speculative. It is unfortunate that neither *Hesperosiren craetegensis* from the Miocene of Florida nor *Caribosiren turneri* from the Oligocene of Puerto Rico, near contemporaries of *H.* (?) *allisoni*, are represented by mandibles or lower dentition. It is possible that one or the other of these species may ultimately by found to be closely related to *H.* (?) *allisoni.*

AGE OF HALIANASSA (?) ALLISONI

The Ysidro Formation, from which the jaw of *H.* (?) *allisoni* was collected, was named by Heim (1922) for clastic sedimentary rocks exposed 2 miles N.E. of La Purisima near the village of San Ysidro. Beal (Anon., 1924; 1948) later extended the usage of the Ysidro Formation recognizing it throughout much of southern Baja California. The Ysidro fauna includes abundant, shallow water, marine mollusks and echinoderms associated with shark teeth, dugongid remains and numerous indeterminate mammal bones. Such molluscan genera as *Lyropecten*, *Codakia*, and *Strombus* associated with *Turritella*, *Cypraea*, *Terebra* and *Chione* point to subtropical marine conditions.

The Ysidro marine invertebrate fauna has been studied by a number of competent paleontologists. Hertlein and Jordan (1927) interpreted collections from the Ysidro at La Purisima, San Ignacio, the Western Cape region and near La Paz as equivalent at least in part to the lower part of the Temblor fauna of California (early to middle Miocene). Loel and Corey (1932) compared a collection of 64 invertebrates, mostly mollusks, from the Ysidro with those of the Temblor and Vaqueros. They concluded that the assemblage as a whole favored a correlation with the upper part of the Vaqueros fauna (early Miocene) of California. The Ysidro fauna with which the jaw of *H.* (?) *allisoni* was associated would appear, on the basis of these opinions, to be not younger than the Temblor (middle Miocene) or older than the Vaqueros (early Miocene) of the California megafaunal sequence (Weaver, 1944). However, until the fauna and biostratigraphy of the Ysidro is more completely known the present interpretation of age for *H.* (?) *allisoni* should be considered as tentative.

Age Relationships with Dugongids from the Pacific Coast

If the preceding correlation of the Ysidro fauna with the Temblor-Vaqueros faunas is correct, then *H.* (?) *allisoni* is older than either *H. vanderhoofi* from the Santa Margarita beds (late Miocene), Santa Cruz County, California or *H.* (=*Metaxytherium*) *jordani* from the Sisquoc Formation (late Miocene-early Pliocene), Santa Barbara County, California. The Santa Margarita and Sisquoc beds are in part equivalent in age but their faunas have been strongly established as younger than those from either the Temblor or Vaqueros formations (Weaver, 1949).

Halianassa sp. indet. was discovered at Punta Pequena located on the Pacific Coast of southern Baja California about 27 miles west of La Purisima. Both *H.* (?) *allisoni* and *Halianassa* sp. indet. were collected from beds mapped as the Ysidro sandstone member of the Ysidro Formation by Beal (1948). This unit was later renamed San Raymundo Formation by Mina (1957). Neither the work of Beal or Mina is, however, sufficiently detailed as to permit the determination of a precise or even approximate stratigraphic relationship between the two dugongid sites.

The marine invertebrate fossils found with *Halianassa* sp. indet. are far too meagre and poorly preserved to be useful in relating the two dugongid sites. According to Reinhart (1959) three molluscan genera were recognized including *Lucina*, *Chione*, and *Turritella* but none of these were identifiable to species. Fragments of a small, scutellid echinoid like *Merriamaster pacificus* were also found. *M. pacificus* is regarded as a Pliocene species by Grant and Hertlein (1938) and has been found in the San Diego and Saugus formations and Pliocene beds on Cedros Island. However, until better fossils can be collected from the Punta Pequena beds no meaningful age interpretation can be made for *Halianassa* sp. indet.

The dugongid remains themselves, the adult *H.* (?) *allisoni* and the juvenile *Halianassa* sp. indet., also do not offer a promising basis for interpretation of relative age. If Reinhart (1959) has correctly interpreted that the juvenile jaw of *Halianassa* sp. indet. in the adult stage would be of a size comparable to either *H. vanderhoofi* or *H. jordani* it may be tentatively concluded that the Punta Pequena species represents a more advanced stage of evolution than *H.* (?) *allisoni* and is, therefore, younger in age. Reinhart (1959) considers

Halianassa sp. indet. as representing a middle to upper Miocene stage of evolution. All that can be stated at present is that *Halianassa* sp. indet. is probably not older than *H.* (?) *allisoni* and there are some indications that it is younger.

CONCLUSIONS

1. The lower jaw from La Purisima is that of an adult dugongid questionably referred to the genus *Halianassa.*

2. The dugongid appears to be a new species and is herein designated *Halianassa* (?) *allisoni.*

3. *Halianassa* (?) *allisoni* is older than either *H.* (=*Metaxytherium*) *jordani* or *H. vanderhoofi* from California.

4. *H.* (?) *allisoni* is probably not younger than *Halianassa* sp. indet. from Punta Pequena, southern Baja California and there are some indications that it is older.

5. *H.* (?) *allisoni* and the associated Ysidro marine invertebrate fauna are considered to be no younger than the Temblor fauna (middle Miocene) or older than the Vaqueros fauna (early Miocene) of the California megafaunal sequence.

6. *H.* (?) *allisoni* is closer phyletically to *Metaxytherium cuvieri* and *Felsinotherium serresi* from Europe than to any known species from the Western Hemisphere.

TABLE OF DIMENSIONS (mm)

Mandible

Maximum length of fragment (Broken posterior edge of ascending ramus to broken anterior edge of symphysis)	195.0
Maximum height of fragment (Broken dorsal edge of ascending ramus to ventral edge of symphysis)	122.0
Maximum width of fragment (Coronoid crest to medial wall of horizontal ramus)	50.0
Thickness of horizontal ramus (Below M_3)	35.0

Lower Dentition

Length of tooth row (Anterior edge of P_3 alveolus to posterior surface of M_3)	87.0
Anterior-posterior diameter:	
M_3	26.5

M_2	2 alveoli	17.0
M_1	2 alveoli	15.0
P_4	2 alveoli	14.0
P_3	alveolus	2.5
Transverse diameter:		
M_3	maximum across hypoconid-metaconid	19.8
	minimum across protoconid-entoconid	18.3
M_2	both alveoli	15.0
M_1	anterior alveolus	10.0
	posterior alveolus	11.0
P_4	anterior alveolus	4.0
	posterior alveolus	5.0
P_3	alveolus	2.5
Crown height above alveolus:		
M_3	labial	14.0
M_3	lingual	10.0

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SEASONAL FLUCTUATIONS IN ECTOPARASITE POPULATIONS OF DESERT RODENTS

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Introduction

Ecologists studying rodents at Indian Cove, Joshua Tree National Monument, California, noted a variation in the number of fleas present on the rodents at various seasons (Chew, *et al.*, 1957). It was therefore decided to make monthly collections of ectoparasites for a period of one year in order to obtain both qualitative and quantitative information on these variations.

Previous studies have indicated a correlation between temperature and flea abundance on the California ground squirrel (Stewart and Evans, 1941; Holdenried, *et al.*, 1951). Longanecker and Burroughs (1952) showed that both temperature and humidity may influence flea populations on ground squirrels. Ryckman, *et al.* (1954) demonstrated that rainfall may also influence ground squirrel flea populations.

These climatic factors are interrelated and vary with the seasons and influence the biology and ecology of both the hosts and the ectoparasites. For example, Evans and Freeman (1950) point out that the degree of relationship between different species of hosts may vary with the seasons and thus be reflected in seasonal differences in the ectoparasites on these hosts. Studies have been made which indicate that the ectoparasite populations existing in the burrows and nests of various rodents may show marked seasonal fluctuations (Stewart and Evans, 1941; Howell, 1955). These variations in the nest populations would also be reflected in the kind and number of ectoparasites to be found on the rodents occupying the nests.

None of these previous studies, however, has been directly concerned with seasonal variation in the Siphonaptera to be found on desert rodents. The available information on this subject consists

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[1] Portion of a Thesis presented to the Faculty of the Graduate School, University of Southern California, in partial fulfillment of requirements for the degree of Master of Science (Zoology).

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chiefly of records of geographical and host distributions. This study, therefore, was designed to provide additional information on the ectoparasites of desert rodents and to shed some light on the environmental factors which may influence their presence or absence. This paper deals with the Siphonaptera and a succeeding paper will be concerned with the parasitic Acarina.

Study Area

The study area (Figs. 1 and 2) was located in Indian Cove, Joshua Tree National Monument, California. Indian Cove is an alluvial fan at the mouth of Rattlesnake Canyon on the north side of the Little San Bernardino Mountains. The trapping area was located about two miles inside the Monument boundary at an elevation of 3100 feet. The predominant plants were the creosote bush, *Larrea divaricata*, and the Mohave yucca, *Yucca schidigera*. Most of the plant cover was provided by bunchgrass, *Hilaria rigida*. See Chew and Butterworth (1964) for a more detailed discussion of the study area.

Procedure

The study area was visited monthly for a period of twelve months beginning in September, 1957 and ending in August, 1958. At each visit a standardized procedure for trapping the rodents and removing their ectoparasites was followed.

In order to evaluate the influence, if any, of climatic conditions upon the ectoparasite population, air temperature and humidity were noted at each monthly visit. This information was recorded at about dusk, 10 PM, and dawn, immediately after running the trap lines. Monthly precipitation records from the weather station in Twentynine Palms, 7 miles to the east, were also obtained.

A trapping grid was established consisting of two permanent lines, one hundred feet apart, each with twenty trap stations located fifty feet apart. In addition to these permanent lines, twenty roving lines, each consisting of twenty trap stations placed at fifty-foot intervals, were extended at right angles along one of the permanent lines. At each monthly visit the two permanent lines and a different combination of two roving lines, one hundred feet apart, were trapped. One Sherman live trap was set at each trap station just before dusk and checked at 10 PM, at which time any captured rodents were transferred to quart Mason jars with screen lids, and the traps were reset. At dawn the traps were collected and the rodents were brought to a

Figure 1. The study area at Indian Cove, Joshua Tree National Monument, California.

Figure 2. Detail of study area in Figure 1.

central processing station. There the rodents were anesthetized and their ectoparasites removed. Then each rodent was sexed, marked by toe clipping and released at the trap station where it had been captured.

In the laboratory the various groups of ectoparasites were segregated and prepared for study. The fleas were bleached in 10% KOH, rinsed, neutralized in acid alcohol, treated with ethyl cellosolve and mounted in Canada balsam.

RESULTS

Host Fauna:

A total of 199 individual rodents was trapped, processed for ectoparasites, marked and released. They belonged to six species representing two families:

- Family: Heteromyidae
  - Subfamily: Perognathinae
    - *Perognathus longimembris* (Coues). Little pocket mouse.
    - *Perognathus fallax* Merriam. Spiny pocket mouse.
  - Subfamily: Dipodomyinae
    - *Dipodomys merriami* Mearns. Merriam's kangaroo rat.
- Family: Cricetidae
  - Subfamily: Cricetinae
    - *Peromyscus eremicus* (Baird). Desert white-footed mouse.
    - *Onychomys torridus* (Coues.) Southern grasshopper mouse.
    - *Neotoma lepida* Thomas. Desert wood rat.

This list probably includes all of the nocturnal rodent species normally resident in the study area. The kangaroo rat, *Dipodomys merriami*, was the most abundant rodent during the study period and comprised 51 percent of the total number of rodents captured.

Ectoparasite Fauna:

A total of 203 fleas was collected from the rodents listed above. The kangaroo rat flea, *Meringis dipodomys* Kohls, was the most abundant flea during the study period and comprised 80.2 percent of the total number of fleas collected. Specimens of this species were taken from all of the rodent hosts except *Neotoma lepida*. The other species of fleas collected were *Hoplopsyllus anomalus* (Baker), *Anomiopsyllus nudatus* (Baker), *Orchopeas sexdentatus* (Baker), *Thrassis aridis* Prince, *Thrassis bacchi gladiolis* (Jordan), *Malaraeus* *sinomus* (Jordan) and *Malaraeus telchinum* (Rothschild). The total number of each species and their distribution among the various hosts is shown in Table 1.

Re-infestation:

Of the total number of individual rodents captured, 32 percent were recaptured at least once. Many were captured on a number of consecutive months. Table 2 presents the number of infestations and the number of fleas taken from *Dipodomys merriami* which were captured on two, three and four successive months. The other species of rodents were not recaptured in sufficient numbers to allow any conclusions regarding re-infestation rates.

Seasonal Prevalence of Ectoparasites:

Perognathus longimembris: Only two fleas were collected from this species of rodent. They were both *Meringis dipodomys*, the kangaroo rat flea, and were collected in February.

Perognathus fallax: Only one flea, *Meringis dipodomys*, was collected from this species. It also was taken in February.

Dipodomys merriami: This was the most abundant species of rodent and provided the most complete data on seasonal fluctuations. These data are presented in Table 3.

Peromyscus eremicus: Only two fleas were collected from this species of rodent. One *Meringis dipodomys* was taken in January and one *Malaraeus sinomus* was taken in October.

Onychomys torridus: Six species of fleas were collected from this species of rodent. Their seasonal prevalence is presented in Table 4.

Neotoma lepida: Two species of fleas were obtained from the eight wood rats captured in this study. One *Orchopeas sexdentatus* was taken in May and another in June. In October, eight *Anomiopsyllus nudatus* were removed from one wood rat.

Climatic Conditions:

The mean of the three air temperature and humidity observations made during the night at each monthly visit is presented in Figures 3 and 4. The monthly precipitation recorded at the Twentynine Palms weather station is shown in Figure 5. Since desert rains may often be very localized, the rainfall at Twentynine Palms may differ from that at Indian Cove; but, it appears to be indicative of seasonal precipitation trends in the latter area also (Chew and Butterworth, 1964).

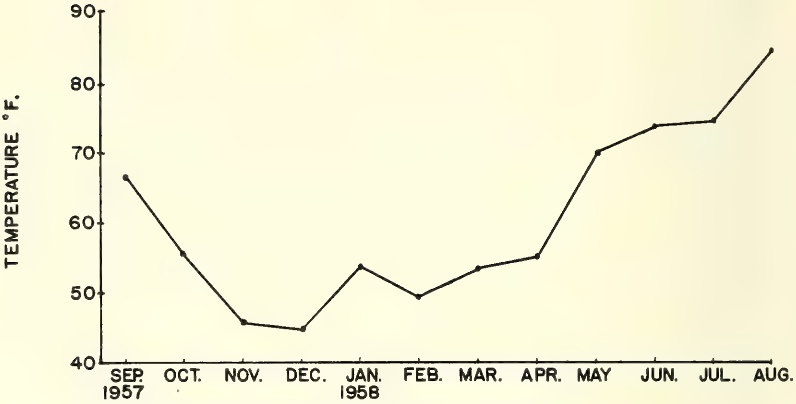

FIG. 3 MEAN NIGHTLY AIR TEMPERATURE.

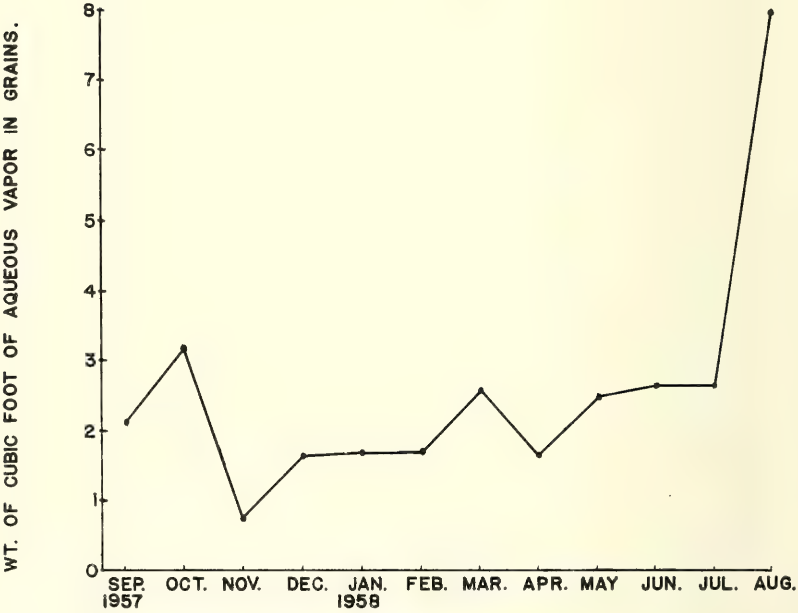

FIG. 4 MEAN NIGHTLY ABSOLUTE HUMIDITY.

Discussion

Host-Ectoparasite Relationships:

Among the various species of fleas collected, several were found on more than one species of rodent or on rodents which are not considered to be the normal host of the flea in question. It is known that the degree of host specificity exhibited by fleas varies greatly among different species of fleas and that some species are highly restricted in their host occurrence, while other species may be found on a number of unrelated small mammals (Evans and Freeman, 1950; Parker and Howell, 1959). The reasons for these varying degrees of host specificity are largely unknown but may include such factors as physiological restriction, environmental distribution (Jameson and Brennan, 1957), seasonal periodism and degree of host interrelationships.

The host distribution of the kangaroo rat flea, *Meringis dipodomys*,

TABLE 1

Index chart of fleas and rodent hosts.
Figure in parenthesis indicates number of captures for each host species.

		Hoplopsyllus anomalus	*Anomiopsyllus nudatus*	*Orchopeas sexdentatus*	*Thrassis aridis*	*Thrassis bacchi gladiolis*	*Meringis dipodomys*	*Malaraeus sinomus*	*Malaraeus telchinum*	Total Number of Fleas on each Host Species
Perognathus longimembris	(62)						2			2
Perognathus fallax	(13)						1			1
Dipodomys merriami	(189)				11		129			140
Peromyscus eremicus	(16)						1	1		2
Onychomys torridus	(30)	4	1		5	7	30		1	48
Neotoma lepida	(10)		8	2						10
Total Fleas by Species		4	9	2	16	7	163	1	1	

as presented in Table 1, seems to be best explained in terms of host interrelationships. This flea is described by Hubbard (1947) as being a "true kangaroo rat flea, but can occasionally be found as strays on other desert mice and rats." This type of stray occurrence or accidental parasitism is common in many species of fleas, but the flea indices are usually highest on hosts belonging to the same genus or family (Jameson and Brennan, 1957). Thus the occurrence of this flea as an occasional stray on the small mice in the study area is to be expected. The fact that it was found in relatively high numbers on *Onychomys torridus* in February and November would seem to indicate that a close ecologic relationship, allowing increased flea transfer, exists at these times between *O. torridus* and the flea's normal host, *Dipodomys merriami*. Since *Onychomys torridus* is reported to be primarily a carnivorous and insectivorous rodent (Bailey and Sperry, 1929), this flea distribution may perhaps be a reflection of a predator-prey relationship similar to that exhibited by the larger carnivores which often harbor ectoparasites characteristic of the animals upon which they feed (Linsdale and Davis, 1956). This same explanation may also apply in the case of *Thrassis aridis* which is normally a kangaroo rat flea but was found in rather high numbers on *O. torridus* in November.

It is perhaps significant to note that the stray occurrence of kangaroo rat fleas on this primarily carnivorous rodent took place largely during the fall and winter of 1957. This was a period of crisis in the study area when plant food was at a minimum (Chew and Butterworth, 1964). Thus it seems feasible to speculate that during this period of hardship the grasshopper mouse was induced to become a predator upon the kangaroo rat.

The occurrence of *Anomiopsyllus nudatus*, a flea normally characteristic of wood rat nests, on *Onychomys torridus* indicates that this rodent must occasionally visit *Neotoma* nests, possibly in search of the rich insect fauna usually present within them. *Hoplopsyllus anomalus* and *Thrassis bacchi gladiolis*, commonly found on the white-tailed antelope squirrel, *Ammospermophilus leucurus*, were also found on *Onychomys torridus* and again seem to indicate that *Onychomys* ranges widely into the burrows of other rodent species in search of food.

Re-infestation:

Rodents which have had their fleas removed become re-infested in a very short time. Evans and Freeman (1950) have demonstrated

TABLE 2

Number of infestations and number of *Meringis dipodomys* taken from *Dipodomys merriami* which were captured on two, three and four successive months.

	Successive Months of Capture			
	First	Second	Third	Fourth
Two-month Records				
Number of Captures	17	17		
Number of Infestations	3	4		
Percent Infested	17.6	24.5		
Total Number of Fleas	7	19		
Fleas per Infestation	2.33	4.75		
Three-month Records				
Number of Captures	6	6	6	
Number of Infestations	3	1	3	
Percent Infested	50	16.6	50	
Total Number of Fleas	3	1	11	
Fleas per Infestation	1	1	3.66	
Four-month Records				
Number of Captures	5	5	5	5
Number of Infestations	1	0	5	4
Percent Infested	20	0	100	80
Total Number of Fleas	1	0	20	9
Fleas per Infestation	1	0	4	2.25

that some rodents regain as many fleas within twenty-four hours as they were found to have after a thirty-day interval of time. In the present study (Table 2), some kangaroo rats were captured and relieved of their ectoparasites on several consecutive months but no difference could be noticed between their flea indices and the flea indices of kangaroo rats captured for the first time.

Seasonal Prevalence:

A number of indices are commonly utilized to indicate the relative abundance of ectoparasites upon their hosts. Table 3 includes the three most significant types of ectoparasite indices, namely: (1) the percent of hosts infested, (2) the mean number of ectoparasites per host, and (3) the mean number of ectoparasites per infested host. Although the relative efficiency of these indices seems to vary somewhat with the species of organism involved and the size of the sample obtained (Cole and Koepke, 1947), the data accumulated in this study clearly indicate a number of seasonal trends.

It is apparent that the two species of kangaroo rat fleas, *Meringis dipodomys* and *Thrassis aridis*, are quite seasonal in their occurrence on their hosts since none were taken during the six-month period from April through September. This absence may be the result of ecologic factors forcing the fleas to abandon their hosts and remain in the burrows and nests, or it may represent an actual decline in the flea population. Howell (1955), utilizing the more readily accessible nests of *Neotoma*, has demonstrated that the flea populations in these nests show an actual decline during the summer months. This may also be the condition existent with the kangaroo rat fleas considered in the present study.

TABLE 3

Monthly prevalences of fleas on *Dipodomys merriami*.
Based on 129 *Meringis dipodomys* and 11 *Thrassis aridis*.
(*T.a.* in parenthesis).

Month	Number Rodents Captured	Number Infested	Percent Infested	Number Fleas	Mean per Rodent	Mean per Infested Rodent
1957						
Sept.	18	0	0	0	0	0
Oct.	25	2	8.0	3	.12	1.50
Nov.	14	10	71.4	34(5)	2.79	3.90
Dec.	14	10	71.4	16(4)	1.43	2.00
1958						
Jan.	24	14	58.3	32	1.33	2.29
Feb.	22	15	68.4	41(2)	1.79	2.87
March	14	3	21.5	3	.21	1.00
April	8	0	0	0	0	0
May	10	0	0	0	0	0
June	16	0	0	0	0	0
July	20	0	0	0	0	0
Aug.	4	0	0	0	0	0

The occurrence of fleas on the other rodent hosts was sporadic and insufficient to clearly define any seasonal fluctuations, but in general the data seem to indicate that there is at least a trend towards reduction in numbers of fleas on their hosts during the summer months.

Climatic Conditions:

The relative abundance of ectoparasites upon their hosts is dependent upon a large number of variable factors. Most of these factors are either directly or indirectly influenced by the climatic conditions characteristic of the various seasons. The factors responsible for the seasonal fluctuations in the fleas previously discussed may vary greatly, but they all appear to be strongly influenced by the high temperatures occurring in the study area during the summer and fall. As indicated in Figure 3, the average nightly air temperature shows a marked rise during the month of May and reaches its peak in August. The nights do not become cool again until October.

TABLE 4

Monthly prevalences of fleas on *Onychomys torridus.*

Month	Number Captured	Number Infested	Percent Infested	Total Fleas by Species	
1957					
Sept.	3	2	66.7	*Hoplopsyllus anomalus*	1
				Malaraeus telchinum	1
Oct.	6	4	66.7	*Meringis dipodomys*	2
				Anomiopsyllus nudatus	1
				Thrassis bacchi gladiolis	2
				Thrassis aridis	1
Nov.	2	2	100	*Meringis dipodomys*	19
				Thrassis aridis	4
Dec.	0	—	—		
1958					
Jan.	0	—	—		
Feb.	3	3	100	*Meringis dipodomys*	9
				Thrassis bacchi gladiolis	1
March	2	1	50	*Thrassis bacchi gladiolis*	1
April	3	2	66.7	*Thrassis bacchi gladiolis*	2
May	1	1	100	*Thrassis bacchi gladiolis*	1
June	4	1	25	*Hoplopsyllus anomalus*	3
July	1	0	0	——	
Aug.	5	0	0	——	

This period of relatively high nightly temperatures corresponds rather closely with the periods when the fleas were reduced in number or absent from their rodent hosts.

The mean nightly absolute humidity in the study area was comparatively low during the months of November, December, January, February and April but was quite high in October and August (Fig. 4), probably due to the high precipitation that occurred during these months. The period of lowest absolute humidity occurred in November, a month which also received only a trace of precipitation (Fig. 5). These monthly fluctuations show less correspondence with the monthly fluctuations in the numbers of fleas found on their hosts than do the monthly temperature variations.

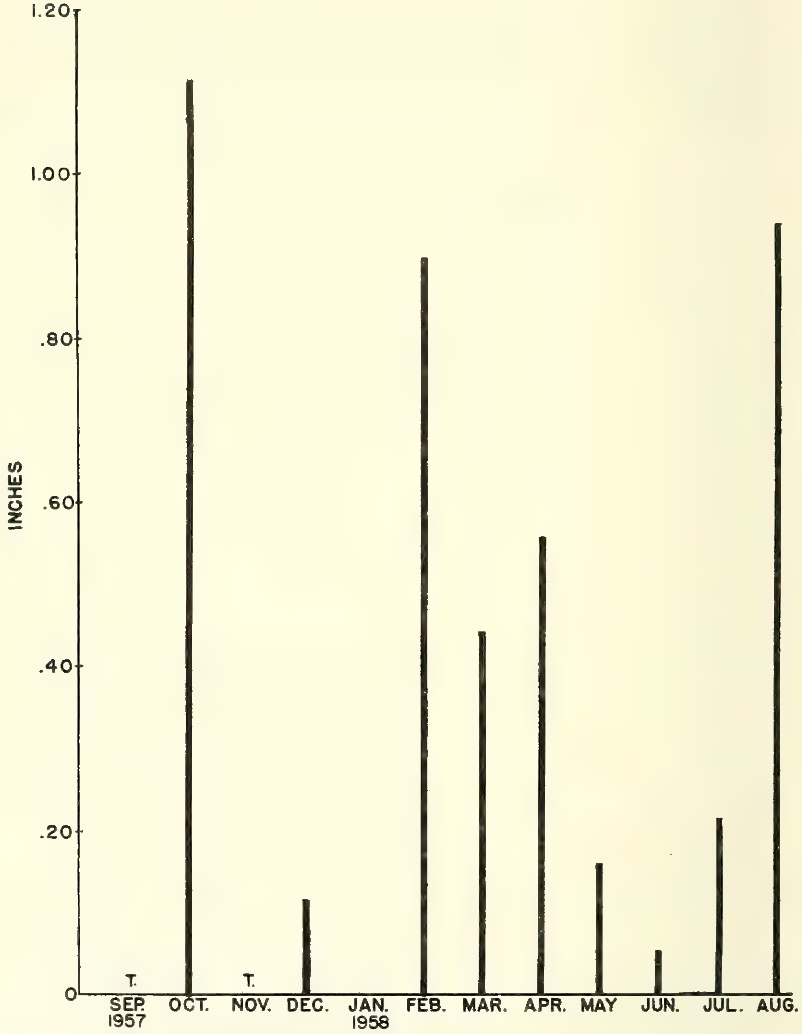

FIG. 5 MONTHLY PRECIPITATION AT TWENTYNINE PALMS WEATHER STATION.

T. = TRACE

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SYSTEMATICS AND VARIATION IN THE SPARID FISH *ARCHOSARGUS PROBATOCEPHALUS*

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In describing the sparid fish *Archosargus oviceps*, Ginsburg (1952) discussed the variation in color pattern and other meristic characters in this form and its presumed near relative, *A. probatocephalus* (Walbaum). While there is slight mean variation between the two nominal forms in the numbers of lateral-line scales, lower-limb gill-rakers and perhaps dorsal fin-rays, the only substantial character used by Ginsburg to distinguish the two forms was the number of dark bars on the side. Not counting the incomplete head bar, the nominal *A. oviceps* has five bars on each side (Fig. 1A), and *A. probatocephalus*, as recognized by Ginsburg, has six (Fig. 1B). I concur with Ginsburg that this is the only useful character for attempting to distinguish the two forms on an individual basis.

Ginsburg found that of 269 specimens of *A. probatocephalus*, 24 had six bars on one side and five on the other, and 14 had five bars on both sides. Of 78 specimens of *A. oviceps*, two had the asymmetrical pattern but none had six bars on both sides. Inasmuch as he found these "variants" only in specimens smaller than 75 mm. (presumably standard length), Ginsburg (p. 97) suggested that ". . . an obvious and plausible explanation . . ." for the variants ". . . is linked with a lethal factor which results in the failure of such variants to reach some size, much less to reach adulthood." He thus postulated a ". . . physiological barrier . . ." as one of the isolating factors between the two forms.

Later (Caldwell, 1958), I questioned this hypothesis and showed clearly that variants, some much more bizarre than those mentioned by Ginsburg, do persist to adulthood in both nominal forms—*oviceps* and *probatocephalus*. The variants illustrated in my earlier paper, as well as additional types, are here illustrated together (Fig. 1). All were found on specimens of at least sub-adult size, and many

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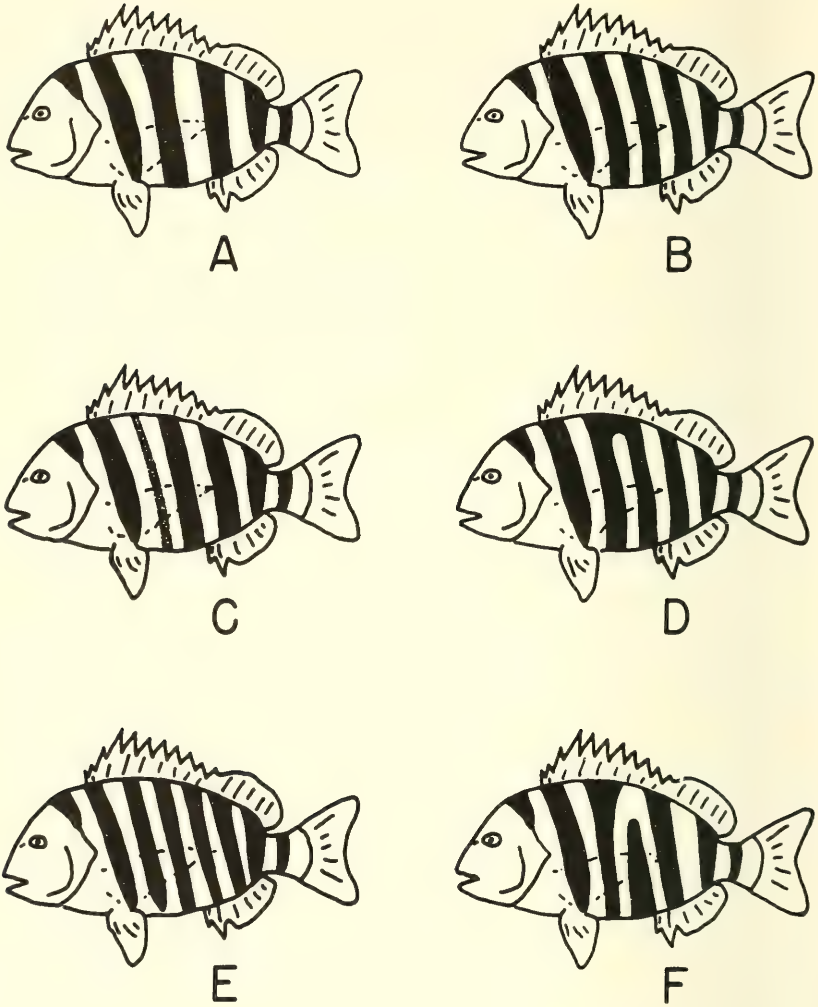
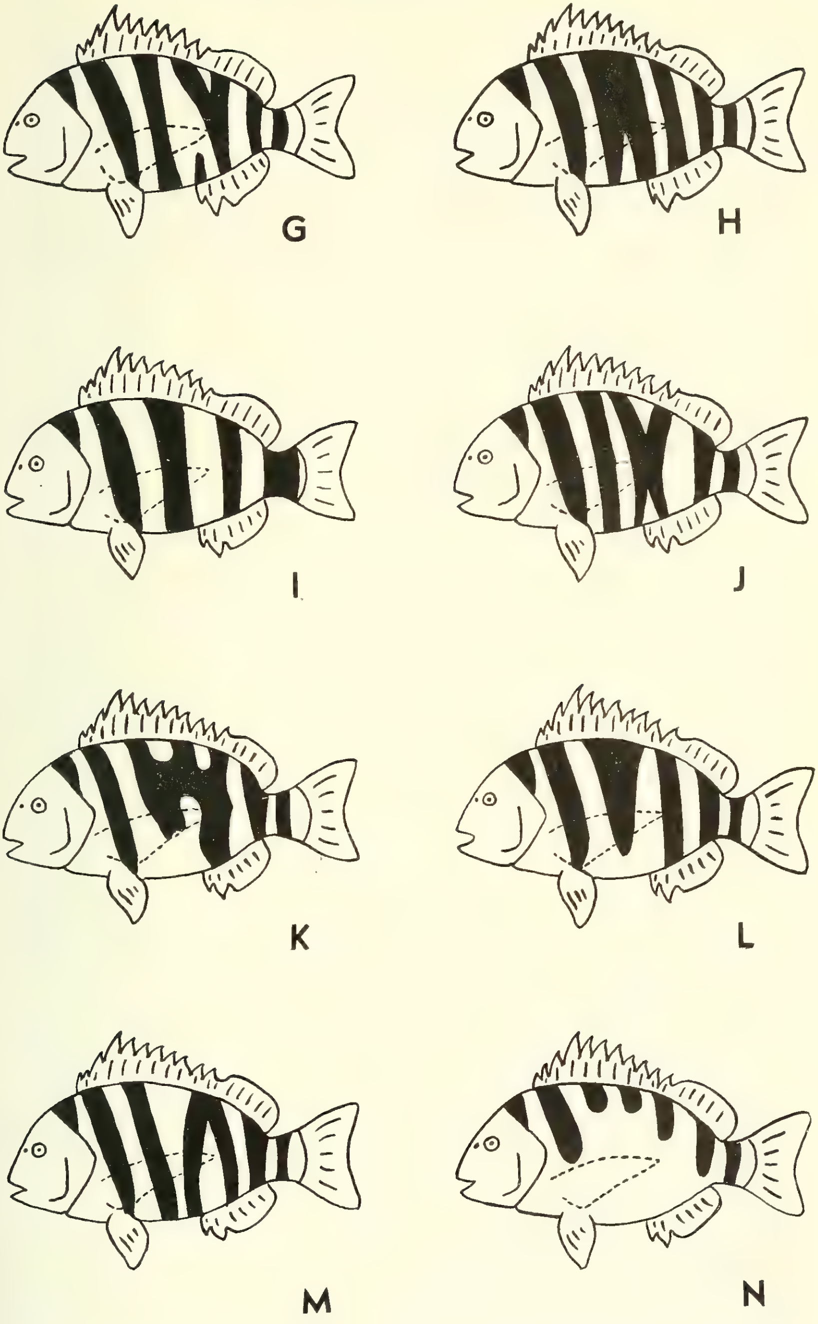


Figure 1. Semi-diagrammatic representation of some variations in bar pattern in the sparid fish *Archosargus probatocephalus.* See text for further discussion of the figures.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were on smaller individuals as well. For the purposes of this paper and, I believe, in concurrence with Ginsburg's intentions, the term "variant" is used to indicate any specimen of "*oviceps*" with a non 5-5 bar pattern, and any specimen of "*probatocephalus*" with a non 6-6 bar pattern. Variants were relatively no more frequent in any one size group than another, and no one side of the fish showed more numbers of variants than the other. Unusually-marked, *i.e.*, bizarre, variants such as those illustrated in Figure 1C-N, usually bore a "normal" pattern of five or six bars (depending on geographical area) on the other side.

On the basis of the above findings, I then questioned the validity of Ginsburg's *A. oviceps* as a full species, but withheld formal opinion on its systematic status until large series of specimens from many localities could be examined. Some recent workers (*e.g.*, Hildebrand, 1955:212) independently have considered *A. oviceps* a junior synonym of *A. probatocephalus*. Other writers (*e.g.*, Joseph and Yerger, 1956:136; Briggs, 1958:281) have done so solely on my suggestion. Still others have retained both species as valid.

To quote my earlier paper (Caldwell, 1958:139), "Although the possibility of sympatric species, or of allopatric species exhibiting parallelism in all age groups . . . cannot be discounted, Ginsburg obviously did not subscribe to these possibilities and considered his species a member of an allopatric species-pair, neither of which exhibits parallelism in the adult or sub-adult stages."

However, while it seems quite unlikely, with the new data I considered the hypothesis that *probatocephalus* and *oviceps* are separate but fully sympatric species, with one or the other being dominant in numbers in the appropriate geographical area. The most obvious reason to discount this hypothesis is the fact that some specimens (*i.e.*, those with five bars on one side and six on the other) would be different species depending on the side examined; the few with 4-4 or 7-7 bars for example would have to be considered as undescribed and very rare species; and other specimens (*i.e.*, those with bizarre bar patterns, see Fig.1) would be no species at all. Such reasoning seems as untenable as Ginsburg's hypothesis (already shown to be invalid) that variants never reach maturity but succumb at an early age to some unknown lethal factor.

The data were examined to determine if the "minority" groups of specimens of each of the hypothetical allopatric species (*i.e.*, 5-barred individuals in the 6-barred geographic range and vice versa, and ignoring the really bizarre individuals) in each case tended to

TABLE 1

Frequency distribution of numbers of lateral-line scales in three subspecies of *Archosargus probatocephalus*

	41	42	43	44	45	46	47	48	49	50	51	52	53	Mean
A. p. probatocephalus	3	3	14	38	50	30	24	11	5	1				45.3
A. p. oviceps			5	10	25	31	36	27	12	4			1	46.7
A. p. aries					2	1	2							46.0

TABLE 2

Variation in numbers of gill-rakers on lower limb of first arch in three subspecies of *Archosargus probatocephalus*

	7	8	9	Mean
A. p. probatocephalus	1	14	14	8.4
A. p. oviceps	1	4	20	8.8
A. p. aries		3		8.0

have the slightly different values of numbers of lateral-line scales (Table 1), lower-limb gill-rakers (Table 2) and dorsal fin-rays (Table 3) that they do when "dominant" individuals from each of the two main geographical areas were compared. For example, if two allopatric species really were involved, 5-barred specimens

TABLE 3

Variation in numbers of dorsal spines (Roman numerals) and soft-dorsal rays (Arabic numerals) in three subspecies of *Archosargus probatocephalus*. When the total number of elements is considered, there is almost no variation between the subspecies; *probatocephalus* tends, rather, to have one more spine and one less soft-ray than *oviceps*, giving the same total count. The few specimens seen of *aries* are included for comparison

	XII	X	XI	XII	X	XI	XII	XI
	10		11			12		13
A. p. probatocephalus	1	1	4	120	2	17	39	1
A. p. oviceps	4		19	74	1	60	8	2
A. p. aries				1			4	

from the 6-barred region should have tended to have a higher mean count of lateral-line scales, lower-limb gill-rakers and dorsal soft-rays and a lower mean count of dorsal spines. Such was not the case, but rather these mean counts tended to be consistent for the appropriate geographical region regardless of the bar count.

Ginsburg (1952:97, 100) suggested that the two nominal forms might be isolated by some geological barrier possibly related to past geologic history. Although this may be the case, Ginsburg had limited material from the particular region, and his line of demarcation (the Florida-Alabama border in the northern Gulf of Mexico) is an unrealistic one due to a lack there of separating physiographic or geologic features. A more realistic line lies some 150 miles to the east, and is one which on the basis of my examination of specimens is related to the dividing point for the majority of each nominal form. This line is represented by the break in general bottom type found in the northeastern corner of the Gulf of Mexico (see Lynch, 1954:79). North and west of this general area (the demonstrated range of "*oviceps*") the bottom generally is soft, while to the east and south of this area (the demonstrated range of "*probatocephalus*") the bottom generally is hard. In this region the distribution of another sparid, *Stenotomus caprinus* (Bean), has been shown (Caldwell, 1955) to be correlated with this break in bottom types. As I noted earlier (Caldwell, 1958:138), specimens from the northern Gulf of Mexico east to Alligator Harbor, Florida, predominantly are 5-5 barred. Specimens from the eastern Gulf south from Cedar Key, Florida, predominantly are 6-6 barred. Thus the break lies somewhere in the 100 miles between. Actually, there is probably a wider zone of integration which might be expected to include most of the northeastern corner of the Gulf of Mexico.

On the basis of the above data, the hypothesis began to emerge that while only one species was involved, there was a tendency for the two nominal forms to be separable on a geographic basis when only the character of bar count was considered. The data for this character were arranged by state, beginning in New Jersey and coming south along the Atlantic Seaboard, around the tip of Florida, and proceeding north and west in the Gulf of Mexico (Table 4). Because of its geographical position, and the fact that the data indicated the break in the distribution of the two nominal forms occurred in its waters, Florida was divided into four segments: East Coast, West Coast of Peninsular Florida north to Cedar Key, Apalachee Bay region from Cedar Key to Cape San Blas, and Panhandle (west from

TABLE 4

Variation in numbers of lateral bars in three subspecies of *Archosargus probatocephalus*. See text for explanation of geographical units, method of making counts and definition of variant and bizarre categories. (*) includes counts from Ginsburg (1952:96). (**) includes counts from Hildebrand (1955:211). I did not see any of these specimens. Only divergence between the subspecies *probatocephalus* and *oviceps* is considered

		6-6	5-5	6-5	4-4	4-5	6-7	7-7	Bizarre	Total Variants	% Divergence from allopatric form
PROBATOCEPHALUS	New Jersey* & Virginia	25	1							1	96
	North Carolina*	182	13	24						37	83
	South Carolina & Georgia	17							1	1	94
	Florida East Coast	77	4	1					1	6	93
	Florida West Coast to Cedar Keys	824	42	50			2		21	115	88
OVICEPS	Apalachee Bay region	1	1							—	—
	Florida Panhandle	11	86	2			2		1	16	84
	Alabama & Mississippi	2	105	5	1	1			3	12	90
	Louisiana	3	51	3	1	1			3	11	82
	Texas**	2	97	3	3	1			1	10	91
	Mexico**	3	14	2						5	74
ARIES	British Honduras	1									
	Venezuela	1									
	Brazil	3									

Cape San Blas). It should be noted here that the species occurs continuously around the southern tip of Florida, which often forms a faunal break between the east and west coasts of the state. In other fishes, the two sides of the peninsula often support disjunct populations of the same species (*e.g.*, Miller, 1959: fig. 5) or allopatric species or subspecies pairs (*e.g.*, Miller, 1959: figs. 2-3). Further geographic breakdown of the Florida data added nothing in clarifying the results. From Table 1, it becomes evident that whenever a sample contained more than just a few specimens it included variants, and their numbers represented some 10-25% of the sample[2].

Therefore, the two populations, even on purely subjective grounds would appear at best to be only of subspecific rank. Objectively, however, in many cases, even the often relatively small "state" samples only show divergence of sufficient magnitude to be considered subspecies using Ginsburg's (1938) own questionable arithmetical definition of a subspecies. When all of the material of each nominal form was lumped, in order to make larger and statistically more significant samples, the divergence at only the subspecific level, using Ginsburg's definition, is even more obvious: 87% of the nominal *probatocephalus* specimens showed the typical 6-6 bar count, and 87% of the nominal *oviceps* specimens showed the typical 5-5 bar count, or in each case (and combined) less than the required 90% divergence (Ginsburg, 1938:261) necessary for separation of the two groups as species.

Although numbers of anal and pectoral fin-rays were counted, and several proportional characters were investigated, none were of any value in separating the two forms.

There is a third nominal form of black-barred sheepshead, *Archosargus aries* (Valenciennes), which apparently falls into this subspecific complex. I have been able to obtain only five specimens of this form from Central and South America. The bar count is 6-6 for all, but there appears to be a tendency for the bars to be slightly narrower (Table 5) than those of the 6-barred northern form, *probatocephalus*, and the anterior profile tends to be more rounded than the somewhat more pointed anterior profile of either of the two northern forms. In the few specimens of *aries* examined, the mean number of lower-limb gill-rakers (Table 2) and pectoral rays was

[2] The majority of museum specimens examined were either collected before Ginsburg's paper appeared, when there was no reason to expect bias due to the collector's selecting a disproportionate number of variants, or special care was taken by the recent collector to save or examine the entire sample collected in order to determine the percentage of variants.

TABLE 5
Variation in mean bar width* in subspecies of
Archosargus probatocephalus

	Bar Number					
	1	2	3	4	5	6
A. p. oviceps	9.9	11.9	10.0	7.7	5.6	
A. p. probatocephalus	8.7	9.0	8.5	8.3	6.5	5.1
A. p. aries	7.8	7.7	6.8	6.4	5.7	4.9

*Bar width is that portion of the lateral line covered by the given bar expressed as percent of standard length. Bars are numbered from anterior to posterior, and do not include the incomplete head bar. Specimens of comparable sizes were studied, but no ontogenetic progression in relative width of a given numbered bar was found, so that specimens of any size may be compared. The wider bars in *oviceps* are, at least in part, a function of the fewer bars arranged over the same expanse of the side of the body. To see which bar is missing in *oviceps*, refer to Figure 1A. Inasmuch as only rarely more than 1% and usually much less than 1% variation was found in the width of the corresponding bar on each side of an individual, all measurements for each numbered bar in each subspecies were lumped to increase the sample size in determining mean values. In the subspecies *probatocephalus* and *oviceps*, variant individuals had bar widths comparable to the usual form (*i.e.*, 6-barred *oviceps* had bars with widths comparable to "normal" *probatocephalus* rather than "normal" *oviceps*, and vice versa).

low, and the mean number of total dorsal elements was high, but the sample is too small to make definitive conclusions.

No other proportional characters of value were found to distinguish *aries* from the other two forms. Examination of the present material failed to corroborate the supposedly narrower incisor teeth in *aries* as described by Jordan (1887:538), Eigenmann and Hughes (1888:69) and Jordan and Fesler (1893:522).

Inasmuch as there seems to be a geographical basis for it, as well as still-uncertain objective and subjective data, I follow Eigenmann and Hughes (1888:69) in considering *aries* a subspecies of *probatocephalus*. A more positive decision will have to await the analysis of large samples from Central and South America.

I therefore conclude that present data indicate that the black-barred sheepsheads of the family Sparidae may be divided into three subspecies, all of which are mainland inhabitants in the Western Atlantic with no records from the West Indian islands—including those close to the South American mainland. The three subspecies of *Archosargus probatocephalus* are:

Archosargus probatocephalus probatocephalus (Walbaum)

Sparus Schöpf. Schriften der Gesellsch. Naturf. Freunde, VIII, p. 152, 1788. New York. (Ref. copied)

Sparus probatocephalus Walbaum. Artedi Pisc., p. 295, 1792. New York. (Based on Schöpf)

Sparus ovicephalus Bloch and Schneider. Syst. Ichth., p. 280, 1801. New York. (Based on Schöpf)

Sargus ovis Mitchell. Trans. Lit. and Phil. Soc. N.Y., I, 1814, p. 392, pl. 2, fig. 5. New York. (Ref. copied)

Range: Cape Cod, Massachusetts (possibly north as a stray), to Cedar Keys, Florida, with no break at the tip of the Florida peninsula.

Archosargus probatocephalus oviceps Ginsburg

Archosargus oviceps Ginsburg. J. Wash. Acad. Sci., 42(3), p. 94, 1952. Louisiana.

Range: St. Marks, Florida, to the Campeche Bank, Mexico. References in whole or part which include "*Archosargus probatocephalus* (Walbaum)" from this geographical region should be amended to provide for this new subspecific combination.

Archosargus probatocephalus aries (Valenciennes)

Sargus aries Valenciennes. Hist. Nat. Poiss., VI, 1830, p. 42 (58). Rio de Janeiro, Brazil, and Maracaibo, Venezuela.

Archosargus probatocephalus aries (Valenciennes). Eigenmann and Hughes, Proc. U.S. Natl. Mus., 10, p. 69, 1888.

Range: Belize, British Honduras, to Bahia de Sepetiba (just southwest of Rio de Janeiro, Brazil).

METHODS

Lateral-line scale counts were made on the left side, counting pored scales beginning at the origin of the lateral line near the upper angle of the opercle and ending at the crease made at the end of the hypural plate when the tail is bent upwards. All first-arch lower-limb gill rakers were counted, including rudiments, beginning with the raker at the angle of the arch. The last dorsal soft-ray, split to the base, was counted as one. The method for making bar counts was discussed in the introductory paragraph of this paper.

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I wish to acknowledge with thanks the following persons who placed all specimens of *Archosargus probatocephalus* under their charge at my disposal. Some of these collections were examined as long ago

as 1956, so that additional material undoubtedly has become available since I saw the collections. The collections studied were: California Academy of Sciences, through W. I. Follett; Cape Haze Marine Laboratory, through Eugenie Clark; Charleston Museum, through E. Milby Burton; Chicago Natural History Museum, through Loren P. Woods; Cornell University Museum, through Edward C. Raney; Florida State Board of Conservation Marine Laboratory, through Victor G. Springer; Florida State University, through Ralph W. Yerger; Gulf Coast Research Laboratory, through Gordon Gunter and Charles E. Dawson; Rijksmuseum van Natuurlijhe Historie, Leiden, through M. Boesman; Stanford University Natural History Museum, through George S. Myers and the late Margaret Storey; Tulane University, through Royal D. Suttkus; University of Florida Collections, through John D. Kilby, John C. Briggs and Daniel M. Cohen; University of Georgia, through Donald C. Scott; University of Miami Ichthyological Museum, through Luis R. Rivas; University of Miami Institute of Marine Science, through C. Richard Robins; University of Michigan Museum of Zoology, through Reeve M. Bailey and Robert R. Miller; University of South Florida, through Jerome O. Krivanek; United States Bureau of Commercial Fisheries Biological Laboratory, Brunswick, Georgia, through William W. Anderson and Jack W. Gehringer; United States National Museum, through Leonard P. Schultz; and University of South Carolina, through William D. Anderson, Jr. Large numbers of specimens in the collections of the Los Angeles County Museum also were examined.

In addition to these materials, several people made bar counts and recorded variations for fresh material which otherwise was not preserved. In this regard, I wish particularly to thank Mr. Arno B. Doudna of St. Petersburg, Florida, who as a commercial sheepshead fisherman was able to furnish several hundred bar counts for that locality. Dr. Victor G. Springer also furnished a large number of bar counts for that locality, and Mr. Charles E. Dawson provided a significant number from the northern Gulf of Mexico. Others who made special (and successful) efforts to obtain specimens, bar counts and/or provision for me to examine significant numbers of living specimens in their charge, and to whom I am most grateful are: William W. Anderson, Edgar L. Arnold, Jr., Frederick H. Berry, Winfield Brady, Melba C. Caldwell, Archie Carr, Jorge Carranza, Eugenie Clark, Thomas R. Hellier, Jr., H. D. Hoese, J. B. Siebenaler, E. G. Simmons and F. G. Wood, Jr.

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STUDIES ON CALIFORNIA ANTS.
2. *MYRMECINA CALIFORNICA* M. R. SMITH (Hymenoptera; Formicidae)

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Los Angeles County Museum

Since it was originally described by Smith (1948) *Myrmecina californica* has remained little known. In spite of the ridiculous assertion of T. W. Cook (1953), this species does not have a habitat range which includes the "entire United States," nor is there a cotype specimen in the California Academy of Sciences. This species was based on a unique specimen, now in the U. S. National Museum collections, collected in Santa Barbara, California.

Until recently, the species has been known only from this unique type specimen. Additional material has since become available, and it may be shown that the range includes the mountainous areas of the California Coast, with apparent extensions into the interior along the inland valleys. The first specimens to come to my attention were two workers collected at Pleasant's Valley, Solano County, on April 15, 1961 by Mr. A. J. Beck. According to Dr. Robert O. Schuster, from whom I received these specimens, "Pleasant's Valley is along the foothills . . . between Winters and Vacaville." The specimens came from a one quart volume Berlese sample of litter of mixed *Quercus* sp. and poison oak.

Three additional workers, also made available by Dr. Schuster, are from a site 5.4 miles southwest of Winters, Yolo County, taken in Berlese sample by Mr. F. C. Raney, April 15, 1960.

The third capture, seven foraging workers, was made in Eaton Canyon wash, near Pasadena, Los Angeles County, on June 6, 1963. I collected these individuals in leaf litter under a small grove of oaks, *Quercus* sp. The workers were picked up singly by searching through the litter. An effort to locate the colony proved futile, and several subsequent visits to the site yielded no additional specimens.

There is, finally, a single specimen, agreeing in all particulars with the above specimens, recovered from a Berlese sample taken at the Southwest Research Station, Chiricahua Mountains, Arizona, on August 7, 1958, by L. M. Smith and R. O. Schuster. Included in this sample were two workers typical of *M. americana brevispinosa* Emery. The discovery of *M. californica* at a station so far removed from what would seem to be its normal habitat is very perplexing. Certainly it points out the necessity for intensive collecting in the Southwest to clarify these puzzling distributional discontinuities.

When *M. californica* was described, Dr. Smith stressed several characteristics as diagnositic of his new species. These were as follows: (1) base of antennal scape broad and flat; (2) anterior border of clypeus distinctly tridentate; (3) body weakly-sculptured, the pronotum and mesonotum largely smooth and shining; (4) body and appendages reddish-brown, gaster blackish.

Two specimens from the Eaton Canyon sample were sent to Dr. Smith for comparison with the type. These specimens, according to him, differ from the type as follows: "the anterior border of the clypeus is not 3-toothed, the antennal scape not as flattened and broad, the head smoother and more polished." All the specimens recorded above agree in these two very important aspects. The differences noted above present us with varying possibilities of interpretation.

Myrmecina americana differs from *M. californica* in lacking the tridentate clypeal border, the slender scape which is not basally flattened, and has the head and thorax with well developed rugae, the pronotum and mesonotum never largely smooth and shining. In addition, fully colored individuals of both subspecies of *M. americana* are much darker in color. Although the specimens from California have the clypeal border and scapal characteristics of the Eastern species, there are still certain characters which seem to be more like those assigned by Smith to *M. californica*. In the latter, the head of the type is 1.06 times as long as broad, while in the material before me, the variance is from 1.05 to 1.07 times as long as broad, so that the type of *M. californica* falls exactly in the middle of this range. In a random sample of *M. americana* (including its subspecies *M. a. brevispinosa*) the variance is from 0.90 to 1.02 times as long as broad.

In the sculpturing of the head and thorax, the present specimens are undeniably close to *M. californica*, of which Smith says ". . . clypeal lobe, frontal area, lower side of head, propleura, pronotum, mesonotum, legs, epinotal declivity and gaster largely smooth and shining; rest of body subopaque." If this condition is the same in the type as in the specimens now at hand, then the differences which separate most of the California material from Eastern are very striking. For these areas of the head and thorax of *M. americana* are crossed by prominent rugae and punctures which give these parts a decidedly subopaque appearance. The two specimens from Pleasant's Valley, however, are somewhat intermediate in these characters; the frontal surface of the head is conspicuously duller than in the other California specimens, with faint rugae and punctures highly suggestive of those seen in *M. americana.* The thorax, too, reflects this intermediate nature; there are a number of prominent, rather widely spaced rugae on the sides of the thorax, and the pronotum and mesonotum are duller than in the rest of the California specimens, with vague suggestions of the longitudinal rugae which are so conspicuous in the Eastern form. In one of these individuals there is an indication of a median tooth on the anterior clypeal border.

The Arizona specimen presents certain problems of its own. The head is almost exactly 1.05 times as long as broad, which places it barely within the head dimension limits of *M. californica.* In cephalic sculpturing it is similar to the above mentioned specimens from Pleasant'sValley, punctate and rugulate, but not so sharply so as in *M. americana.* The dorsum of the thorax is smooth and shining, as in most of the California specimens, but with prominent widely spaced rugae on the mesopleurae and epinotal sides. The anterior border of the clypeus not only lacks the median tooth, but has the lateral ones so reduced in size that they are barely perceptible. At this point it may perhaps be pertinent to point out an inconsistency in regard to Smith's treatment of the clypeal dentition. In his key to the *Myrmecina* species he says ". . . anterior border of clypeal lobe *distinctly* tridentate . . ." (Italics mine), while his description on the same page states that the median tooth is ". . . small and *indistinct*." (Italics mine). It is difficult to reconcile these two contradictory statements. The fact that a feebly tridentate condition is known to occur in *M. americana* (as well as the opposite condition; almost total reduction of all teeth) would seem to indicate caution in relying very heavily on a feature known to be highly variable.

Little mention has been made thus far of color, since this is a notoriously poor indicator of specificity. However, it seems worthwhile to point out that all California specimens seen thus far are consistently lighter colored than are any individuals I have seen of either *M. a. americana* or *M. a. brevispinosa.* The majority of the specimens referred to *M. californica* have the head, thorax, petiole and postpetiole light yellowish-red, with the gaster light reddish-brown, or at least somewhat darker. The one Arizona specimen has the head and thorax reddish-brown, the gaster somewhat darker. This is in rather strong contrast to the uniformly dark brownish color seen in the other forms.

As outlined above, the features by which *M. californica* has been separated from *M. americana* are highly variable, and tend to emphasize the close relationship of the two. Since it seems probable that the former is no more than a morphologically distinct form of the latter, I propose to reduce *M. californica* to the level of a subspecies of *M. americana*. The nearly complete breakdown of the distinctive characteristics of *M. californica* has shown that continued recognition of this form as a full species is no longer tenable. Furthermore, reducing it to the level of a subspecies is in keeping with the presently established treatment afforded morphological races in other genera.

In the key presented below I have attempted to facilitate the identification of the various forms now known to occur in the United States. Because it apparently is known only from the original specimens, *M. a. texana* Wheeler is included on the basis of the description only. This key is based on workers only.

KEY TO SUBSPECIES OF *Myrmecina americana*

1. Base of first gastric segment smooth and shining, with only scattered piligerous punctures; epinotal spines usually without recurved tips; thoracic sculpturing variable 2
Base of first gastric segment shagreened, subopaque; epinotal spines well developed, stout, tips strongly recurved; longitudinal thoracic rugulae unusually coarse (Texas) . . . . subsp. *texana* Wheeler.

2. Thoracic dorsum smooth and shining, with scattered piligerous punctures, longitudinal rugulae obsolete or absent; top of head usually smooth and shining, sometimes surface roughened by indistinct rugulae; epinotal spines less than twice as long as basal width of spines; head and thorax yellowish to reddish brown, gaster darker (California, Arizona) . . . . subsp. *californica* M. Smith.
Thoracic dorsum with prominent longitudinal rugulae; top of head with distinct longitudinal rugulae; epinotal spines variable; body concolorous, or very nearly so 3

3. Epinotal spines long, usually turned upward apically; cephalic rugulae heavy; occipital border with pronounced median impression; length 3.5 mm. (Atlantic states south to Georgia and Alabama, west to Iowa; Colorado) . . . . .subsp. *americana* Emery.

Epinotal spines shorter, dentiform; cephalic rugulae weak, sometime absent medially; occipital border feebly impressed; length 2.5 mm. (southeastern states to New York, west to Arizona) .... subsp. *brevispinosa* Emery.

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A NEW BROMELIAD FROG OF THE GENUS *ELEUTHERODACTYLUS* FROM COSTA RICA

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On the evening of February 4, 1963, accompanied by Professor John L. Mohr and Richard S. Casebeer of the Department of Biological Sciences of the University of Southern California, I visited the famous bird collecting locality (Carriker, 1910) at La Hondura, Provincia de San José, Costa Rica. The area is little changed since Carriker's day and as it was the middle of the dry season relatively few amphibians were taken. Just before returning to San José for the night, Dr. Mohr suggested that we examine some bromeliads that he had located. The first bromeliad contained only the common *Eleutherodactylus diastema*, but another plant produced two small frogs, one an *E. diastema*. The other example had a brilliant green body and bright red-orange head and eyes, and appeared to represent a species not previously known from Central America. Subsequent study has confirmed this original impression and the single specimen must be regarded as being from an undescribed species population. The new form will be called,

Eleutherodactylus moro, new species

Figure 1

Holotype: Costa Rican series number 765, University of Southern California.

Type Locality: Costa Rica: Provincia de San José: Canton de Coronado: La Hondura, 1245 meters (4085 feet).

Diagnosis: A species differing from all known Central American members of the genus in the striking life colors of red and green. Apparently related to the *Eleutherodactylus diastema* group (*diastema* Cope, 1875; *hylaeformis* Cope, 1875; *vocator* Taylor, 1955) with which it shares the character of weakly T-shaped terminal phalanges. *E. moro* differs from *diastema* and its allies and the other

Figure 1. Dorsal view of holotype of *Eleutherodactylus moro*, new species. Photograph by William A. Bussing.

small *Eleutherodactylus* with which it might be confused when preserved, *E. caryophallaceous* and *E. ridens*, in lacking supraorbital warts and a wart on the heel. From all of these species except *caryophallaceous*, it further differs in having a completely smooth dorsum without warts or pustules.

General Characteristics: Head viewed from above, as broad as long. Snout subovoid. Upper eyelid smooth, much longer than broad, length about one-third head length. Eyes bulge up prominently above surface of interorbital region. Canthus rostralis rounded, loreal region slighty oblique. Skin of head smooth.

In profile canthus slopes gently from eye to nostril, outline of tip of snout slopes posteriorly at a slight acute angle to mouth. Nostrils directed laterally and slightly upward. Orbit longer than high, greatest diameter about half of tarsus length. Pupil horizontally elliptical; eye covered by two membranous eyelids. Distance from eye to tip of snout greater than orbit. Tympanum barely indicated. Throat weakly granular.

Tongue cordiform; vomerine teeth in two small patches posterior and internal to choanae; choanae ovoid, main axis at right angle to longitudinal axis of head; a pair of large vocal slits at level of posterior base of tongue, ostia pharyngea small.

Dorsum and upper surfaces of limbs smooth. Upper arm completely free of any axillary fold, approximately one-half standard length. Fingers in order of increasing length 1-2-4-3; no webbing. All fingers with distinct rounded disks, slightly broader than fingers of fingers 1-2, about 1.5 times as broad as fingers 3-4. Well-developed rounded palmar tubercle and elongate thenar tubercle; palm smooth, subarticular tubercles large, rounded. Legs much longer than standard length. Toes in order of increasing length 1-2-3-5-4; fourth toe slightly shorter than tarsus; no webbing. All toes with distinct rounded disks, about equal to those on fingers, slightly broader than toe 1, about 1.5 times as broad as toes 2-3-4-5. No tarsal fold. Inner and outer metatarsal tubercles smaller than palmar and thenar tubercles; outer rounded and raised, inner flat and elongate. Sole with a number of smooth tubercles; subarticular tubercles large, rounded equal to those on hand. Belly and posterior surface of thigh distinctly granular.

Measurements: Standard length 19.5 mm. Subsequent measurements indicate values in millimeters, followed by percentage of standard length in parentheses. Head length 7.0 (36); head width 7.0 (36); orbit 2.5 (13); snout, eye to tip, 3 (15.2); upper eyelid length 3 (15.2); arm 11 (56.5); third finger length 4 (20.5); hind leg 29 (174); tibia 7 (36); tarsus 5.5 (28.4); fourth toe length 5 (25.5).

Coloration: In life, dorsal surfaces of body and limbs dull enamel green, limbs slightly lighter than back. A dark mark across wrist. Upper eyelids and area from halfway between eyes to snout bright orange-red. A few red flecks continuing posteriorly from eyelid to posterior margin of head. Red coloration extending down about halfway to lip in loreal region, below nostrils and two-thirds way down anterior tip of snout toward lip. Iris of eyes orange-red. Undersides pale greenish yellow. Belly transparent, peritoneum white, clearly visible through skin; pericardial sac white; a pair of large white glands visible through skin of throat directly below eyes. No other internal organs visible through skin.

In preservative (Fig. 1), dorsum and upper surfaces of limbs pale white, transparent. Some brownish pigment on upper surfaces of legs and arms; a dark brown mark across wrists. Surface of head pale brownish-white, with a distinct brown interorbital blotch between posterior half of eyes. A narrow brown line runs from posterior corner of eye backward at oblique angle onto back. Tip of snout and loreal region with considerable brown punctations, a weak dark postorbital line present. Undersurfaces, except for some pigment along lower lip, immaculate yellowish-white.

Distribution: Known only from the type locality at La Hondura in the Subtropical Rainforest association of Holdridge (1964).

Remarks: The inadvisability of describing new forms of *Eleutherodactylus* based upon single specimens has been repeatedly demonstrated. The most recent example is Lynch (1964) where two nominal species, obviously junior synonyms, are proposed from single poorly preserved specimens from Panamá: *Eleutherodactylus tiptoni* [= *Eleutherodactylus cerasinus* (Cope, 1875)] and *Eleutherodactylus marshae* [= *Eleutherodactylus dubitus* Taylor, 1952 = *Eleutherodactylus cruentus* (Peters, 1873)]. Nevertheless, *E. moro* is so strikingly different from any other known member of the genus in morphology and coloration that description seems justified. Repeated attempts to collect other examples at the type locality proved fruitless.

The new species is named for my colleague and fellow Costa Rican enthusiast, Dr. John Luther Mohr, who has specialized in studies of the opalinid ciliate protozoa of anuran digestive tracts.

This paper is the first in a series aimed at a revision of the systematics of the Middle American frogs of the genus *Eleutherodactylus*.

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THE EFFECT OF FRESH-WATER RUN-OFF ON A POPULATION OF ESTUARINE POLYCHAETOUS ANNELIDS

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Introduction

The effect of fresh water from rainfall on marine fauna have been studied in the past. MacGintie (1939) reported the effects of a heavy run-off of fresh water at Newport Bay, California, in March 1938. He reported that the lethal effect to the animals coincided with the depth of fresh water. The greatest number of fatalities occurred among the sessile organisms in the upper bay. Sandison and Hill (1959) found an annual mortality and renewal of invertebrate populations at Lagos Harbour, Nigeria. Repopulation by larvae from deeper water populations within the harbor followed the rainy season. Goodbody (1961) reported mass mortalities of sedentary populations followed heavy rains at Kingston Harbor, Jamaica. Pearse and Gunter (1957) stated that completely euryhaline invertebrates are rare; most of the aquatic species are stenohaline. Bay and estuary organisms can usually withstand salinity increases, but very few are able to withstand decreases in salinity. The length of duration of fresh water influx is critical for many organisms (MacGinitie, 1939; Goodbody, 1961; Sandison and Hill, 1959); variations in survival are influenced by local conditions such as circulation, tides, currents, and fouling of the water by the dead organisms.

The purpose of this study was to record the effects of fresh water run-off from rain on three species of estuarine polychaetous annelids, namely, *Captella capitata* (Fabricius), *Streblospio benedicti* Webster, and *Polydora nuchalis* Woodwick. These species are known to inhabit waters of varying chlorinities (Woodwick, 1953).

Description of Study Area

Collections were made from a concrete apron of a former natural drainage stream which empties into the Cerritos Channel area of

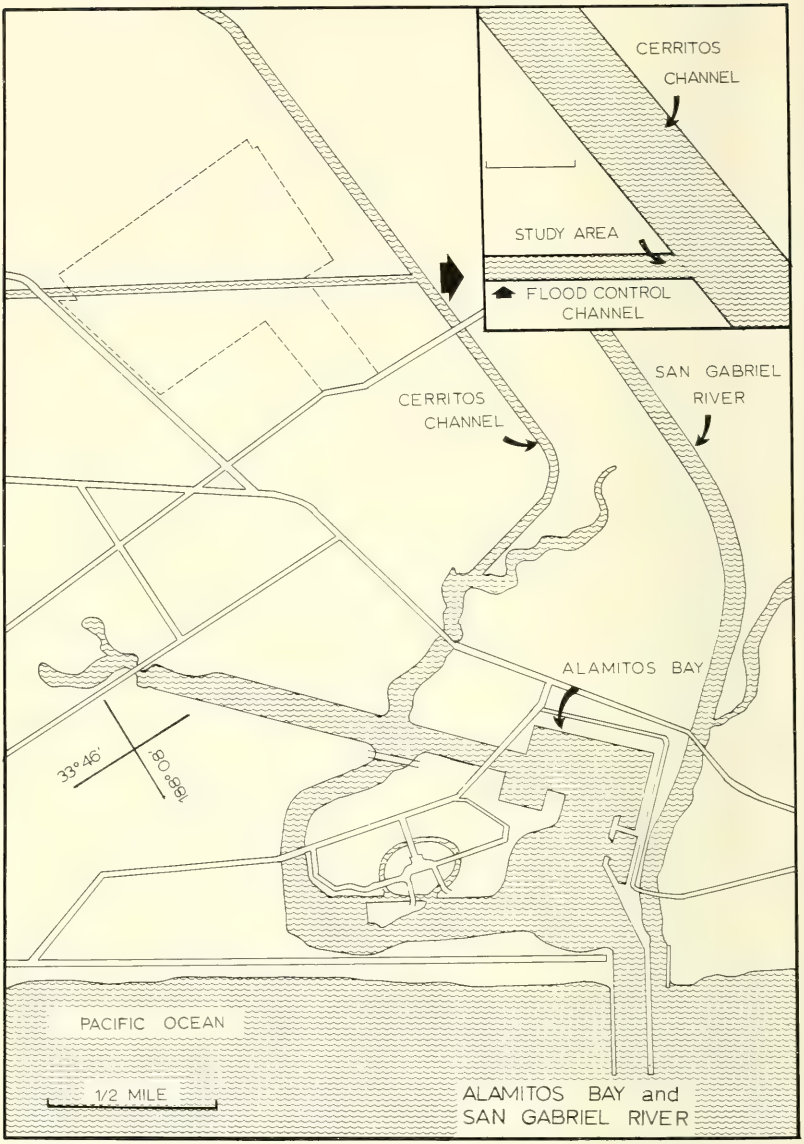

Figure 1. Map of Alamitos Bay, inset shows area of study. Scale in inset indicates 175 feet.

Alamitos Bay (Fig. 1). This flood control channel crosses the California State College at Long Beach campus, then proceeds southeast to the Cerritos Channel (Fig. 1, insert). The streambed was excavated and lined with concrete during the summer of 1958. The excavation lowered the bed so that sea water enters from Cerritos Channel during high tides. The apron lies at the junction of Cerritos Channel and the flood control channels, and was exposed during low tides.

Materials and Methods

Samples were taken at approximately monthly intervals from November 1958, through January 1960. The collecting dates are given in Figure 2. A metal one gallon container, open at both ends, was used for collecting samples. It measured 16.7 cm. in diameter, giving a surface area of 219 cm.[2] The sampler was pushed into the substratum until the top was even with the surface of the sediments, or until it reached the concrete. The material was removed by hand, placed in a gallon jar, and preserved with formalin. A water sample was taken for chlorinity determination (Barnes, 1959).

Samples were washed through a screen with 60 openings per inch (0.256 mm.). The animals retained on the screen were sorted into groups with particular attention given to the three species of polychaetes noted above. The sex was determined whenever possible and the length of each specimen measured. Mature males, females, and females with eggs were counted as adults; immature specimens were considered as young adults, and if they still possessed some larval characteristics they were counted as larvae.

The three principal species of polychaetes were separated as to the various stages of development, *i.e.*, larval, young adults, mature adults, and females with eggs present in their coelom. The different stages for the three species of polychaetes were distinguished as follows.

Capitella capitata: young adults measured 1 to 7 mm. in length, genital hooks on segments 8 and 9 absent (presence of these hooks indicates male; females lack these setae); adults measured 6 to 20 mm., males distinguished by genital hooks on segments 8 and 9 and females with eggs developing in coelom.

Streblospio benedicti: young adults measured 1.5 to 7.0 mm.; adults measured 7 to 19 mm.; female distinguished by the presence of eggs in coelom.

Polydora nuchalis: larvae measured 0.75 to 2.5 mm., modified fifth segment not yet developed; young adults (and probably mature males) measured 2.5 to 12 mm., modified fifth segment developed; protandric females measured 12 to 23 mm., eggs present either in coelom or in egg sacs in the tube (stages as defined by Woodwick, 1960).

Various mollusks, crustaceans, insects and foraminiferans were identified in so far as possible. The oligochaete was identified by the late Dr. A. Weir Bell, Pacific Lutheran College.

The rainfall data were taken from the City of Long Beach listing in the Bureau of Standards climatological data for California (1958-1960).

THE EFFECT OF FRESH-WATER RUN-OFF FROM RAINFALL ON THE ENVIRONMENT

Rain had an effect on the chlorinity of the water, the thickness of the sediments, and the polychaete population. During the 15 months of study the chlorinity content of the water varied from 2.7 to 18.7% (Fig. 2). The lowest value was measured on January 7, 1959, immediately following a rainfall of 0.65 inches earlier that day. Recovery back to normal chlorinity for this area is apparently rapid; one of the highest chlorinity readings was measured on February 26, 1959, which followed rainfall of total of 3.99 inches on 9 different days over the preceding 3 weeks (Fig. 2). The lowered chlorinity values measured during the summer are probably the result of run-off of water into the gutters from people watering their lawns during the warmer months.

Sediments. The amount of sediments present on the apron varied seasonally from a low of 15 centimeters following the winter rainy seasons to a high of 50 centimeters just prior to the onset of the rainy season. The run-off from six days of rain in seven days in January 9 to 15, 1960, which totaled 2.74 inches, apparently was of sufficient quantity to remove all the sediments and animals from the concrete apron.

Polychaetes. All stages of *Capitella capitata* (Fig. 2) occurred throughout the period of study with the exception of February 26, 1959; no young adults were collected at this time. The peak of 3732 specimens collected on February 6, 1959, was composed of 3230 young adults, 351 females with eggs, 150 males, and 1 female incubating eggs within her tube. The population was reduced to 7 adult specimens following the rainfall of few days later. One month later the population increased to 921 specimens, the majority of which were young worms. The population fluctuated during the 10 months with small numbers encountered during late summer and early fall

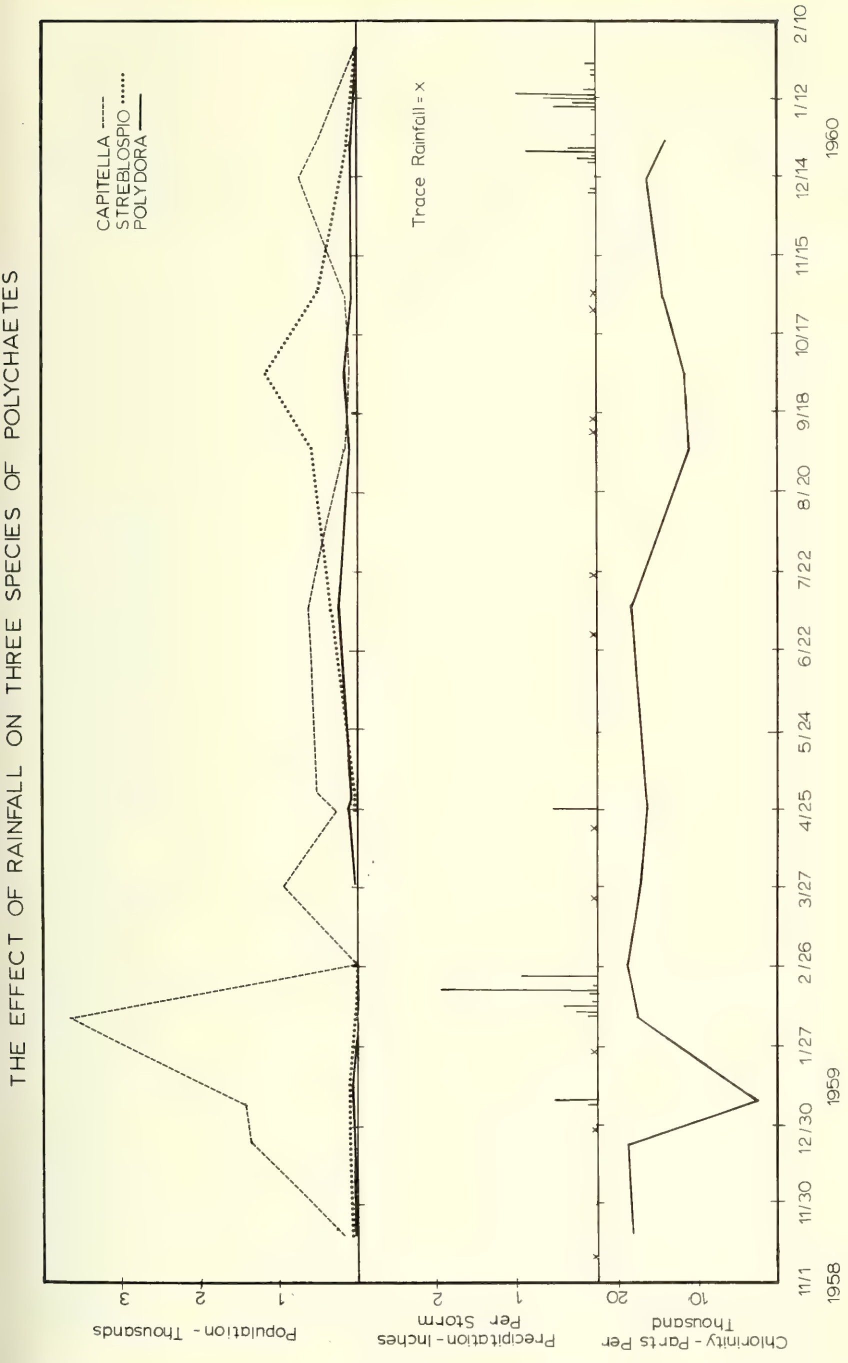

Figure 2. A graph showing the relationship rainfall and chlorinity of the sea water to the population of three species of estuarine polychaetous annelids.

and higher numbers collected just prior to the elimination of the population in January 1960. *Capitella capitata* is known to reproduce throughout the year in southern Californian waters with reproductive peaks in winter and summer (Reish, 1961b). Apparently small amounts of run-off from rainfall do not affect the population of *C. capitata* (Fig. 2, September to October 1959). Rainfall in amounts greater than 0.5 inch reduced the population (Fig. 2, February 26, 1959).

Streblospio benedicti were present at all times except February and March 1959, and at the conclusion of the study. A peak in the population of this species occurred during the summer and fall of 1959 (Fig. 2). A total of 387 specimens were collected on July 8, 1959, of which 238 (62%) were juveniles and 105 (38%) were adults. The number of speciments continued to increase with a peak of 1196 individuals collected on October 3, 1959, of which 859 (72%) were adults and 337 (28%) were juveniles. The number of *S. benedicti* collected thereafter was less each succeeding month until the entire population was eliminated in January 1960. Females with eggs were observed from July through December and occasionally throughout the remainder of the year. Apparently *S. benedicti* is sensitive to rainfall. A drop in the population was noted after each major rainfall during the period of study (Fig. 2). For example, the collection of 34 specimen were made on April 25, 1959, was made in the morning before the rain began to fall in the afternoon. A week later only 8 worms were collected. The larger rainfalls of February and December 1959 and January 1960 either greatly reduced or eliminated *S. benedicti* from this area.

The adults of *Polydora nuchalis* were present throughout the year with the exception of February 1959. This species was reported by Woodwick (1960) to be a protandric hermaphrodite. Females with eggs developing within their coelom were observed from May through October 1959. *Polydora nuchalis* apparently was unaffected by the lighter rainfalls of January 7 and April 25, 1959 but was affected by the heavier rainfalls of February and December 1959 and January 1960 (Fig. 2).

Other animals. A typical marine-brackish-water foraminiferous fauna was present at the site of study (Phleger, 1960). This shallow-water benthonic association of foraminiferans included *Elphidium sp., Triloculina sp., Quinqueloculina sp., Nonion sp.,* and *Discorbis sp.* The oligochaete, *Paranais salina* Cernosvitov, was present throughout the period of study except during March 1959. Population peaks of 561, 193 and 588 specimens were obtained on February 6, April 25, and December 27, 1959, respectively. The run-off from the rainfall in February 1959 and January 1960 eliminated *P. salina* from the area. This oligochaete was previously known only from Lake Poopo, Bolivia (*fide* Dr. A. Weir Bell).

Other invertebrates seen during this study, either in the samples or from the area include the cumacean *Oxyurostylis pacifica* Zimmer, the barnacle *Balanus amphitrite* Darwin, the crab *Hemigrapsus oregonensis* (Dana), the pelecypod *Ostrea lurida* Carpenter, the gastropod *Cerithidia californica* Haldeman, and unidentified dipterous larvae and pupae, juvenile clams, copepods, and the green alga *Enteromorpha sp.*

Discussion

Recolonization of the marine environment following mass mortality due to excessive run-off from rainfall is rapid. Repopulation was evident one to two months later at Nigeria (Sandison and Hill, 1959), at Jamaica (Goodbody, 1961), and in southern California (data reported herein). It is interesting to note that the same species which had been killed were the ones which recolonized immediately. Apparently succession in these environments is of little or no importance as has been reported elsewhere for the subtidal benthos (Reish, 1961a).

Since recolonization is so rapid, the source of larvae presumbly must be from nearby localities and from adults which have long or continuous reproductive seasons. Sandison and Hill (1959) stated the source of larvae in some cases can come from outside Lagos Harbor away from the influence of freshwater flooding. Goodbody (1961) found some populations of some of the species were below the depth affected by the dilution of the marine waters. Furthermore, he stated that many of the sedentary forms reproduce throughout the year. The three species of estuarine polychaetes are found along the banks and bottom of nearby Cerritos Channel of Alamitos Bay (Fig. 1). While it was not investigated, it seems logical to assume that the population on the bottom of the channel would be less affected by the run-off than the intertidal population studied, and therefore be a source for repopulation. These studies dealing with repopulation following mass mortality have been carried out in temperate or subtropical seas where the organisms have either extended or continuous reproductive seasons; studies have not yet been carried out in colder areas where the organisms have limited reproductive seasons. Such studies would be of interest especially with regards to recolonization.

SUMMARY

1. The effect of run-off from rainfall on three species of estuarine polychaetes, *Capitella capitata, Streblospio benedicti*, and *Polydora nuchalis*, in southern California was studied over a period of 15 months.

2. Rainfall in excess of 0.5 inches either reduced or killed one or more of these species. Greater amounts of rainfall over a period of days completely eliminated these polychaetes. Repopulation by larvae occurred rapidly.

3. All three species were present throughout the period of study except after excessive rainfalls. Juvenile *Capitella capitata* were seen at all times when this species was collected. The occurrence of juvenile *Streblospio benedicti* and *Polydora nuchalis* were limited to the last half of the year.

4. The other species encountered during the study were recorded. Notable among these was the first report of the occurrence of the oligochaete *Paranais salina* from North America.

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NORTH ATLANTIC PILOT WHALE WITH A TRIANGULAR DORSAL FIN

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Variation in the form of the dorsal fin of some Cetacea is common; *i.e.*, the blue whale, *Balaenoptera musculus* (Linnaeus), (Gilmore, *pers. comm.*, 1965), but this is not the case in the pilot whale, genus *Globicephala*. Unless injured, the only major differences found in the adult pilot whale are those of sexual dimorphism. Sergeant 1962:410) reported that the dorsal fins of adult males have a thickened leading edge and a more rounded form than the fin of adult females. This paper reports the first dorsal fin anomaly, known to the present writers, in *Globicephala*.

On 11 August 1964, in Charleston, Newfoundland, approximately 25 pilot whales, *Globicephala melaena* (Traill), were being flensed for blubber. Several had been processed when a medium-sized female(standard length, 427 cm.) was pulled onto the flensing platform. Figure 1 illustrates the dorsal fin of this whale which had a definite triangular shape. Four measurements were taken on the fin: (1) anterior insertion to apex of fin, 48 cm., (2) posterior insertion to apex of fin, 31 cm., (3) height of fin, 22 cm., and (4) length of fin, 81 cm. The fin was removed from the animal and cut in cross sections. No scar tissue was found along the anterior or posterior edges.

We know of only one published report of a delphinid with a triangular fin. This was reported and illustrated for a live albino Atlantic bottlenosed dolphin, *Tursiops truncatus* (Montagu), by Essapian (1962:343). This animal later was viewed at the Seaquarium in Miami, Florida, by Brownell. The shape of the fin was similar to that of our pilot whale, including an absence of external scarring, and even possessed the small bump on the lower posterior edge, suggesting a comparable origin. We asked Dr. D. E. Sergeant of the Fisheries Research Board of Canada if he had ever seen a *G. melaena* with a dorsal fin like the one reported herein during his extensive studies on this species. Dr. Sergeant stated that he had not (*pers. comm.*, April 6, 1965). In our opinion, the fin reported herein and

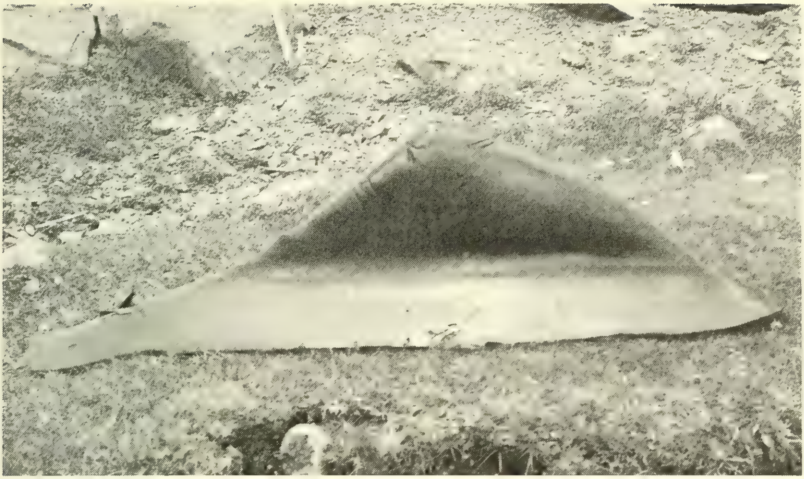

Figure 1. Right lateral view of triangular dorsal fin of *Globicephala melaena* discussed in text.

that noted by Essapian demonstrate a genetic trait or an abnormality occurring during embryonic development, rather than a defect acquired post-natally.

We wish to thank Drs. Sergeant and Raymond M. Gilmore for their comments and advice during the preparation of this note. Brownell also wishes to thank Mr. Burton Clark, Vice President and General Manager of Miami's Seaquarium, for the courtesies shown him while visiting that establishment. This investigation was supported in whole by Public Health Service Research grant HE 07146, from the National Heart Institute.

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A CONFIRMATION OF THE VALIDITY OF *NOTORHYNCHUS PECTINATUS*; THE SECOND RECORD OF THIS UPPER CRETACEOUS COWSHARK

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Los Angeles County Museum
Los Angeles, California

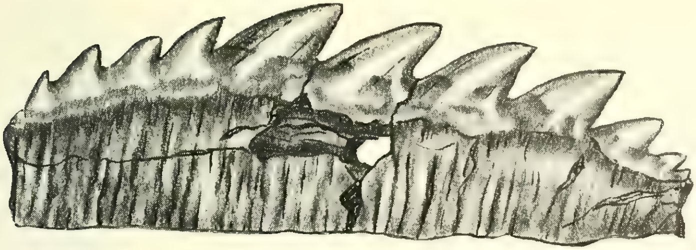
Camp (1942) and Welles (1943) mentioned the occurrence of sharks' teeth in the Moreno formation of the Panoche Hills, Fresno County, California. Dr. S. P. Welles of the University of California, has kindly lent the teeth in question; which are from the paleontology museum of the University of California at Berkeley.

U.C. Mus. Pal. 57551 is a lower left lateral, not the most anterior tooth nor the most posterior (Fig. 1). On the inside of the root there is a prominent ridge going almost straight across the tooth. Above this ridge is an irregular edge formed by the base of the crown. The crown is composed of a number of saw-like projections on the posterior portion of the tooth; these projections will be referred to as crownlets since they are subdivisions of the crown. There are 7 crownlets in our tooth and they are directed posteriorly. In front of the crownlets are similar structures which we shall call denticles, a term more readily applied to the modern *Notorhynchus*; in our tooth there are 6 denticles. The first three are almost equal in size; the last three are much smaller. None of the crownlets or denticles bear serrations.

In U.C. Mus. Pal. 57551 the total length of the tooth measured along the posterior ridge is 42.1 mm. Crownlet heights are 9.1 mm., 8.4 mm., 7.3 mm., 6.9 mm., 5.1 mm., 2.3 mm., 0.9 mm. Denticle heights are 5.9 mm, 5.3 mm., 5.0 mm., 3.7 mm., 1.8 mm., 0.8 mm. Crownlet height was measured from the tip to a point at the base of the enamel and in the center of the crownlet. Denticle height was measured from the tip to a point at the base of the enamel and in the center of the denticle.

U.C. Mus. Pal. 57552 is a tooth from the same species of shark and of similar size, perhaps even from the same individual. It is a lower left posterior. In this tooth there were 10 crownlets, but 4 are broken off at the base. Anteriorly 4 denticles are present. The end of the tooth is broken but 5 or 6 denticles probably were present.

Total length of 57552 measured along the posterior ridge is 49.5 mm.



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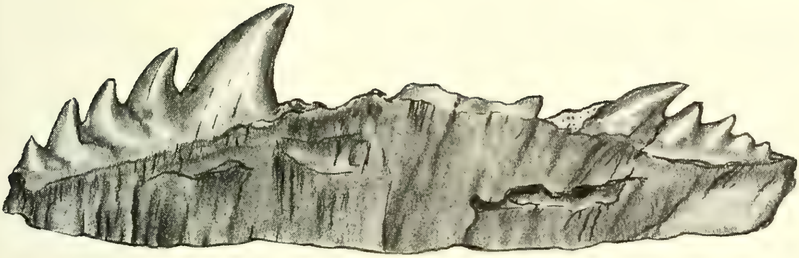

2

Figure 1. U.C. Mus. Pal. 57551, a lower left lateral of *Notorhynchus pectinatus* (Agassiz). *Figure 2.* U.C. Mus. Pal. 57552, a lower left posterior of the same species.

Crownlet heights are 8.0 mm. (four broken ones), 5.7 mm., 4.0 mm., 3.0 mm., 1.4 mm., 0.5 mm. Denticle heights are 5.8 mm., 5.0 mm., 4.8 mm., 3.4 mm.

When this tooth is compared with recent hexanchids the enlarged denticles are conspicuously different. However, a similar lateral has been figured by Agassiz (1843) and called *Notidanus pectinatus* Agassiz. The more common British Cretaceous hexanchid is *Notidanus microdon* Agassiz. Agassiz (1843:221-222), stated that his tooth differed from *Notidanus microdon* in having enlarged tooth-like serrations and was therefore worthy of a specific name. Woodward (1886) remarked in connection with *Notidanus pectinatus*, "This type of tooth appears to be extremely rare and I have not seen any examples." Woodward (1889:160) placed *Notidanus pec-*

tinatus in synonymy with *Notidanus microdon* but puts in front of the name a question mark in parenthesis. Woodward (1893:192) remarked that no new teeth of *Notidanus* differing from *Notidanus microdon* had been found and added that the discovery of teeth showing much larger serrations (denticles) than those indicated in the accompanying plates (All *N. microdon*) was much desired. Woodward's illustrated teeth are definitely serrate and could not be considered to have denticles as we have termed the projections in *Notorhynchus pectinatus*. Woodward (1912:252) referred to *Notidanus pectinatus* in the appendix of his famous chalk monograph stating as did Agassiz (1843), that the tooth was originally in the Mantell collection, and that no other specimen had been discovered. The location of the type was not given.

This cloud of uncertainty surrounding the validity of the species of Agassiz' is largely dispelled with the recognition of the two Panoche Hills' teeth. The rediscovery of this species so far removed from the type area dramatically points out the need for considering fossil sharks in the light of a world fauna. For if some modern shark species, such as the great white, the blue and the tiger, have worldwide distribution we should suspect the same with a number of the fossil species as well, as is borne out in the Miocene by *Carcharodon megalodon* Agassiz, *Galeocerdo aduncus* Agassiz and *Hemipristis serra* Agassiz.

The use of the genus *Notidanus* is regrettably an artificial one for in it are placed both the genera *Hexanchus* and *Notorhynchus*. Recent studies suggest that it is possible to separate these two genera on the basis of teeth, the lower laterals in particular. *Hexanchus* possesses serrations on the front edge of its most anterior crownlet. *Notorhynchus* has small unequal denticles and the third genus in the family Hexanchidae, *Heptranchus* has one or two distinct narrow anterior denticles. Agassiz' *Notidanus pectinatus* has unequal denticles which decrease in size anteriorly as in *Notorhynchus*; because of this similarity I am referring *N. pectinalis* to the genus *Notorhynchus* on a tentative basis until a revision of the entire group can be undertaken. *N. pectinatus* is quite similar to the Paleocene *N. loozi* Priem described from the Paris Basin by Priem (1911).

In association with the plesiosaur there were also ammonite shells. Welles (1943:128), suggests that the shark or sharks (along with the ammonites) may have been feeding on the Plesiosaur carcass as the disarrangement of the bones on the upperside suggested to him the feeding of scavengers. To my knowledge, the

Hexanchidae, the family to which these teeth belong, is not known to have a scavenging record, yet there is no reason to think that these sharks would not scavenge when an opportunity appeared. The fact that sharks are at times scavengers is well illustrated in a shark similar in size but not particularly closely related, the tiger shark, *Galeocerdo cuvier* (Lesueur). Bigelow and Schroeder (1948) relate that the tiger shark feeds on all kinds of carrion, *i.e.*, parts of sheep, dead dogs and beef bones. This scavenging of the tiger shark can be carried into the fossil record, if we may use circumstantial evidence. We recently received at the Los Angeles County Museum a yet undescribed or studied Miocene trunkback turtle from Altamira shale, Miocene of Palos Verdes. At the rear of the specimen enclosed in the same concretion we found several teeth of *Galeocerdo aduncus* Agassiz, the Miocene fossil tiger shark. The modern tiger shark feeds frequently on sea turtles and its saw-like teeth must be well suited for cutting the shell. This food preference was evidently established as far back as Miocene times. More recently we have found, in the Altamira shale, teeth of this same species of Miocene fossil tiger shark in close association with bones of an uncollected cetothere, in a huge concretion, from a nearby locality in the same formation, another evidence of scavenging.

Sharks replace their teeth throughout their life (Breder, 1942). Since the teeth ultimately loosen and fall out, one would expect that teeth would be commonly lost while feeding, a time when great force is applied to the teeth. Loose teeth are often found on the deck when bringing live sharks aboard ship and several times we have seen a tooth ready to drop out of the jaws, held only by a thread of flesh. When viewed in the light of this information Welles (1943:128), contention of scavenging sharks is not unreasonable, and there is a good possibility similar associations will be found in the fossil record.

The two sharks' teeth associated with the Cretaceous plesiosaur are the lower teeth of a sevengilled shark, tentatively, *Notorhynchus pectinatus* (Agassiz). This modern genus is placed in the family Hexanchidae (Bigelow and Schroeder, 1948). Both the recent and fossil genera and species of this family are in need of further study and revision.

The drawings in this paper were done by Mrs. Pearl Hanback.

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NOTEWORTHY RECORDS OF THE GEKKONID LIZARD GENUS *HOMONOTA* GRAY FROM ARGENTINA

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In 1963, Dr. Osvaldo A. Reig of the Laboratorio de Investigaciónes Herpetologicas, Universidad de Buenos Aires, Argentina (LIHUBA) sent a large collection of gekkonid lizards of the genus *Homonota* Gray to Dr. Ernest E. Williams of the Museum of Comparative Zoölogy (MCZ), at Harvard University for further indentification. Dr. Williams knew of my revision of *Homonota*, which was in press at that time (Kluge, 1964), and referred the specimens to me for additional study. The material, which consists of five species, represented by 27 specimens, was not received in time to be included in the revision. However, the importance of the collection is acknowledged in the form of the following separate report. I wish to thank Dr. Reig and Dr. Williams for the opportunity to study and publish on the material at hand. The meristic and mensurable terminology and methodology follows that of the revision (p. 3). All measurements are in millimeters.

Homonota borelli (Peracca)

Gymnodactylus borelli Peracca, 1897:2. Type locality. Salta, Salta Province, Argentina.

LIHUBA Lot 281, no. 1.—El Barreal, Sierra Brava (ESE of La Rioja), La Rioja Province, collected November, 1960.

The El Barreal specimen appears to be the third known example of *borelli* and extends its range over 500 kilometers southward from Salta, the nearest known exact locality. The specimen agrees with Peracca's (1897) original description of the species and that given by Kluge (1964) for a single example from the Chaco region of Argentina. It differs only slightly from these in the following characteristics: rostral crease slightly more than one-half its height; five supralabials; 5/6 infralabials (right and left sides respectively); six scales between postnasals and preocular granules; 15 interorbital scales; three pairs of distinct longitudinal dorsal body rows of keeled scales and an obscure fourth pair; one or two granules separate the secondary from the tertiary and the tertiary from the quaternary paravertebral keeled scale rows; 35 enlarged, keeled scales in primary paravertebral row between axilla and groin; 43 enlarged scales around midbody (excluding 11 dorsal granules); fourth finger with 11/10 subdigital lamellae; fourth toe with 14 subdigital lamellae; snout to vent length 31.3; tail incomplete; head length 8.0 (25.6); head width 6.0 (19.2); snout length 3.1 (9.9); distance from eye to ear 3.0 (9.6); diameter or orbit 2.4 (7.7); distance from axilla to groin 14.8 (47.3); length of forelimb 10.4 (33.2); length of fourth finger 2.3 (7.4); length of hind limb 14.6 (46.6); length of fourth toe 3.2 (10.2).

Through the courtesy of Director G. Bacci, during the summer of 1964, I was able to visit the Musei di Zoologia e di Anatomia comparata della R. Università di Torino, Torino, Italia, and examine the type series of gekkonid lizards located in the collections. Records in the museum list a specimen as the holotype of *borelli*, however, I was unable to locate it during my brief stay. Due to the lack of curatorial assistance during recent years the collections of the museum have become somewhat disorganized and it is possible that the specimen has only been misplaced.

Homonota horrida (Burmeister)

Gymnodactylus horridus Burmeister, 1861:309. Type locality: near Mendoza (in a gorge near Challao), Mendoza Province, Argentina.

LIHUBA Lot 202, no. 1.—El Quebrachal (ESE of Salta), Salta Province; Lot 282, no. 1.—La Rioja, La Rioja Province, collected November, 1960; Lot 302, no. 1.—Gancedo, Chaco Territory, collected February, 1961; Lot 303, no. 1—Tafí Viejo (N of San Miguel de Tucumán), Tucumán Province, collected August, 1960; Lot 564, no. 1—Ischigualasto, Valle Fertil Department, San Juan Province, collected April-May, 1961; Lot 770, no. 1.—Embalse San Felipe (NE of San Luis), San Luis Province, collected January, 1962; Lot 771, no. 1 and Lot 1016, nos. 1-3.—Naschel (NE of San Luis), Chacabuco Department, San Luis Province, collected January and June, 1962; Lot 1019, no. 1.—Finca El Salvador, Choya (SW of Santiago del Estero), Santiago del Estero Province, collected July, 1962; Lot 1193, no. 1.—Valle Hermoso (NNW of Córdoba), Córdoba Province, collected January, 1963.

The above records fill in many of the gaps in the range of the species that was indicated in the earlier revision (Kluge, 1964: fig. 1). None of the new material exhibits any of the diagnostic features of *Homonota fasciata* (Duméril and Bibron), the most closely related species to *horrida* as can be seen from the following comparisons: 10-13 (11.6) interorbitals (16 in *fasciata*), all margins of external ear opening strongly denticulate (only anterior margin of ear opening has slight denticulation in *fasciata*), postmentals moderately large (greatly enlarged in *fasciata*) and anterior gular scales large and plate-like (small and granular in *fasciata*).

Homonota darwinii Boulenger

Homonota darwinii Boulenger, 1885:21, pl. 3, fig. 7. Type locality: Puerto Deseado (Port Desire), approximate latitude 48° S, Santa Cruz Province, Argentina.

LIHUBA Lot 203, nos. 1-3,5,6,11,15,26 (8 specimens).—El Quebrachal (ESE of Salta), Salta Province.

The LIHUBA material extends the range of *darwinii* well over 800 kilometers NE of the nearest known locality of Cuaró, Artigas Department, Uruguay. The specimens, although slightly different from previously studied *darwinii* (See Table 1), exhibit most of that species' diagnostic charcaters and are provisionally referred to it. The presence of ventral body pigmentation and lower numbers of fourth finger and toe lamellae can still be used to differentiate *darwinii* from *underwoodi*, its closest relative, but the number of interorbitals can not be used in view of the new material (See Table 1). The LIHUBA specimens of *darwinii* do not exhibit any general morphological trend toward *underwoodi*, although the geographical ranges of the two species are now known to be considerably closer.

TABLE 1.
Meristic and mensurable differences between
Homonota darwinii and *H. underwoodi*

	darwinii[1]	*darwinii*[2]	*underwoodi*[3]
Postnasal to preocular granules	4-7 (5.5)	4-5 (4.5)	6-8 (6.7)
Interorbitals	14-16 (15.1)	14-18 (15.4)	16-20 (17.9)
Postmentals	2-3 (2.7)	2	2-4 (3.2)
Paravertebrals	70-76 (73.0)	56-66 (61.5)	70-79 (73.9)
Midbody scales	58-64 (60.8)	55-63 (58.7)	59-70 (65.2)
Fourth finger lamellae	12-14 (12.8)	10-13 (12.0)	12-18 (14.3)
Fourth toe lamellae	16-19 (17.0)	14-18 (15.4)	18-23 (19.7)
Vental body pigmentation	present	present	absent
Head length	21.0-23.4	24.7-28.7	24.6-27.2

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[1] data taken from Uruguayan and eastern costal Argentinian specimens studied by Kluge (1964).

[2] data taken from 8 specimens from El Quebrachal, Salta Province, (LIHUBA Lot 203).

[3] data taken from all known specimens (including type series).

It is possible that the El Quebrachal specimens represent an inland race of the more coastal typical *darwinii* as suggested by the lower number of paravertebral scales and longer head (see Table 1). Further study of this problem must await the acquisition of geographically intermediate material.

Homonota underwoodi Kluge

Homonota underwoodi Kluge, 1964:25, figs. 2G, 7. Type locality: Agua de la Peña, Hoyada de Ischigualasto, 82 kilometers NW of San Augustin de Valle Fertil, Valle Fertil Department, San Juan Province, Argentina.

LIHUBA Lot 201, nos. 1-5.—Ischigualasto, San Juan Province, collected April, 1960.

Presumably, the LIHUBA material is from the type locality of *underwoodi*. The five new specimens are nearly identical with the type series (MCZ 58140-2) with the exception of the following more important minor deviations: 4-6 (5.2) supralabials (six in the type series); 16-18 (17.2) interorbitals (18-20, avg. 19.0 in the type series); 12-15 (13.2) fourth finger lamellae (14-18, avg. 16.2 in the type series). These differences are not considered to be significant.

Homonota whitii Boulenger

Homonota, whitii Boulenger, 1885:22, pl. 3, fig. 6. Type locality: Cosquín, Córdoba Province, Argentina.

LIHUBA Lot 216, no. 1.—Valle Hermoso (NNW of Córdoba), Córdoba Province, collected February, 1958.

The Valle Hermoso specimen falls within the geographical range of *whitii* and is morphologically nearly identical with previously studied material of that species except in the following characters: internasal present, 16 interorbitals and three postmentals (internasals absent, 13-14, avg. 13.5 interorbitals and two postmentals in specimens used in the revision).

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A COLLECTION OF WHALE-LICE (CYAMIDAE: AMPHIPODA)

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In work on the Chonotrichida, ciliated protozoans, ectocommensals of various crustaceans, Professor J. L. Mohr and his co-workers (J. A. LeVeque, H. Matsudo and the writer) have been collecting series of their hosts. The whale-louse (Cyamidae: Amphipoda) is one of these hosts (Mohr, Matsudo and Leung, 1963). The accumulated cyamids now constitute one of the largest and most complete collections of these amphipods (now housed at the Allan Hancock Foundation of the University of Southern California). Not only are there a large number of specimens, but the collection includes 15 of the 16 described species in the family, together with an unnamed species of *Cyamus* and one of *Platycyamus*. There are representatives of the type series of *Cyamus nodosus* Lütken as well as some specimens of *C. monodontis* Lütken collected in 1865 and 1866 and identified by Lütken. The collection also includes a paratype of *C. bahamondei* described by Buzeta (1963) and a large group of specimens representing a number of species donated by the Academy of Sciences of USSR, Moscow.

As whale-lice infest both the whalebone whales (Mysticeti) and the toothed whales (Odontoceti), the hosts were collected from the whaling grounds of Greenland, Norway, USSR, Alaska, Aleutian Islands, Canada, British Columbia, California, Chile, Hawaii, Australia, New Zealand, Polynesia, South Africa, and Western Antarctica. Original identifications have been checked and new ones made on the basis of the descriptions of Lütken (1873), Barnard (1932), Stephensen (1942), Margolis (1954, 1955), Hurley and Mohr (1957), and Buzeta (1963).

The whale nomenclature is that proposed by Scheffer and Rice (1963). Except where latitudes and longitudes are given, the locations in the following table are those that were recorded by the collector, and in most cases are the port or shore station where the whales were landed and butchered.

The collection consists of about 9000 specimens, excluding Dr. Floyd E. Durham's recent collection of more than 100,000 individuals from a single gray whale. The following is the inventory of that collection.

No. and Species	Host	Location	Collector	Date
CBO 1 *Cyamus boopis*	*Megaptera novaengliae* (humpback whale)	Picton, New Zealand	R. Brensdon	July 1954
CBO 2 *Cyamus boopis*	*Megaptera novaengliae* (humpback whale)	Coal Harbor, British Columbia	C. Diedrich	Aug. 15, 1957
CBO 3 *Cyamus boopis*	*Megaptera novaengliae* (humpback whale)	Norway	S. Schneider	Nov. 1, 1957
CBO 4 *Cyamus boopis*	*Megaptera novaengliae* (humpback whale)	Coal Harbor, British Columbia	C. Diedrich	1957
CBO 5 *Cyamus boopis*	*Megaptera novaengliae* (humpback whale)	Coal Harbor, British Columbia	G. C. Pike	Aug. 7, 1953
CBO 6 *Cyamus boopis*	*Megaptera novaengliae* (humpback whale)	Coal Harbor, British Columbia	C. Diedrich	Aug. 1957
CBO 7 *Cyamus boopis*	*Megaptera novaengliae* (humpback whale)	Coal Harbor, British Columbia	G. C. Pike	July 14, 1953
CBO 8 *Cyamus boopis*	*Megaptera novaengliae* (humpback whale)	Coal Harbor, British Columbia	G. C. Pike	Aug. 6, 1953
CBO 9 *Cyamus boopis*	*Megaptera novaengliae* (humpback whale)	Durban, South Africa	R. Gambell	June 22, 1963
CBO 10 *Cyamus boopis*	*Megaptera novaengliae* (humpback whale)	Richmond, California	M. Nishiwaki	Oct. 6, 1963
CBO 11 *Cyamus boopis*	*Megaptera novaengliae* (humpback whale)	San Francisco, California	D. W. Rice	April 20, 1964
CBO 12 *Cyamus boopis*	*Megaptera novaengliae* (humpback whale)	Richmond, California	M. Nishiwaki	Sept. 1963
CBO 13 *Cyamus boopis*	*Megaptera novaengliae* (humpback whale)	Carnarvon, Australia	C. Chittleborough	July 1957
CBO 14 *Cyamus boopis*	*Megaptera novaengliae* (humpback whale)	Coal Harbor, British Columbia	G. C. Pike	July 25, 1940

No. and Species	Host	Location	Collector	Date
CBO 15 *Cyamus boopis*	*Megaptera novaengliae* (humpback whale)	51°20′N: 172°20′W	Whales Research Institute, Japan	June 24, 1954
CBO 16 *Cyamus boopis*	*Megaptera novaengliae* (humpback whale)	Antarctic	Whales Research Institute, Japan	1954
CBO 17 *Cyamus boopis*	*Megaptera novaengliae* (humpback whale)	Tonga Island	W. H. Dawbin	
CBO 18-20 *Cyamus boopis*	*Megaptera novaengliae* (humpback whale)			
CCA 1 *C. catodontis*	*Physeter catodon* (sperm whale)	Antarctic		1954
CCA 2 *C. catodontis*	*Physeter catodon* (sperm whale)	Coal Harbor, British Columbia	G. C. Pike	July 16, 1953
CCA 3 *C. catodontis*	*Physeter catodon* (sperm whale)	67°12′S: 20°32′W	Netherlands Whaling Company	March 8, 1947
CCA 4 *C. catodontis*	*Physeter catodon* (sperm whale)	55°04′S: 17°04′E	Netherlands Whaling Company	Nov. 16, 1947
CCA 5 *C. catodontis*	*Physeter catodon* (sperm whale)	Albany, Australia	G. Chittleborough	Nov. 6, 1957
CCA 6 *C. catodontis*	*Physeter catodon* (sperm whale)	54°40′S: 25°15′E	Karl J. Pettersen	Jan. 14, 1961
CCA 7 *C. catodontis*	*Physeter catodon* (sperm whale)	67°50′S: 82°40′W	Karl J. Pettersen	1961
CCA 8 *C. catodontis*	*Physeter catodon* (sperm whale)	66°35′S: 78°46′W	Karl J. Pettersen	Dec. 18, 1960
CCA 9 *C. catodontis*	*Physeter catodon* (sperm whale)	57°20′S: 17°35′E	Karl J. Pettersen	Dec. 8, 1961

No. and Species	Host	Location	Collector	Date
CCA 10 *C. catodontis*	*Physeter catodon* (sperm whale)	63°43′S: 66°40′W	Karl J. Pettersen	Dec. 21, 1960
CCA 11 *C. catodontis*	*Physeter catodon* (sperm whale)	60°29′S: 53°50′W	Karl J. Pettersen	April 6, 1961
CCA 12 *C. catodontis*	*Physeter catodon* (sperm whale)	Coal Harbor, British Columbia	G. C. Pike	July 16, 1953
CCA 13 *C. catodontis*	*Physeter catodon* (sperm whale)	Durban, South Africa	R. Gambell	June 4, 1963
CSC 1 *C. scammoni*	*Eschrichtius glaucus* (gray whale)	San Francisco, California	Mildred Barr	Feb. 1953
CSC 2 *C. scammoni*	*Eschrichtius glaucus* (gray whale)	Santa Barbara, California	J. H. Connell	April 4, 1958
CSC 3 *C. scammoni*	*Eschrichtius glaucus* (gray whale)	Point Barrow, Alaska	R. T. Holmes	July 19, 1959
CSC 4 *C. scammoni*	*Eschrichtius glaucus* (gray whale)	Santa Barbara, California	J. West	March 22, 1958
CSC 5 *C. scammoni*	*Eschrichtius glaucus* (gray whale)	San Pablo, California	Yuk M. Leung	March 15, 1964
CSC 6 *C. scammoni*	*Eschrichtius glaucus* (gray whale)	San Pablo, California	Yuk M. Leung	March 14, 1964
CSC 7 *C. scammoni*	*Eschrichtius glaucus* (gray whale)	San Pablo, California	F. E. Durham	March 24, 1964
CSC 8 *C. scammoni*	*Eschrichtius glaucus* (gray whale)	Richmond, California	J. L. Mohr	March 1962
CSC 9 *C. scammoni*	*Eschrichtius glaucus* (gray whale)			

No. and Species	Host	Location	Collector	Date
CCE 1 *C. ceti*	*Eschrichtius glaucus* (gray whale)	San Francisco, California	Mildred Barr	Feb. 1953
CCE 2 *C. ceti*	*Eschrichtius glaucus* (gray whale)	Newport Beach, California	F. S. Truxal	Feb. 6, 1960
CCE 3 *C. ceti*	*Eschrichtius glaucus* (gray whale)	Richmond, California	J. L. Mohr	March 1962
CCE 4 *C. ceti*	*Balaena mysticetus* (bowhead)	Point Barrow, Alaska	F. E. Durham	May 11, 1961
CCE 5 *C. ceti*	*Eschrichtius glaucus* (gray whale)	Point Barrow, Alaska		
CCE 6 *C. ceti*	*Eschrichtius glaucus* (gray whale)	San Pablo, California	Yuk M. Leung	March 14, 1964
CKE 1 *C. kessleri*	*Eschrichtius glaucus* (gray whale)	Point Barrow, Alaska	R. T. Holmes	July 19, 1959
CKE 2 *C. kessleri*	*Eschrichtius glaucus* (gray whale)	Point Barrow, Alaska		Aug. 16, 1964
CKE 3 *C. kessleri*	*Eschrichtius glaucus* (gray whale)	San Pablo, California	Yuk M. Leung	March 14, 1964
CKE 4 *C. kessleri*	*Eschrichtius glaucus* (gray whale)	Point Barrow, Alaska		
CBA 1 *C. balaenopterae*	*Balaenoptera physalus* (fin whale)	52°05′N: 171°20′W	Whales Research Institute, Japan	June 7, 1954
CBA 2 *C. balaenopterae*	*Balaenoptera physalus* (fin whale)	56°S: 7°E	Netherlands Whaling Company	Dec. 19, 1946

No. and Species	Host	Location	Collector	Date
CBA 3 *C. balaenopterae*	*Balaenoptera physalus* (fin whale)	56°11′S: 7°13′E	Netherlands Whaling Company	Dec. 19, 1946
CBA 4 *C. balaenopterae*	*Balaenoptera physalus* (fin whale)	Carnarvon, Australia	G. Chittleborough	June 8, 1959
CGR 1 *C. gracilis*	*Balaena glacialis australis* (South right whale)	South Sea, Antarctica	Kr. Möller	
CGR 2 *C. gracilis*	*Balaena glacialis japonica* (North Pacific right whale)	Kodiak Island, Alaska		June
CGR 3 *C. gracilis*	*Balaena glacialis japonica* (North Pacific right whale)	47°01′N: 150°25′E	S. K. Klumov	June 19, 1955
CGR 4 *C. gracilis*	*Balaena glacialis japonica* (North Pacific right whale)	Kirittappu, Japan		
CNO 1 *C. nodosus*	*Monodon monoceros* (narwhal)	Greenland	E. Bertelsen	Aug. 23, 1933
CNO 2 *C. nodosus*	*Monodon monoceros* (narwhal)	Greenland	E. Bertelsen	
CNO 3 *C. nodosus*	*Monodon monoceros* (narwhal)	Greenland		ca. 1860
CNO 4 *C. nodosus*	*Monodon monoceros* (narwhal)	East Greenland	N. Tinbergen	July 1933
CNO 5 *C. nodosus*	*Monodon monoceros* (narwhal)	East Greenland	N. Tinbergen	July 1933
CMO 1 *C. monodontis*	*Monodon monoceros* (narwhal)	Greenland	Fleischer	1866

No. and Species	Host	Location	Collector	Date
CMO 2 *C. monodontis*	*Monodon monoceros* (narwhal)	Greenland	E. Bertelsen	Aug. 23, 1933
CMO 3 *C. monodontis*	*Monodon monoceros* (narwhal)	East Greenland	A. Rosenkrantz	July 28, 1927
CMO 4 *C. monodontis*	*Monodon monoceros* (narwhal)	Greenland	Fleischer	Oct. 2, 1965
CMO 5 *C. monodontis*	*Monodon monoceros* (narwhal)	West Greenland	Fleischer	Oct. 1, 1865
CMO 6 *C. monodontis*	Narwhal	Greenland	Fleischer	Oct. 2, 1865
CMO 7 *C. monodontis*	Narwhal	Baffin Bay, Canada	A. W. Mansfield	July 15, 1963
CER 1 *C. erraticus*	*Balaena glacialis japonica* (North Pacific right whale)	49°44′N: 157°17′E	S. K. Klumov	July 13, 1955
CER 2 *C. erraticus*	*Balaena glacialis japonica* (North Pacific right whale)	47°01′N: 150°25′E	S. K. Klumov	June 19, 1955
CER 3 *C. erraticus*	*Balaena glacialis japonica* (North Pacific right whale)	46°23′N: 152°24′E	S. K. Klumov	June 1, 1955
CER 4 *C. erraticus*	*Balaena glacialis australis* (South right whale)	New Zealand		
CER 5 *C. erraticus*	*Balaena glacialis japonica* (North Pacific right whale)	Ayukawa, Japan		June 23
CBA 1 *C. bahamondei*	*Physeter catodon* (sperm whale)	Iquique, Chile	R. Buzeta	1961

No. and Species	Host	Location	Collector	Date
COV 1 *C. ovalis*	*Balaena glacialis japonica* (North Pacific right whale)	50°00′N: 154°25′E	S. K. Klumov	Aug. 28, 1955
COV 2 *C. ovalis*	*Balaena glacialis japonica* (North Pacific right whale)	47°01′N: 150°25′E	S. K. Klumov	June 19, 1955
COV 3 *C. ovalis*	*Balaena glacialis japonica* (North Pacific right whale)	49°42′N: 154°31′E	S. K. Klumov	July 22, 1955
COV 4 *C. ovalis*	*Balaena glacialis japonica* (North Pacific right whale)	50°47′N: 155°21′E	S. K. Klumov	Aug. 10, 1955
COV 5 *C. ovalis*	*Balaena glacialis japonica* (North Pacific right whale)	50°00′N: 155°21′E	S. K. Klumov	Aug. 10, 1955
COV 6 *C. ovalis*	*Balaena glacialis japonica* (North Pacific right whale)	49°42′N: 156°35′E	S. K. Klumov	July 22, 1955
COV 7 *C. ovalis*	*Balaena glacialis japonica* (North Pacific right whale)	50°22′N: 155°12′E	S. K. Klumov	Aug. 10, 1955
COV 8 *C. ovalis*	*Balaena glacialis japonica* (North Pacific right whale)	46°23′N: 152°54′E	S. K. Klumov	June 1, 1955
COV 9 *C. ovalis*	*Balaena glacialis japonica* (North Pacific right whale)	50°00′N: 154°25′E	S. K. Klumov	Aug. 28, 1955
COV 10 *C. ovalis*	*Balaena glacialis japonica* (North Pacific right whale)	49°34′N: 156°35′E	S. K. Klumov	July 22, 1955
COV 11 *C. ovalis*	*Balaena glacialis japonica* (North Pacific right whale)	50°00′N: 154°25′E	S. K. Klumov	Aug. 28, 1955
COV 12 *C. ovalis*	*Balaena glacialis japonica* (North Pacific right whale)	51°05′N: 155°51′E	S. K. Klumov	Aug. 11, 1955
COV 13 *C. ovalis*	*Balaena glacialis japonica* (North Pacific right whale)	50°47′N: 155°21′E	S. K. Klumov	Aug. 10, 1955
COV 14 *C. ovalis*	*Balaena glacialis japonica* (North Pacific right whale)	45°08′N: 149°46′E	S. K. Klumov	May 17, 1955

No. and Species	Host	Location	Collector	Date
COV 15 *C. ovalis*	*Physeter catodon* (sperm whale)	44°55′N: 150°15′E	S. K. Klumov	Sept. 10, 1955
COV 16 *C. ovalis*	*Balaena glacialis japonica* (North Pacific right whale)	Kirittappu, Japan		July 1, 1954
COV 17 *C. ovalis*	*Balaena glacialis australis* (South right whale)	Durban, South Africa	R. Gambell	Aug. 15, 1963
COV 18 *C. ovalis*	*Balaena glacialis australis* (South right whale)	Picton, New Zealand	W. H. Dawbin	1951
IDE 1 *Isocyamus delphini*	*Globicephala sp.* (pilot whale)	Kona Coast, Island of Hawaii	K. Norris	July 23, 1961
IDE 2 *Isocyamus delphini*	*Globicephala malaena* (pilot whale)	Jervis Bay, Australia	W. Dawbin	Oct. 8, 1963
NPH 1 *Neocyamus physeteris*	*Physeter catodon* (sperm whale)	Iquique, Chile	R. Buzeta	1962
NPH 2 *Neocyamus physeteris*	*Physeter catodon* (sperm whale)	Coal Harbor British Columbia	C. E. Diedrich	Summer 1953
NPH 3 *Neocyamus physeteris*	*Phocoenoides truei*	Kuril Islands	S. K. Klumov	Sept. 1955
PTH 1 *Platycyamus thompsoni*	*Hyperoodon rostrata* (bottle-nose whale)	Faroes, North Atlantic	Müller	1857
P 1 *Platycyamus* sp.	*Berardius bairdii* (Baird's beaked whale)	Coal Harbor British Columbia	G. C. Pike	July 28, 1953

No. and Species	Host	Location	Collector	Date
C 1 *Cyamus* sp.	*Berardius bairdii* (Baird's beaked whale)	44°29′N: 149°26′E	S. K. Klumov	Sept. 25, 1955
C 2 *Cyamus* sp.	*Berardius bairdii* (Baird's beaked whale)	Ayukawa, Japan	Whales Research Institute, Japan	July 1953
C 3 *Cyamus* sp.	*Berardius bairdii* (Baird's beaked whale)	Coal Harbor British Columbia	C. E. Diedrich	May 11, 1957
C 4 *Cyamus* sp.	*Berardius bairdii* (Baird's beaked whale)	Vancouver Island, British Columbia	F. Wilke	Aug. 20, 1958
C 5 *Cyamus* sp.	*Berardius bairdii* (Baird's beaked whale)	Coal Harbor British Columbia		Aug. 28, 1957
C 6 *Cyamus* sp.	*Berardius bairdii* (Baird's beaked whale)	Faralone Island, California		Sept. 17, 1959
C 7 *Cyamus* sp.	*Berardius bairdii* (Baird's beaked whale)	37°40′N: 123°10′W	D. W. Rice	Sept. 17, 1959
C 8 *Cyamus* sp.	*Berardius bairdii* (Baird's beaked whale)	San Francisco, California	D. W. Rice	Sept. 1964

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ON *LYMANTES* SCHOENHERR (COLEOPTERA, CURCULIONIDAE)[1]

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Recently while examining the monumental generic study, Curculionidae of America north of Mexico, of Kissinger (1964) it was noted that *Lymantes* Schoenherr was placed in the unrecognized genera. This brought to mind the fact that the type of the genus, *Lymantes scrobicollis* Gyllenhal, had been examined several years ago and that drawings and notes had been made. This paper is to establish its position in the North American genera of Curculionidae, to bring attention to generic synonymy, and to describe several new forms in the genus.

Upon examination of the type of *Lymantes* it was noted that the types of *Lymantes* and *Typhloglymma* Dury are congeneric. As will be noted in the species discussion to follow, these genera are very closely related and it is impossible to even retain *Typhloglymma* as a subgenus.

The placing of *Lymantes* (as *Typhloglymma*) in the Hylobiinae is a rather arbitrary decision on the part of Kissinger. For ease in keying the genus out it is a rather practical decision. When the generic characteristics are looked at critically and then compared with other genera, it appears that this genus could fit equally well in the Hylobiinae or Cossoninae, and it has many characteristics of the Raymondionyminae as discussed by Gilbert (1956:70-71). However, I am for the present at least, in favor of leaving *Lymantes* in the Hylobiinae as placed by Kissinger with the notation of the following points: *Lymantes* demonstrates certain relationships to *Dryotribus* of the Cossoninae and *Gononotus* and *Metopotoma* of the Hylobiinae. Comparing *Lymantes* with *Dryotribus*, the apex of the rostrum, scrobes, "eye" position, constriction between head and rostrum, number and form of elytral striae, ascending brush of setae on inner edge of tibiae, and the general form are similar. *Dryotribus*, however, lacks the apical comb lateral to the base of the uncus on tibiae 3 and has the forecoxae much more widely separated and the funicle 5-segmented compared to 7 segments in *Lymantes*. Comparing *Lymantes* and *Gononotus* the "eye" position is approximately the same.

[1] Biological Sciences Contribution #16 California State College at Long Beach.

There is a faint indication of a constriction between head and rostrum. The prosternal characteristics, notably the coxal separation and tibia 3 are similar. *Gononotus*, however, has non-expanded apex on rostrum, a scrobe that is more lateral, and while the elytra are also 10-striate, 10 is complete to apex (in *Lymantes* it is short and in basal third only). *Gononotus* lacks the ascending brush on inner edge of tibiae one. The general form is also quite different. *Lymantes* and *Metopotoma* are very close, especially in form, eye position, coxal separation, tibial structure and third tarsal segment. The antennal funicle in *Metopotoma* is 6-segmented.

Lymantes Schoenherr

Lymantes Schoenherr 1838: 1085.
Typhloglymma Dury 1901:243. *New synonymy.*
Type species. Lymantes scrobicollis Gyllenhal

Rostrum about three-fourths as long as prothorax, apical third to two-fifths expanded appearing quadrate from above, distinctly separated from head by a very deep transverse groove; very deeply closely punctate. Scrobes lateral apically, passing inferior, reaching base of rostrum at junction with head. Antennae 7-segmented, inserted near apical third, behind the apical quadrate area of rostrum; scape gradually clavate, attaining or passing below raised ocular area; segment one globular, 2 elongate, obconic, 3-7 quadrate, closely placed, gradually increasing in width. Club moderately large, subglobular and compact. Ocular area on base of rostrum, lateral, minute. *Head* globular. *Prothorax* oblong quadrate, depressed, constricted apically, truncate at apex and base. Scutellum invisible. *Elytra* 10-striate, the 10th short; moderately convex, gradually declivous behind, narrower at posterior third, not larger at base than prothorax and feebly emarginate, conjointly rounded at apex. Metepisterna absent. Forecoxae feebly separated. Femora clavate, the anterior more strongly than the others. Tibiae narrow, a little compressed, slightly arcuate at the apex, which is uncinate; inner edge with a shallow denuded groove or flattened area extending from base to apex, tibiae one with apical comb lateral of uncus and a short dorsal comb on posterior side, tibiae 2 and 3 with only apical combs lateral of the uncus. Tarsi short, filiform, first three segments with a narrow brush of setae each side of middle of venter; fourth segment long. Claws slender and feebly divergent.

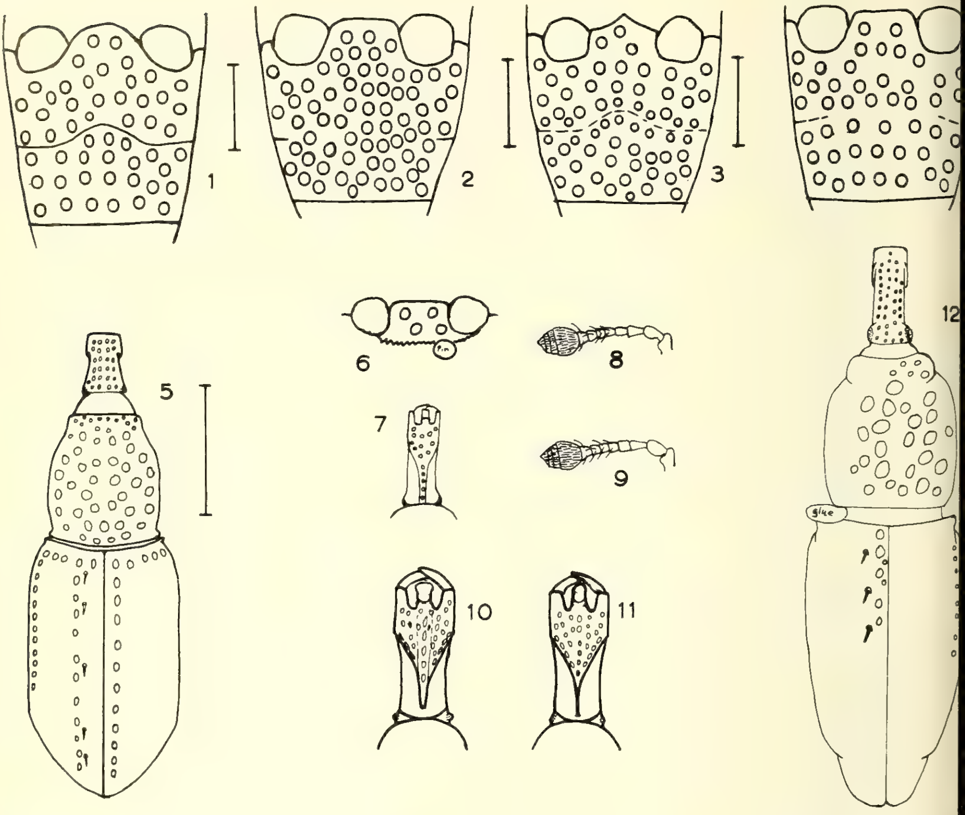

Figure 1. Abdominal sternites 1 and 2 of *Lymantes puteolatum puteolatum* (Dury). *Figure 2.* Same of *Lymantes puteolatum dietrichi* Sleeper. *Figure 3.* Same of *Lymantes arkansasensis* Sleeper. *Figure 4.* Same of *Lymantes sandersoni* Sleeper. *Figure 5.* Dorsal outline of *Lymantes puteolatum puteolatum* (Dury). *Figure 6.* Remainder of abdominal sternite 1 of *Lymantes scrobicollis* Gyllenhal (Holotype). *Figure 7.* Ventral side of rostrum of *Lymantes scrobicollis* Gyllenhal (Holotype). *Figure 8.* Funicle and club of *Lymantes scrobicollis* Gyllenhal (Holotype). *Figure 9.* Funicle and club of *Lymantes puteolatum puteolatum* (Dury). *Figure 10.* Ventral side of rostrum of *Lymantes arkansasensis* Sleeper. *Figure 11.* Ventral side of rostrum of *Lymantes puteolatum puteolatum* (Dury). *Figure 12.* Dorsal outline of *Lymantes scrobicollis* Gyllenhal (Holotype). Figures 1-5 and 12, line equals one mm. Figures 6-11 not to scale.

KEY TO THE NORTH AMERICAN FORMS OF *Lymantes*

1. Humeri behind with obvious emargination, emargination extending downward toward extreme lateral edge of elytra .... *scrobicollis* Gyllenhal

1′. Humeri without such emargination 2

2. Gular area between the scrobes with prominent lateral carinae, the groove between the carinae with punctures (fig. 10) 3

2′. Gular area between the scrobes with the lateral carinae fusing to form a single carina for most of their length (fig. 11) 4

3. Intercoxal process of first abdominal sternite projecting forward at middle (fig. 3) ....*arkansasensis* new species

3′. Intercoxal process without a median projection (fig.4) .... *sandersoni* new species

4. Eighth elytral interval with sharp carina in apical third; apical comb of tibiae one with 10 spines, 2 with 8-9, 3 with 8-9 ....*puteolatum puteolatum* (Dury)

4′. No elytral intervals formed into sharp carinae; apical comb of tibiae one with 6 spines, 2 with 8 and 3 with 6 ....*puteolatum dietrichi* new subspecies

Lymantes scrobicollis Gyllenhall

Figures 6, 7, 8, and 12

Lymantes scrobicollis Gyllenhall, *In* Schoenherr, 1938:1086.

Holotype. "Am. Borealis" with following labels: #1 "Typus" (red label), #2 "Lymantes scrobicollis Gyll.", #3 "3" (pink label) in Stockholm.

Sex undetermined. Length 3.28 mm., width 1.2 mm. Surface, especially of the elytra, with a dull iridescent luster, much as in *Ithaura.*

Rostrum as in generic description. Mandibles overlapping. Scrobes passing inferior, the raised gular area between with limiting carinae, between which there is a punctate groove. Ocular area protruding but not visibly faceted. Antennae as in generic description. Head globular, behind the constriction of the rostrum an alutaceous area. *Prothorax* nearly straight sided the apical constriction more or less pronounced laterally but not extending across the disc, disc flat, the punctures large and very irregular. *Elytra* as in generic description; slightly more than one-half longer than broad; humeri with an obvious emargination which extends toward extreme lateral edge of the elytra and is denuded of the film; striae with rows of shallow fovae which are not connected longitudinally by grooves on the disc but forming grooves on declivity; intervals narrow and slightly convex, with suberect amber setae most of which are missing; on declivity distinctly convex. *Venter* with prosternum convex in front of forecoxae; forecoxae very narrowly separated, mesocoxae separated by less than one-fourth diameter, metacoxae separated by about twice the diameter. Abdominal sternite one with the intercoxal process feebly arcuate. Femora, tibiae and tarsi as in generic description.

Distribution. The type was only indicated as from "Am[erica] Borealis." The elytra of what is probably this species has been taken by the author while sifting litter in Highlands Hammock, Florida. No living or complete individuals were encountered.

Unfortunately at the time the type was examined complete descriptive data were not taken. The above description is based on the notes taken at time of examination. The holotype is in poor condition. The prothorax is held on by a patch of glue on the left side, which obscures the emargination in part. The tarsi are mostly broken, only one of the third intact. The antennae were intact. The abdomen was almost entirely absent. In rostral structure this species is quite like those forms described below from west of the Mississippi River, but in body form it is nearer *puteolatum puteolatum*. From the latter *scrobicollis* differs in being smaller, in the structure of the gular area of the rostrum; the rostrum in dorsal view on *puteolatum* appears a little wider so that the broad sulcus paralleling the upper edges of scrobe is distinctly visible while scarcely so in *scrobicollis*; in *puteolatum* the apical part of the rostrum is broader and therefore more distinctly set off from the basal part; in *scrobicollis* the elytra are more tapering posteriorly; in *puteolatum* the elytra are somewhat widened posteriorly. The shape of the humeri in the two is quite different. On *scrobicollis* the film is more evident.

Lymantes puteolatum puteolatum (Dury), new combination

Figures 1, 5, 9, and 11

Typhloglymma puteolatum Dury 1901:243. (Type supposedly in the Charles Dury Collection at the Cincinnati Museum of Natural History.)

Female. Length 3.4 mm., width 1.3 mm. Slender, elongate, feebly depressed on dorsum; reddish black often covered with a dirty gray film; antennae black; very sparsely clothed with scattered yellow reclinate to erect setae.

Rostrum length 0.85 mm., width at base, antennal insertion and apex 0.33 mm., just behind antennal insertion 0.25 mm., three-fourths as long as prothorax; feebly arcuate in lateral aspect, thickness 0.25 mm.; deeply, rugosely punctate, the line of punctures just above dorsal edge of scrobe coalescent, more or less forming a groove. Scrobes passing inferiorly and forming a very narrow carinae in posterior third. Antennae inserted at apical third; scape reaching lower part of ocular area; funicle clothed with a dirty film and long sparse setae, segments with exception of first two quadrate, ratio 1.0:1.0:0.6:0.6:0.5:0.6:1.0. Club oval, basal segment constituting one-half the mass of the club and sparsely clothed with setae, remaining 3 segments densely clothed with short fine setae. *Head* globose, smooth, very minutely punctate at a magnification of 130x. Ocular area on base of rostrum feebly granulate and prominent. *Prothorax* about one-fifth longer than wide, the sides feebly arcuate, apical constriction pronounced but not continuous across dorsum, disc more or less flattened, very coarsely punctured, the latter separated by one-half or more their diameter and each with a short erect setae, punctures on sides more closely placed. *Elytra* one-third longer than wide and one-third longer than prothorax, humeri not pronounced but a carina that borders anterior edge of elytra gives the appearance of humeri; side more or less arcuate, widening to beyond apical third then convergent to apices; disc somewhat depressed but not as much as that of prothorax; striae 7 and 8 not reaching base of elytra, 9 complete, 10 present only in basal third, the striae not impressed, the punctures very deep, quadrate, each with a very short scale; intervals feebly convex, the eighth carinate in apical third, all intervals shining frequently interrupted by transverse grooves, especially laterally, each interval with a single row of very distant erect slender yellowish setae and minute punctures. *Venter* except for the prosternum without coating or film; punctures coarse and with short setae; prosternum not passing between coxae; in front of coxae strongly convex with a transverse groove of the apical constriction cutting deeply into it. Forecoxae subcontiguous with a shallow depression behind; mesocoxae separated by one-third width of coxae, a short triangular projection of mesosternum between; metasternum strongly, transversely convex and coarsely punctured, metacoxae separated by nearly two and one-half times width of coxae; intercoxal process of abdominal sternite one arcuate, abdominal sternites flattened, very coarsely irregularly punctured, suture between one and 2 deep at sides very feebly evident at middle, the remaining sutures very deep. First two sternites subequal, each three times longer than 3 and 4 combined, the 5th three-fourths as long as second, its apex evenly rounded. Femora one strongly clavate, 2 and 3 feebly clavate, all unarmed. All tibiae nearly as long as femora, flattened, all with a longitudinal groove on inner edge. Tibiae one with 10 apical spines, 2 with 8-9, 3 with 8-9. Tarsi about one-third as long as tibiae, first two segments very short and inconspicuous, third longer than two preceeding combined, but not lobed, fourth segment slender, slightly longer than third. Claws stout and divergent.

The above description, for the most part, was drawn from a female specimen in the E. L. Sleeper Collection (ELS) from Hamilton Co., Redbank, VI-10-51, ELS, near Cincinnati, Ohio. Efforts to find the type of this species in the Dury Collection in August, 1961, proved fruitless. In 1955 this specimen was compared with the type which was then in the collection. The type was also a female, somewhat larger (4.0 mm.) but was otherwise nearly identical to this example. In 1951 a second example was in the collection of Dr. Joseph Wright of Cincinnati, Ohio, from Adams Co., Ohio, Ralph Dury Collr.

Lymantes puteolatum dietrichi, new subspecies

Figure 2

Typhloglymma puteolatum Dietrich 1942: 178.

Holotype. Mississippi, Lucedale, XII-4-30, H. Dietrich, in Entomological Collections, Cornell University.

Female. Length 3.25 mm., width 1.3 mm.; reddish brown; proportionately shorter and broader than *puteolatum puteolatum* and differing in addition to the characteristics mentioned in the key by more distinctly impressed striae, more convex intervals of elytra; venter very feebly shining, the punctures of the first two abdominal sternites evenly, closely placed, separated by less than one-half their diameter (in *puteolatum puteolatum* irregularly placed and most separated by their own diameter); the suture between one and 2 connate but evident, not impressed at sides.

Male. Differing from the female by a slightly shorter rostrum and very feebly concave abdominal sternites one and 2.

Type material. Two paratypes, one ♂, same locality as holotype, XII-30-30, H. Dietrich in (ELS), length 3.28 mm., width 1.4 mm.; 1 ♀, same locality, IV-24-31, H. Dietrich, in (USNM), length 4.2 mm., width 1.6 mm., slightly darker than the holotype, hind legs missing and all tarsi missing except front right one. All specimens were taken from beneath bark.

Lymantes arkansasensis, new species

Figures 3 and 10

Holotype. Arkansas, "Washington-Benton Co.", 1959, in (ELS #75).

Female. Length 3.25 mm., width 1.25 mm.; reddish brown. Differing from *puteolatum puteolatum* by the characteristics outlined in the key, and by color, the distinctly convex, more coarsely punctured prothorax, the latter with arcuate sides and a pronounced apical constriction; elytra with surface duller than prothorax due to alutaceous derm; the venter with forecoxae very narrowly separated with prosternum extending between; with first two abdominal sternites concave, the abdominal suture between one and 2 absent.

Male. Unknown.

Type material. Holotype and one paratype; the latter with same data as holotype and a length of 3.6 mm. and width 1.3 mm.

The type material was taken by Berlese funnel sampling of woodland litter.

Lymantes sandersoni, new species

Figure 4

Holotype. Missouri, (Iron Co.) Anapolis, Champion Spring, VIII-19-49, G. A. Ulrich acc. 49572 in Collections of Illinois Natural History Survey.

Female. Length 3.5 mm., width 1.3 mm. In addition to the characteristics indicated in the key this species differs from *puteolatum puteolatum* in that *sandersoni* is not shining, but dull due to an alutaceous derm; the rostrum and general form is more slender with the ocular area at base of rostrum small and only feebly indicated; the punctures of the disc of prothorax are much coarser; the elytra with striae moderately impressed; intervals carinate becoming subcarinate at sides, with very few indications of transverse interruptions; punctures of intervals much larger; venter with prosternum extending between forecoxae, separating them by about one-eighth their transverse width; intercoxal process of abdominal sternite one feebly arcuate.

The unique holotype was taken from debris at the mouth of a cave. It is a pleasure to name this species in honor of Dr. Milton W. Sanderson of the Illinois Natural History Survey.

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I wish to express my thanks to the following individuals: Dr. Henry Dietrich of Cornell University (retired), Dr. Milton W. Sanderson of the Illinois Natural History Survey, Mrs. Rose Warner Spillman of the United States National Museum, and Dr. L. O. Warren of the University of Arkansas for the loan of material in this and related genera; to Mr. Ralph Dury of the Cincinnati Museum of Natural History for courtesies extended while at that institution; to Mr. Vincent Caccese of California State College at Long Beach and Miss Marda L. West of the University of California at Los Angeles for aid in securing library references.

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NOTES ON THE LIFE HISTORY OF *PHILOTES ENOPTES DAMMERSI*

John Adams Comstock
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Del Mar, California
and
Christopher Henne
P.O. Box 1
Pearblossom, California

The lycaenid, *Philotes enoptes dammersi* was published by the authors in 1933. The types were taken in Snow Creek and Chino Canyon, Riverside County, California, and paratypes were distributed to the several museums of North America that maintain important entomological collections.

The insect's flight coincides with the flowering of *Eriogonum elongatum* Benth., a wild buckwheat which is more widely distributed in southern California and Baja California than is the associated butterfly. Doubtless, further collection will demonstrate a wider distribution for *dammersi* than is at present on record.

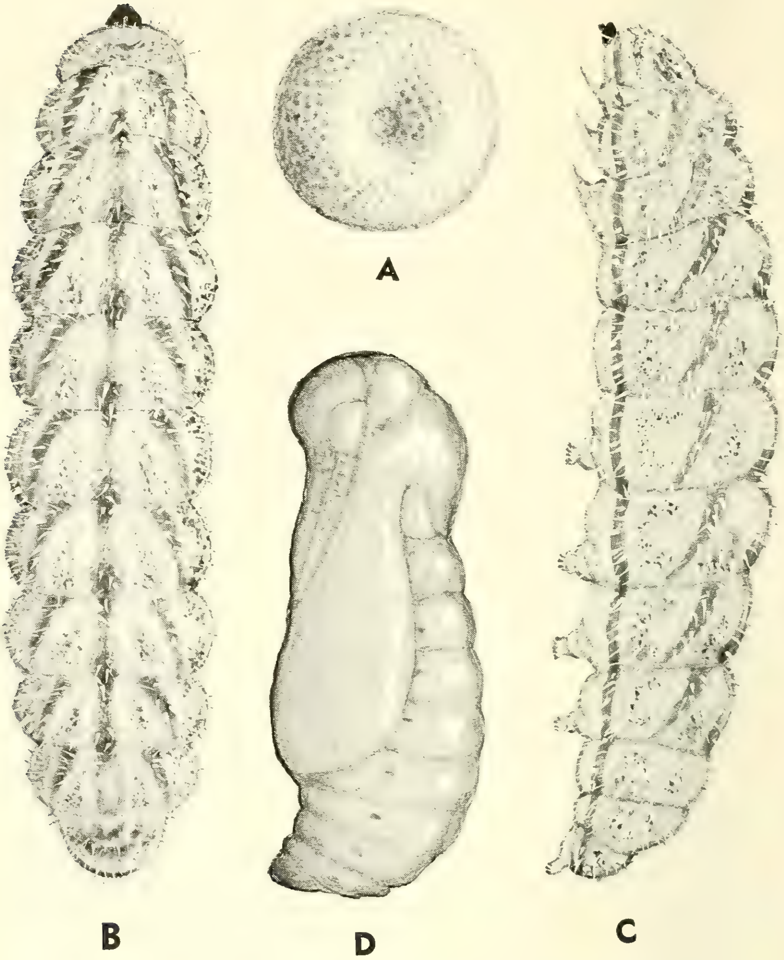
Langston's discussion (1963) of the races of *Philotes* occurring in central coastal California does not include *P. enoptes dammersi*. Mattoni (1945) gives the range of *dammersi* as ". . . the Colorado and Mohave Deserts, Arizona, west to central deserts." Mattoni named *P. enoptes smithi* as a close relative of *dammersi*, and gave its range as the Cismontane central coast ranges and the Santa Lucia Mountains, ". . . on a tall annual *Eriogonum* which is apparently a fall bloomer." Perhaps this is *E. saxatile* Wats.

In our original description of *P. e. dammersi* we promised later notes on the early stages. Very belatedly we redeem this promise. *Egg.* (Fig. 1a) Echinoid, top deeply depressed and the centrally placed micropyle relatively small. Color, light blue-green.

The exposed surfaces are covered with a reticulation of small pits surrounded by raised walls. These pits tend to run in parallel lines diagonally upward from the flattened base, but this is less apparent when viewed from the top as in our figure. It is slightly more noticeable in a photograph of the egg published in 1953.

The eggs are laid singly in the buds or blossoms of *Eriogonum elongatum*, and larval feeding is confined exclusively to the flower.

We do not have notes or drawings of the earlier larval instars. The unpublished notes of Commander Dammers state that in the first instar the larva is white with a black head, the whole insect covered



Reproduced from watercolor drawing by J. A. Comstock.

Figure 1. Early stages of *Philotes enoptes dammersi*. a. Egg, enlarged approximately X 60. b. Mature larva, dorsal aspect, and c. lateral aspect, enlarged X 11. d. Pupa, enlarged X 11.

with long white hairs, and that in successive instars the larva gradually assumes the markings of the mature larva.

Three larvae were collected by Henne on September 26, 1964, in the New York Mountains, seven miles southeast of Ivanpah, San Bernardino County, California, elevation 5000 ft. They were feeding on *Eriogonum wrightii trachygonum* S. Stokes. At the same time two females were confined, and resultant ovae were used in our illustration.

This same locality had previously been discovered and searched in August and September, 1936, and a series of imagos obtained.

Apparently *Philotes e. dammersi* is the only fall-flying *Philotes* in that area.

It is interesting to note that the food-plant in that region is the same as that recorded for *Philotes rita* in Ramsey Canyon, Arizona.

A single example of a mature larva from the New York Mountains 1964 series was compared with Commander Dammers' unpublished drawings, and was obviously about intermediate in character between the lightly marked and the dark forms of this highly variable larva. Our drawing closely approximates the intermediate form.

Mature Larva. (Fig. 1b and c.) Length, approx. 10 mm. Width, 3.4 mm.

Head, jet black, and nearly retracted except when feeding.

Body, ground color, ivory-white, with tinges of pink. There is a longitudinal middorsal band of pinkish-brown, accented on the segmental junctures. Dorso-laterally a series of lanceolate brown dashes run from segment to segment, each dash pointing caudally. A narrow pinkish longitudinal stripe runs substigmatally the length of the body. Blotches of pink occur on each segment between the longitudinal lines and dashes.

All of these markings are somewhat blurred by a complete covering of multiple short white setae, giving the larva a frosted appearance. The setae on the cephalic and caudal ends are relatively longer.

Legs, colorless. Prolegs and anal prolegs, soiled yellow.

According to Dammers notes, pupation occurred on the floor of the rearing cage, supported by a silk girdle and a caudal silk button.

Our single example failed to pupate.

Pupa. (Fig. 1d) Length, 6 mm.

Color, uniform pale chestnut.

Apparently the pupal surface is smooth, the head well rounded and the eyes prominent.

Our figure is redrawn from Dammers manuscript sketch.

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FOSSIL ARTHROPODS OF CALIFORNIA
26. THREE NEW FOSSIL INSECT SITES IN CALIFORNIA

W. Dwight Pierce
Los Angeles County Museum
Los Angeles, California

1. An Upper Miocene Weevil Wing from Los Angeles County

It is with pleasure that I add to the well-known fossil insect sources, an entirely new source: a deposit of Altamira shale, of Upper Miocene, disclosed by road excavators on Woodcrest Drive, off Sepulveda Boulevard, Los Angeles County, Recorded as site LACMIP 438. In December 1961, Eric Sorrenson broke a piece of shale and found a weevil elytron and its impression.

This elytron is characterized by deeply punctate striae and strongly resembles the elytra of the genus *Rhyssematus* to which I am tentatively assigning it.

Order Coleoptera
Family Curculionidae (*sens. lat.*)
Subfamily Cryptorhynchinae
Genus *Rhyssematus* Schönherr

Rhyssematus miocenae, new species, fossil.

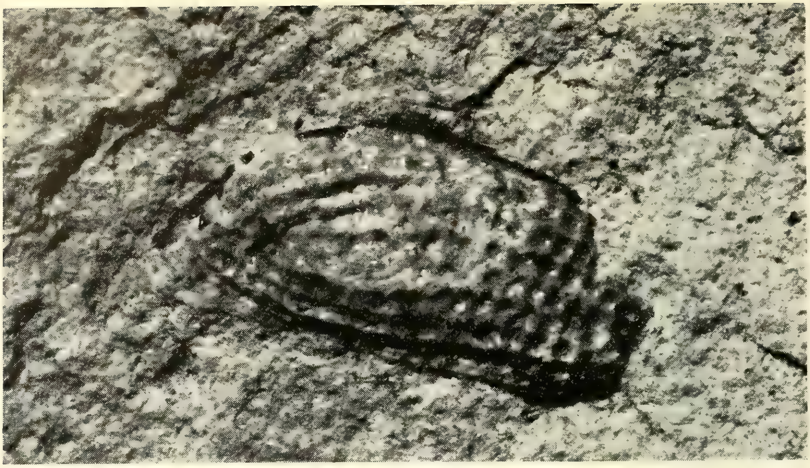
Figure 1

Description: Described from fossil elytron and its impression. Registered as type S9112 in Invertebrate Paleontology Collections, Los Angeles County Museum. Color of integument black, but only marginal traces of the original outer surface remain. The subsurface is colored ferruginous.

Length of elytron 5.8 mm.; width 2.2 mm.

The elytral intervals are more or less evenly convex, except that the second and eighth intervals are more elevated, and unite apically. The strial punctures are very large and deep and narrowly separated in the striae.

In this genus the species *parvulus* Casey, *ovalis* Casey, *pruinosus* Boheman, and *aequalis* Horn have the elytral intervals almost equally convex, but these belong to two groups, based on the separation of the eyes, and they differ individually by the prothoracic sculpture. As we do not have any other part, the specimen must be set aside as a probable record of this interesting genus.



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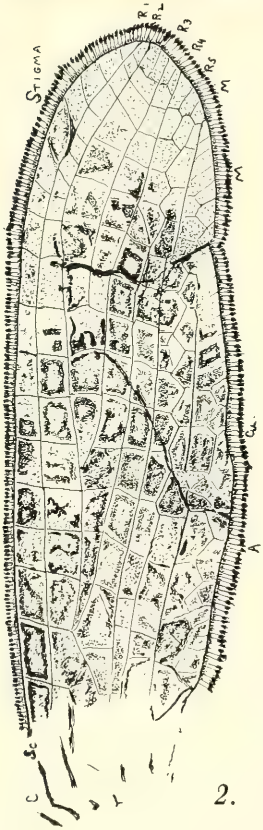

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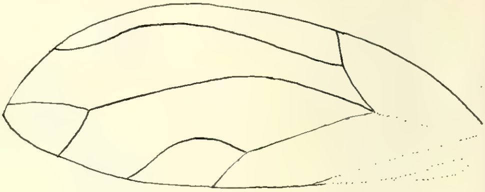

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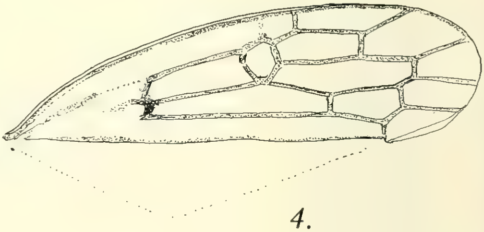

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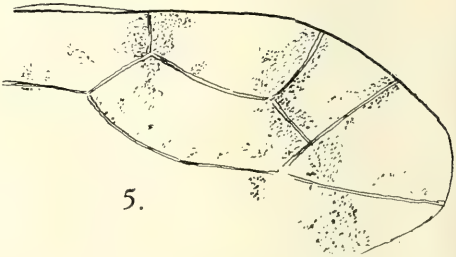

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Figure 1. Outside of weevil elytron in Altamira shale, Upper Miocene, Los Angeles, California. *Rhyssematus miocenae*, new species.

Figure 2. Wing of fossil insect, *Sobobapteron kirkbyae*, new species.

Figure 3. Wing of jumping plant louse, *Trioza sp.*, from submarine core.

Figure 4. Anterior wing, without anal section, of a leaf hopper of the genus *Eutettix*, subgenus *Mesamia*, from submarine core.

Figure 5. Fragment of wing of a membracid leaf hopper from submarine core.

2. A WING OF AN EXTINCT ORDER OF INSECTS FROM RIVERSIDE COUNTY

While California is rich in fossil insects, found in the Pleistocene asphalt deposits, and those enclosed in Miocene lake bed nodules from volcanic mountain areas, few other sources have been put on record.

It is with pleasure that I now add an interesting wing found by Mrs. Ruth Kirkby in Riverside County, on the west side of Gunsight Pass just outside the Soboba Indian Reservation in SW ¼, NW ¼, Section 28, R.I.E., T.4.S., on the San Jacinto SW ¼ Banning 15′ Quadrangle, northeast of San Jacinto, California. The site is recorded as LACMIP 437. It was found in a shale supposed by Dr. D. I. Axelrod to be Pleistocene, but which I believe must be older, nearer Permian.

The rock was split, perfectly dividing the layers of the wing on each piece of the shale, so that what we see is the insides of the wing. However, the pigment pattern and the venation are clearly visible, and enable me to interpret its position in ordinal classification.

A unique feature is that the wing is completely margined by a fringe of clubbed hairs; fringed wings are rare among insects, occurring however throughout Thysanoptera, in Diptera, Psychodidae; and in Embiida. Other features indicate that this wing does not belong to an existing order.

In his volume on the Wings of Insects, Comstock (1918) placed emphasis on the types of branching of the radius. Among the described fossil orders there are two genera:

Hapaloptera in Handlirsch's Order Hapalopteroidea and *Permobiella* in Martynov's Order Caloneurodea which have R_5 separating from R_{2-4}, and R_3 branching from R_2 or from cross veins between R_2 and R_4. Both of these ancient genera belong to the period from Carboniferous (Pennsylvanian) to Permian. Carpenter groups *Hapaloptera* with the Protorthoptera, and places Caloneurodea next to it. In no modern order does this type of radius appear. Hence the finding of this type of radius in our specimen indicates ancient origin.

Our new wing differs from these two genera in the fact that the subcosta is the marginal vein, not costa; but agrees in the elongate narrow shape without emphasis of an anal area. It is probably a forewing.

I therefore tentatively place the wing in the generalized Order Protorthoptera of Handlirsch, superfamily Hapalopteroidea Handlirsch, and believe that the rock is older than Pleistocene.

Order PROTORTHOPTERA Handlirsch
Superfamily HAPALOPTEROIDEA Handlirsch
Genus **Sobobapteron,** new genus

Sobobapteron kirkbyae, new species, fossil.
FIGURE 2

DESCRIPTION: Described from a wing in two pieces, upper and lower surfaces on two slabs of shale, numbered as type S9113 in the Los Angeles County Museum Invertebrate Paleontology series, found by Mrs. Ruth Kirkby, in whose honor it is named.

Size of wing 13x3.75 mm.

An elongate fossil wing split between upper and lower surfaces on a small slab of shale, probably a mesothoracic wing. Outer margin fringed, with clubbed hairs on entire periphery (a new ordinal character).

On one piece there is indication that there may have been a brief basal costal area. Otherwise the subcosta is the marginal vein to apex. Radius is parallel from base to apex where it joints the subcosta, and the two veins are separated by 18 cross veins, forming oblong cells. The 14th and 15th cross veins are diagonal and strongly emphasized and form a stigma, a character present in the forewings of only a few orders. The base of radial sector is connected with radius by a cross vein before basal fourth of wing, at which point it divides into R_{2}-$_{4}$, and R_5. A little before middle of wing R_{2}-$_{4}$ splits into R_2+_3 and R_4. These are joined by three cross veins, the third angled and giving rise to R_3. Seven cross veins cross R_3 and unite it with R_2 and R_4 forming quadrate cells.

In this last character the genus is separable from *Hapaloptera* and *Permobiella.*

The entire wing is divided by cross veins into quadrate cells, except in the anal and apical portions where the cells are often pentagonal. The last series of cross veins in the radial area give rise to additional longitudinal veins and from R_1 to Media there are eight small longitudinal apical cells. M_1 is complete from base to apex, but M_2 extends as a straight line only to basal third, beyond which it is a zigzag vein. One cubital vein is more or less complete. But beyond this the cubital-anal area is filled with irregular cells. There is only a slight widening for anal area at basal third.

3. RECOVERY OF INSECT WINGS FROM OCEAN BASIN CORES

In parts 2 and 3, I presented two new sources of fossil insect wings from the land, but now Carol Jean Bumgardner, formerly of the Scripps Institute of Oceanography and now of the Los Angeles County Museum, adds an entirely new source for insect fossil material; the underwater cores of oceanic deposits.

From the central region of Santa Barbara Basin at 600 meters depth, cores were taken by Andrew Soutar of the Institute down to 56 cm. below the surface, with age of the material 100 to 150 years. The site is recorded as LACMIB 439. From these cores Miss Bumgardner has delicately removed several fragments of insect wings found among fish scales and bones.

It is of course not infrequent that insect wings are carried on the wind from land to sea; and we also know that insects caught by birds, and probably fish, have the wings cut off and cast aside, because they are impalatable. So it is natural that many insect wings should settle to the bottom. But this is the first time that they have actually been found in the bottom deposits of oceanic waters in original unfossilized condition.

The four wings before me are 100-150 years old, and it is to be hoped that deeper cores will yield older material, because Miss Bumgardner says some of the core material already taken is 1,000 years old.

From Santa Barbara Basin Core No. 1, taken in the Central Region of Santa Barbara Basin at 120°03′W, 34°15′N at 600 meters depth, slide (A) taken 10 inches below the surface of the core, contained a pair of wings of a jumping plant louse, order Chermodea, family Chermidae, probably belonging to the genus *Trioza*, (Figure 3). The bases of both wings are broken and the costal veins out of position, with another basal vein in distorted position, but the pattern is that of *Trioza*. Specimen S9133 in Los Angeles County Museum Collections in Invertebrate Paleontology.

From Santa Barbara Basin Core No. 2, taken in the same region but without depth data, is an anterior wing (Figure 4), minus its anal region, of a leaf hopper, Homoptera, family Jassidae, subfamily Jassinae, which is close to the genus *Eutettix*, having all the cells as in *Eutettix (Mesamia) cincta* Osborn and Ball, but not the markings. Although that species has a wide range, it does not occur in the west. Specimen S9134 in the Los Angeles County Museum Collections in Invertebrate Paleontology.

From Santa Barbara Basin Core No. 3, taken in the same region, 56 cm. below the surface, and possibly 100-150 years old, is the tip of an anterior wing (Figure 5), which is probably that of a leaf hopper, order Homoptera, family Membracidae. Only five terminal cells are present. Specimen S9135 in the Los Angeles County Museum Collections in Invertebrate Paleontology. The specimens were from laminated undisturbed sediments but not from the same stratigraphic layer.

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ADDITIONAL RECORDS OF *CHOERONYCTERIS MEXICANA* FROM SOUTHERN CALIFORNIA AND BAJA CALIFORNIA

Richard C. Banks and Chris Parrish
San Diego Natural History Museum
San Diego, California

The details of an invasion of long-tongued bats, *Choeronycteris mexicana*, into the San Diego area of California in the fall of 1946 were recorded by Olson (1947) and by Huey (1954). From September to December of that year, 39 specimens were obtained from 11 localities in the vicinity of San Diego, and many others were observed. After December 20, 1946, there were no further reports of *Choeronycteris mexicana* in southern California.

On October 15, 1963, Mr. Chris Butler brought to the San Diego Natural History Museum a live long-tongued bat which he had found at his home in Lemon Grove, on the outskirts of San Diego, San Diego County, California. The bat had been captured in a net soon after its discovery that morning. It was found in a partly open wash room on the porch, in a semi-dark situation similar to several of the locations mentioned by Huey (1954).

The documentation of the 1946 invasion was made possible by the use of newspaper publicity, which resulted in numerous reports telephoned to the Natural History Museum. Similar publicity, both on television and in newspapers, yielded no results in 1963. We are thus led to believe that the more recent occurrence of *Choeronycteris* in this area was not an invasion, as in 1946, but rather was the result of the wandering of one or a few individuals. The possibility remains, of course, that this species is a regular vistor to the San Diego area, but in such small numbers that it is usually not detected.

Huey (1954) reported this bat from two localities in northern Baja California, where he had observed them in June, 1947. In the afternoon of August 22, 1961, the junior author revisited one of these localities, a turquoise mine some 20 miles east of El Rosario, and once again found *Choeronycteris mexicana*. A thorough search of the approximately 100 yards of multileveled, maze-like tunnels, including vertical shafts and short side tunnels, disclosed about 20 bats. They were found singly or in small groups, hanging in plain sight from the tops of the tunnels rather than secreting themselves in the numerous cracks and crevices. The largest group consisted of seven bats found in a short side tunnel. The bats were quite alert and would swivel about by twisting their legs and would bend their heads up to peer at the intruders. If frightened, they did not hesitate to take flight. Most of them would re-alight in another section of the mine but several flew out of the tunnel and across the adjacent valley.

The occurrence of long-tongued bats in northern Baja California in the summers of two widely separated years suggests that the population is permanently resident there. It is probable that this area is the source of the bats which occasionally appear in southern California. Whether the species occurs in the territory intervening between northern Baja California and the next nearest station of record, in southeastern Arizona, remains to be determined.

Incidentally, although Hall and Kelson (1959:119) indicate in the dental formula for this species that there are but two upper premolars, their illustration of a skull of a specimen (fig. 77, p. 120) shows three. None of the specimens from California or Baja California examined by us had the extra tooth.

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PROCEEDINGS OF THE ACADEMY

The Southern California Academy of Sciences met seven times during the fiscal year 1964-65. Six of these meetings were at the Los Angeles County Museum, and the seventh was the Annual Meeting at California State College, Fullerton. The Section on Earth Sciences held several meetings at different institutions in the area.

The following papers were presented at the meetings at the Los Angeles County Museum: The Anthropology Section, on September 18, 1964, presented Dr. Charles Rozaire of the Los Angeles County Museum who spoke on "Archeology of the Channel Islands." On October 16, 1964 the Earth Sciences Section presented Dr. Frank W. Dickson, University of California, Riverside, who spoke on "Recent Advances in the Problem of the Origin of Granitea." The Botany Section on November 20, 1964 presented Dr. E. Yale Dawson, San Diego Natural History Museum, who spoke on "Tropical Plants in Cold Water." The Invertebrate Zoology Section presented on January 15, 1965, Dr. Richard B. Loomis, California State College, Long Beach, who spoke on "Chiggers in the North American Deserts." The Experimental Biology Section presented on February 19, 1965 Dr. Frank E. Swatek, California State College, Long Beach, who spoke on "Rockets, Jets, Hydrocarbons, and Microbiology."

The Board of Directors and Advisory Board met on May 3, 1965 to hear reports and elect officers for 1965-1966.

The Fifth Annual Meeting was held at California State College, Fullerton, on May 19, 1965. The scientific sessions were well attended and 38 papers were presented, 13 of which were student papers.

The papers presented were:

General Sessions (*Student Papers)

David L. Walkington, (Calif. State College at Fullerton): "Morphological and Chromatographic Evidence of Hybridization in Some Species of *Opuntia* Occurring in Southern California."

Richard J. Vogl, (Calif. State College at Los Angeles): "Fire and Knobcone Pine in the Santa Ana Mountains, California."

John R. Swanson, (San Fernando Valley State College): "A Revision of Generic Limits in the Montioideae (Portulacaceae)."

Louis C. Wheeler, (Univ. So. Calif.): "Trace Elements in Orchids."

Marilyn Canfield (Calif. State College at Fullerton): "Growth in Vitro of Tissue from etiolated Shoots of *Lorphophora williamsii* for Studies of Alkaloid Biosynthesis."

Barbara Gittins, (Calif. State College at Fullerton): "Morphological Variation in *Isomeris arborea* Nutt."

*Brian C. Miller, (Calif. State College at Los Angeles): "The Vegetational Composition of a Virgin Yellow Pine Forest—Mt. Pinos, California."

*Edith S. Kinucan, (Calif. State College at Los Angeles): "Fire Ecology of the San Gabriel Mountains."

*John L. Price, (Whittier College): "The Relation of the Fatty Acid Content of Macadamia Leaves to Frost Resistance."

*Brian C. Myres, (Calif. State College at Fullerton): "Social Behavior in the Spiny-tailed Iguana."

*Roberta V. Seibel, (Calif. State College at Fullerton): "Food Selection in House Finches, *Carpodacus mexicanus*."

*Charles Leavell, (Calif. State College at Fullerton): "Social Behavior in The Tubercular Gecko."

*David F. Haven, (Calif. State College at Fullerton): "Thermoregulatory Behavior in Rattlesnakes."

*Julius C. Geest, (Calif. State College at Long Beach): "The Sidewinder, *Crotalus cerastes*, in Joshua Tree National Monument."

*Guy N. Cameron, (Calif. State College at Long Beach): "Investigation of Sympatric Relationships Between Two Species of Wood Rats in Joshua Tree National Monument."

Jim W. Dole, (San Fernando Valley State College): "Home Range and Migratory Movements of Leopard Frogs, *Rana pipiens*."

Dennis G. Rainey, (Calif. State College at Long Beach): "The Fallen Joshua Tree as a Microhabitat for Vertebrates."

Arden Brame (Univ. of So. Calif.): "A New *Batrachoseps* (California Slender Salamander) from Santa Barbara County, California."

Dallas A. Sutton (Chico State College): "New Taxonomic Techniques for Western Chipmunks."

David H. Worthington, (Calif. State College at Fullerton): "A Comparative Analysis of the Chromosome Morphology and Numbers of Four Species of Leporids."

Peter Paul Vaughn (Univ. of California at Los Angeles): "Actinopterygian Vertebrae with Ossified Centra from the Lower Permian of Utah."

Hildegarde Howard (Los Angeles County Museum): "A Significant Discovery of Fossil Birds in Orange County, California."

John A. White (Calif. State College at Long Beach): "The Cranium of *Hypolagus* sp. from the Arroyo Seco Local Fauna (Blancan)."

Richard H. Tedford (Univ. of California, Riverside): "Pleistocene Mammal Faunas of Australia."

Phillip A. Adams (Calif. State College at Fullerton): "A Revised Interpretation of Dragonfly Wing Venation."

James L. Lucas* (Speaker) and R. B. Loomis (Calif. State College at Long Beach): "Factors in Reporting Chigger Occurrence."

*Lynell K. Tanigoshi (Calif. State College at Long Beach): "A Preliminary Survey of Ectoparasites Recovered from Pocket Mice (Genus: *Perognathus*) in Joshua Tree National Monument, California."

*Sister Mary Andrew Bergon, I.H.M. (Immaculate Heart College): "The Biology of *Lophogorgia chilensis* Under Laboratory Conditions."

*Robert K. Mullen (Univ. of So. Calif.): "Comparative Electrocardiography of the Squamata."

*Sister Mary Ermenilda Muzyka, CSSF (Pomona, Calif.): "Morphological Changes Observed on *Stentor coeruleus* in the Effects of Long Term Lithium Ion Cultures."

G. K. Anderson* (Speaker) and R. A. Kroman (Calif. State College at Long Beach): "Some Aspects of the Biology of Symbiotic Microorganisms Isolated from Trombiculid Mites."

Mary Ritzel Corcoran (San Fernando Valley State College): "Native Inhibitors of gibberellin-induced growth."

Kenneth C. Jones (San Fernando Valley State College): "Isolation and Characterization of a New Gibberellin Produced by *Fusarium moniliforme* Sheld."

Harry Sobel, Kyung Dong Lee, and Martinez L. Hewlett (Veterans Administration Hospital): "Effect of Estrogen on Hyaluronic Acid."

C. H. Eriksen (Univ. of Toronto, Canada): "Diurnal Limnology of Highly Colloidal Ponds."

Robert T. Galbraith (Fullerton Junior College): "Homing Behavior in the Limpets *Acmaea digitalis* and *Lottia gigantea*."

Yuk-maan Leung (Univ. of So. Calif.): "Whale-lice (Cyamidae: Amphipoda) ectoparasites of cetaceans."

Gerald Scherba (Calif. State College at San Bernardino): "Observations on the Vole, *Microtus*, Nesting in Ant Mounds."

Eighty members and guests attended the Annual Dinner Meeting which was held in the College Cafeteria at California State College, Fullerton. Dr. Robert Thorne of the Rancho Santa Ana Botanical Garden and Claremont Graduate School, spoke on "New Caledonia, Storehouse of Relicts."

The following members were elected Fellows of the Academy: Dr. John L. Mohr, University of Southern California, and Dr. James A. Peters, United States National Museum.

Winners of the Student Awards were: first prize ($35.00) to Mr. Arden Brame and second prize ($15.00) to Mr. Guy N. Cameron. Mr. David F. Haven was awarded an "honorable mention." A grant provided by A.A.A.S. was awarded to Mr. Jere Lipps.

Thanks are extended to Dr. Bayard H. Brattstrom, chairman of the local committee and to other faculty members and students of the Department of Biology at California State College, Fullerton for their help in making this meeting an outstanding success.

BULLETIN OF THE SOUTHERN CALIFORNIA ACADEMY OF SCIENCES

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PUBLICATIONS OF THE SOUTHERN CALIFORNIA ACADEMY OF SCIENCES

The Academy has published to date the following:

PROCEEDINGS, 1896 to 1899. Six numbers—Vol. 1, Nos. 1 to 6.

MISCELLANEOUS BULLETINS issued under the imprint of the Agricultural Experimental Station, 1897 to 1907. *Ten numbers.*

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VOL. 64 OCTOBER-DECEMBER, 1965 PART 4

STUDIES ON THE BIONOMICS OF SPHECOID WASPS. II. *PHILANTHUS GIBBOSUS* (FABRICIUS) AND *PHILANTHUS ANNA* DUNNING. (HYMENOPTERA: SPHECIDAE)

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INTRODUCTION

Ground-nesting wasps of the genus *Philanthus* are represented in America north of Mexico by 26 species, 3 of which are listed as being unplaced (Muesebeck, Krombein and Townes, 1951). Of the 23 definitely-placed species, biological observations have been published on nine. Three of these accounts (*P. eurynome* Fox, *P. sanbornii* Cresson and *P. flavifrons* Cresson) contain little more than the prey records. So far as known all the species provision their nests primarily with bees and usually with species belonging to the family Halictidae although they have also been found to use Andrenidae, Colletidae and Apidae. Evans and Lin (1959) reported that *P. solivagus* Say also includes occasional specimens of 3 species of vespid and 3 species of sphecid wasps among the prey. One species of sphecid wasp was interred by *P. gibbosus* (Fabricius) along with its bee prey. Honey bees (*Apis mellifera* Linnaeus) were found to be prey of *P. sanbornii* by Evans (1955) and of *P. flavifrons* by Bohart (1954).

Most of the biological studies have been made in relatively few locations in the eastern or midwestern states. Evans and Lin (1959) studied *P. politus politus* Say, *P. solivagus*, *P. gibbosus* and *P.*

bilunatus Cresson in New York; Reinhard (1922, 1929) studied *P. gibbosus* in Maryland; Evans and Lin (1959) studied *P. eurynome* in Florida and *P. sanbornii* in Kansas; Peckham and Peckham (1898, 1905) studied *P. gibbosus* and *P. ventilabris* (Fabricius) in Wisconsin; Rau and Rau (1918) studied the same 2 species in Missouri; Evans and Lin (1959) studied *P. ventilabris* in Texas and *P. albopilosus* Cresson in Arizona; and G. Bohart (1954) recorded the prey of *P. flavifrons* in Utah. Only 2 of the species listed above (*P. gibbosus* and *P. ventilabris*) have been studied more than once by different individuals in separate locations and although both are widely distributed throughout the United States, southern Canada, and northern Mexico, they are still recognized as being monotypic. In contrast, *P. politus* which has a similar distribution is polytypic with 9 recognized subspecies. It is unfortunate for comparative purposes that only one of these subspecific populations has been studied biologically. A study of the comparative geographical bionomics of the various subspecies would be of considerable interest.

Although we cannot make such a comparison at the moment, one of the purposes of this paper is to present the bionomics of the southwestern population of *P. gibbosus* and to compare this with similar studies on the same species made in Missouri, Maryland, Wisconsin and New York. These locations are over 1500 miles northeast of the Arizona site. The behavior, ecology, progressive preparation of the burrow and the parasites and predators of this species will be given. A partial account of the bionomics of *P. anna* Dunning will be presented for the first time.

ACKNOWLEDGMENTS

The writers would like to express their special appreciation to Paul D. Hurd, Jr., University of California, Berkeley, for the determinations of the *Philanthus* species, their bee prey and the mutillid parasites. We would also like to express our thanks for assistance rendered in this project by E. G. Linsley and Ray F. Smith, University of California, Berkeley, and to Arthur Raske of the same institution. We are indebted to William E. Ferguson, San Jose State College; H. A. Scullen, Oregon State University, Corvallis; C. W. Sabrosky and Karl V. Krombein, Insect Identification and Parasite Introduction Research Branch, U.S. Dept. of Agriculture, Washington, D.C., for identifications and other assistance rendered in connection with this project. To Dr. and Mrs. Ralph G. Willy we extend our appreciation for allowing us the use of their ranch during the summer months.

All the photographs were taken by the junior author. This project was supported by National Science Foundation Grant GB-379.

HABITAT

The following observations were made at Portal, Cochise County, Arizona, in the enclosed yard area of the Willy ranch located at the mouth of Cave Creek Canyon, Chiricahua Mountains, at an elevation of 4700 feet in the thorn-shrub area bordering Cave Creek. The primary vegetative cover surrounding the landscaped residential compound consisted of *Prosopis juliflora* (Swartz) D.C. (mesquite); *Mimosa biuncifera* Benth, (wait-a-minute); *Acacia constricta* Benth, (white-thorn); *Flourensia cernua* D.C. (tar-bush); *Fallugia paradoxa* (D. Don) Endl. (Apache-plume); *Larrea tridentata* (D.C.) Coville (creosote-bush); *Opuntia phaeacantha* Engelm, *Opuntia engelmanni* Salm-Dyck, *Sapindus saponaria* L. (soapberry); *Bumelia lanuginosa* (Michx.) Pers. (chicle); *Celtis reticulata* Torr. (netleaf hackberry, paloblanco, sugar-berry). Many less conspicuous shrubs and herbs abound in the locality.

The vegetation within the compound consisted of a mixture of introduced ornamentals, fruit and shade trees, and a number of native plants that grow wild in the immediate vicinity. The main shade cover was provided by Chinese elm trees (*Ulmus* sp.), but there were also small apple (*Malus* sp.), plum (*Prunus* sp.), peach (*Prunus* sp.), apricot (*Prunus* sp.), walnut (*Juglans major* [Torr.] Heller), elderberry (*Sambucus* sp.), and hackberry (*Celtis reticulata* Torr.) trees in the yard. Several plants of *Larrea*, *Fouquieria*, *Opuntia*, *Ferocactus*, *Agave*, *Atriplex*, *Caesalpinia* and *Sphaeralcea* were also present. There were several landscaped beds of *Iris* sp. and a few other ornamentals. Most of the above mentioned plants were associated either directly or indirectly in various wasp biology projects that were undertaken in this enclosure. There were several areas that were open and devoid of the trees and shrubs, although bordered by them, in which the ground was sandy, rocky, or with loose or compact soil. These were especially favored as nesting areas, although not exclusively so by any means, and were scarcely utilized by wasps until each spot was soaked with water.

ECOLOGY

On 3 June 1963 when we arrived in Portal the area was very hot and dry, few flowers were in bloom, no rain had evidently fallen for several weeks and there was comparatively little wasp activity around or in the compound. During the night of 10 June there was a light rain that dampened the ground but on the morning of 11 June, between 8:10 and 8:20 A.M., a moderately heavy, local rain and hail storm swept down Cave Creek Canyon, across the compound and over a plot, 2 miles northeast, soaking the ground to a depth of 3.2 cm. in exposed areas. This stimulated an increase in wasp activity, sepecially at the latter location where there was no tree cover. However, by 13 June the ground was dry again and wasp activity began to decline markedly.

Between 3 June and 16 June the trees and shrubs in the enclosure had been watered occasionally by filling the catch basins at the base of each but no noticeable increase in wasp activity was observed in these isolated spots. However, on 16 June the water was inadvertently left running overnight at the base of a small apple tree on the western edge of a large open area, and by morning had overflowed the catch basin and soaked an area about two by four meters on its eastern side. By 2:30 P.M. on 18 June 2 active burrows of *Cerceris conifrons* Mickel were found in the moist area beneath the overhanging branches of the apple tree and both females were bringing in prey. On the following day 7 more burrows of the same species were active in the same 60-cm.-square spot as were females of other wasp genera. Our first example of *P. gibbosus* was found next to this spot on 20 June. Later experiments on soaking dry desert areas disclosed the fact that some species of wasps will begin nesting along the edges of damp areas while the water is still running, whereas others move in from a few minutes to several hours or days after watering. There appears to be a succession of immigrants into such an area both in terms of time and with respect to the amount of soaking, with some preferring the edges whereas others nest in the wetter portions. Additional studies are being conducted on this interesting aspect of desert ecology.

Bionomics of Philanthus gibbosus (Fabricius)

New burrows: On 20 June at 8:10 A.M., while observations were being made on the activities of *C. conifrons*, the first burrow of *P. gibbosus* was located on level ground about 91 cm. south of the *C. conifrons* burrows. It was on the edge of the soaked area beneath the overhanging branches of an apple tree, near the bases of several small mallow plants (*Sphaeralcea* sp., probably *laxa* Woot. and Standl.) (Fig. 1). The surface soil was loose for about 2.5 cm. but

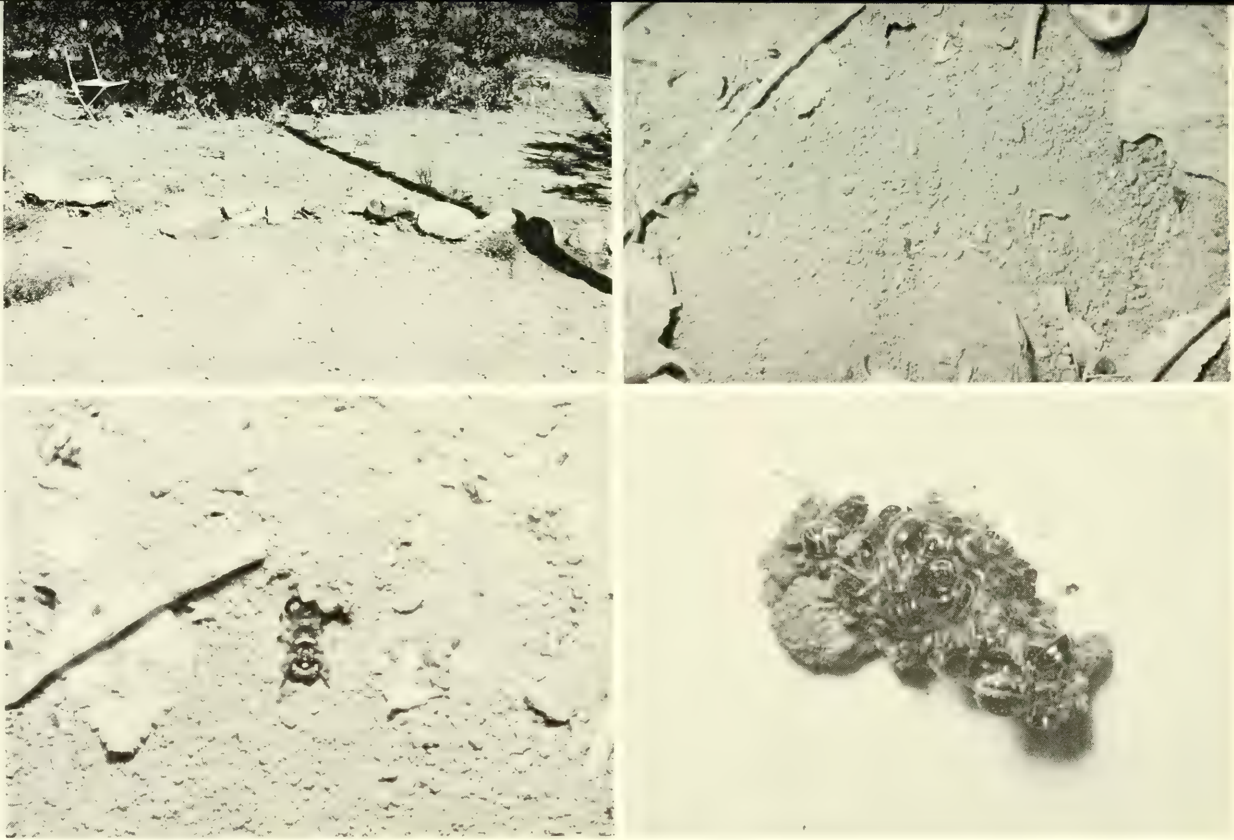

Figure 1 (upper left). Habitat of two new burrows of *Philanthus gibbosus.* In front of chair and beneath overhanging branches of the apple tree. The first *Philanthus anna* burrow was located near the lower left hand edge of the picture, made at Portal, Arizona. *Figure 2* (upper right). Entrance to *Philanthus gibbosus* burrow showing tumulus in front of hole. *Figure 3* (lower left). Female *Philanthus gibbosus* cautiously leaving burrow entrance. *Figure 4* (lower right). Pupal case from cell number 9, burrow number 4, showing remains of bees entangled in loose, white silken threads surrounding the pupal case of *Philanthus gibbosus.*

hard packed and slightly moist beneath. A small fly, *Senotainia* (*trilineata* Wulp complex) sp. was observed trying to dig its way into the base of a fan-shaped pile of loose soil that had obviously been pushed or thrown out of a burrow. While the fly was thus engaged, the female *P. gibbosus* pushed her way rapidly out of the burrow, head first, and began throwing loose dirt back over the entrance with her front legs. She spent 2 minutes in these closing activities and was collected at 8:12 A.M. as she attempted to fly away. When the burrow was excavated the following day both the entrance and the burrow were found to be nearly round and 5 mm. in diameter. The burrow extended westward into the ground at about a 40° angle for 17.8 cm. and to a depth of 11.4 cm. below ground level. There were no enlargements or cells along the burrow nor had any prey been deposited in it. About 5 cm. from the entrance the burrow bent sharply around a rock, resuming the same direction on the opposite side, and beginning at about 10 cm. it proceeded in a half circle to the end. When collected, the female was evidently making her first prey-collecting trip and must have spent the preceding day or more digging the burrow. This would mean that she selected this nesting site one or 2 days after it was soaked.

The second female of *P. gibbosus* was first observed at 3:18 P.M. on 25 June in the same habitat only 91.4 cm. north on level ground within 7.6 cm. of 3 *C. conifrons* and one *Moniaecera asperata* (Fox) burrows. She was engaged in excavating activities and was throwing loose dirt out behind her with the front legs as she entered the burrow head first. While inside she would throw dirt back into the entrance and back out through it without excavating until she was about 2.5 cm. from the entrance. She would then re-enter head first throwing dirt out behind. During 3 minutes time she made 4 of these excavating trips and at 3:21 P.M. she came out head first, rapidly covered the entrance with loose dirt and flew away. She returned 2 minutes later without prey, opened the burrow, entered and stayed for 5 seconds, reappeared, closed the entrance and flew away. At 3:28 P.M. she returned with prey, started to open the burrow but was disturbed by the approach of a worker ant, *Dorymyrmex pyramicus* (Roger), and flew away without opening or entering the burrow. At 3:31 P.M. she returned but landed on the top of a 20.3 cm. high *Sphaeralcea* plant located about 15 cm. from the burrow entrance. She stayed in this position for 2 minutes, holding the bee prey venter up against her venter with her middle legs. She departed at 3:33 P.M. without going to the nest. This disturbed behavior was probably the result of her encounter with the ant at the nest entrance. According to Creighton (1950: 348) this species of ant is not only predaceous but also emits a strong butyric acid odor.

At 3:37 P.M. she returned with prey, rapidly opened the burrow entrance with her front legs and entered without releasing the prey. A minute later she slowly reappeared in the burrow entrance looked around, came out briefly, went back in for about 3 seconds, cautiously reappeared at the entrance for 10 seconds before coming out, hurriedly closed the entrance and flew away. This very hesitant behavior upon leaving the burrow was evidenced on all subsequent trips and the entrance was closed before each departure. In one hour and 37 minutes this female collected 10 bees. On the undisturbed trips she spent from 3 to 10 minutes (average 4.6 minutes) collecting the bees and from 4 to 40 seconds (average 17 seconds) storing them in the burrow. She was collected as she came in with prey at 4:10 P.M.

The entrance and the burrow were nearly round and 5 mm. in diameter. The burrow extended into the ground at about a 35° angle for 16.5 cm., terminating at a depth of 9.5 cm. below ground level with no terminal cell. From the entrance the burrow extended straight south for 5.1 cm., made a rather sharp bend westward at this point and continued to circle for almost 360° until the end was within 7 mm. of being directly beneath the entrance. The first 5.1 cm. of the burrow was filled with loose dirt and the next 7.6 cm. were open down to where the first bee was encountered. All 9 stored bees were packed in loose dirt in the last 3.8 cm. of the burrow which was not enlarged. Each bee had been placed head first in the burrow, all but the fourth one were ventral surface upward and each was still twitching when exhumed. The fourth bee was dorsal surface upward and was the only one that had pollen on its legs and the base of the abdomen. No egg had been laid.

The 9 bees in the burrow and the one collected with the female all belonged to the family Halictidae. There were eight females of *Halictus (Seladonia) tripartitus* Cockerell and two females of *Lasioglossum (Dialictus) microlepoides* (Ellis).

Comparison: Rau and Rau (1918) excavated a new burrow of *P. gibbosus* near St. Louis, Missouri, and although the female was found at the end of the burrow there was no indication of cell construction nor of prey storage. The entrance was in an embankment, 2.5 cm. below ground level, the burrow extended horizontally for 5.1 cm. to the south, turned at right angles toward the west and extended downward at 45° for 25.4 cm., turned at right angles again and extended straight downward for 5.1 cm. This U-shaped pattern approaches the circular pattern we found in our second burrow which descended at a 35° angle as compared to the first one that had a 40° angle. Rau and Rau also reported burrows with descending angles of 30° and 45° with the termination of the first at 12.7 cm. below ground level. They also found a number of burrows that extended horizontally into clay banks. Reinhard (1922) reported finding one female of *P. gibbosus* in Maryland that had "met with so many obstacles that the terminus of her burrow was only two inches [5.1 cm.] from the entrance—she had tunneled in a circle." In our circular burrow we found no obstacles that would necessitate such a pattern and it appears that this is probably a part of the normal variation in digging behavior rather than a design contingent on various obstacles. Most burrows do not, however, exhibit this even when obstacles are encountered as was the case with our first burrow in which there was a deviation around a rock.

In addition to contributing information on the establishment of basic design, the study of new and incomplete burrows supplies data on prey storage, cell construction and the developmental history of the nest with respect to the age of the various cells. As shown by Rau and Rau (1918) and indicated by our first burrow, the initial step in nest establishment is that of excavating a simple burrow without cells. This is evidently followed by a period of hunting, paralysis and transportation of prey which are stored temporarily in loose soil at the end of the burrow. Evans and Lin (1959) found this to be the case in their burrow number 1497, as we did in our second burrow. The wasp then reverts to a period of excavating during which time a cell is constructed. Rau and Rau (1918) excavated a 30.5 cm. burrow and located a "short branch gallery or neck" leading off the main burrow before its termination. This branch ended in a cell containing a pupal case and some heads and wings of bees. As indicated by Reinhard (1922) and Evans and Lin (1959) the main burrow would then be deepened, short side burrows with single cells would be progressively constructed and provisioned, and the youngest progeny or newest cells would be the most distant from the burrow entrance.

Old burrows: Older burrows in various stages of contruction have been described by Rau and Rau (1918, Missouri), Reinhard (1922, Maryland), Evans and Lin (1959, New York) and all agree fairly closely in the same basic design. Since the 2 advanced burrows excavated at Portal, Arizona, show a rather radical departure they will be given in detail for comparative purposes.

Number three burrow: On 5 and 12 June the catch basin around the base of an elm tree behind the laboratory building was flooded with water which soaked the surrounding ground out to about 20 cm. on the west side. The earth on this side was a sandy soil which was loose on top to a depth of about 2.5 cm. and hard packed below this level. On 27 June a female of *P. gibbosus* was observed going in and out of her burrow several times prior to 2:25 P.M, and at 2:26 P.M. she came in with prey and the burrow was marked. The entrance was located under the overhanging branches of the elm tree, 1.5 m. west of the tree trunk, 50 cm. from the edge of the catch basin, about 30 cm. from the soaked area outside the basin, and 5 cm. west of a small *Sphaeralcea* sp. plant. The entrance was surrounded on 3 sides by a fan shaped pile of excavated dirt which was highest directly in front (west) of the burrow entrance.

Behavior: When first observed on 27 June this female was already gathering prey and as it turned out she had been thus engaged for quite some time, as there were 6 cells on 3 branches off the main burrow. On 28 June the burrow was checked at 8:50 A.M. and was found to be closed; however, the plug was slightly concave medially, thus indicating that it had been closed from within. At 8:57 A.M. the entrance was open and at 9:00 A.M. loose dirt was being thrown out by the wasp who remained out of sight. Within a few seconds the entrance was plugged again and remained so until 9:23 A.M. when the female backed out of the burrow throwing dirt behind her. During the next 5 minutes she repeated the process several times, backing out of the burrow for from 1.3 to 6.3 cm. away from the entrance, throwing loose dirt behind with her front legs as she backed up. She would then move slowly forward into the entrance throwing dirt behind as she did so. These excavating activities had created a fan-shaped pile of dirt on the west side of the entrance (Fig. 2) and after several trips there was a median, shallow channel in this accumulation since she followed the same course each trip. No doubt the channel changes position from time to time thus creating the fan-shaped tumulus pile. At 9:28 A.M. she entered the burrow, closed it from the inside and was not seen again until 11.27 A.M. when she appeared at the entrance, made 5 clean-out trips, entered the burrow and left the entrance open until 11:45 A.M. when it was closed from the inside.

The burrow remained closed until 12:13 P.M. when she opened the entrance by pulling the dirt plug back into the burrow with her mandibles and probably the front legs. Her head then appeared in the entrance for about 10 seconds, moving from side to side, before she cautiously came out (Fig. 3), closed the entrance and flew away. Observations were resumed at 12:57 P.M. when she was seen coming in with prey and had difficulty locating the burrow entrance. She tried digging in two separate spots about 2 cm. from the correct location before finding it, opened the entrance with her front legs without releasing the prey and entered the burrow. She remained inside for 40 seconds, came out after a brief pause at the entrance, closed the burrow and made an almost verticle orientation flight to a height of about 75 cm. before flying away at 12:59 P.M. She returned with prey at 1:06 P.M., stayed in the burrow for 55 seconds, hesitated at the entrance before emerging, closed the burrow and made an orientation flight at about a 60° angle to a height of about one m. in 12 to 15 step-like movements. She was seen coming in with prey at 1:38 and 1:57 P.M. and between 2:27 and 3:48 P.M. (one hour, 14 minutes) she brought in 8 bee prey, spending from 3 to 19 minutes (average 11 minutes) collecting each, and was in the burrow storing them for 40 to 60 seconds (average 48 seconds). Between 12:57 P.M. and 3:48 P.M. (2 hours, 51 minutes) she collected and stored at least 12 bees.

Orientation: The step-like orientation flight was observed on a number of occasions and is unlike that of many other wasp species, including the eastern *P. gibbosus*. Once the burrow entrance is closed the female orients so she is facing it, takes wing and either proceeds straight up above it or at a steep angle, 50-60°, away from it. Her movements are jerky but form a definite pattern. From 2 to 4 hovering stops are made, each one being from 3 to 5 cm. higher than the preceding, and after each series of from 2 to 4 stops she goes from side to side 2 or 3 times in an almost straight line for a distance of from 5 to 10 cm. Each straight flight is at a slight angle away from the burrow. This is then followed by another series of vertical, hovering stops. We have observed as many as 15 steps in the first orientation flight but as the number of flights from the burrow increases, the orientation flight decreases in length, height and the number of steps taken until there is no discernable orientation. The homing flights to the burrow follow a similar pattern except that the straight flights are forward and slightly downward toward the burrow rather than lateral as in orientation. As more homing flights are made the approach loses its step-like character, the angle decreases (20-40°)

until it becomes a gradual, downward, glide-like flight beginning from 3 to 5 m. away from the entrance. After about the sixth prey-collecting trip in each period of such activities, the step-like characteristics of the orientation and homing flights are lost. On 29 June this female made an unusually long orientation flight to a height of 5.5 m. after which she was captured. All departure flights of this female were made from east to west and all return flights from west to east, the latter being on almost the same course each time so that she was often seen while still 4 to 5 m. from the burrow entrance.

Burrow design: The entrance was irregular, but roughly 6 mm. in diameter as was the burrow for most of its length. The entrance was on level ground and for the first 5.1 cm., to the *Sphaeralcea* roots, the burrow descended at an angle of about 30° toward the east. It angled sharply downward at this point, descending in a shallow arc toward the east for 7.6 cm. where there was a small hole in the south side of the burrow wall. This appeared to be a branch off the main burrow but it was plugged with small pebbles and further excavating in this direction failed to disclose any sign of a burrow or of cells. From this point the burrow angled sharply downward for 5.1 cm., leveling off gradually toward the east and extending in this direction for 2.5 cm. It then angled sharply downward for 2.5 cm. to the top of a loose dirt fill that extended for 1.3 cm. to the top of a mud-pellet plug which was 3 mm. thick. Below this plug the burrow continued downward at the same steep angle for an additional 15.1 cm. into the top of an enlarged, empty, chamber about one cm. in diameter.

The exit from this chamber was near the bottom on the western side and the burrow extended toward the west and only slightly downward for 3.8 cm., narrowing to 3 mm. in diameter. At this point it made a 90° turn toward the south for about 5 mm. and then abruptly downward and back under itself, extending irregularly downward at a steep angle toward the east for 5.1 cm., ending in an empty cell which was evidently ready to be stocked. This cell was 24.8 cm. below ground level and a linear distance of 49.9 cm. from the burrow entrance. The maximum offset from the entrance was to the east for 19.0 cm. to cell 5. Cell 4 was offset northwest for about 17.5 cm. and was at the lowest depth of 25.4 cm. below ground level.

The cells were arranged in pairs, 2 each on 3 branches off the main burrow. Cells 5 and 6 were on the same level, 15.2 cm. below ground level, and were separated from each other by 2.5 cm. Cell one was found at a depth of 23.5 cm. below ground level near the burrow leading to cell 2 and separated from this cell by 3.8 cm. Cell 2 which was empty and evidently ready for stocking, was at the end of the open burrow at a depth of 24.8 cm. Two additional cells (3 and 4) were found to the west of cell 2 but there was no evidence of the connecting burrow. Both of these were at a depth of 25.4 cm. below ground level and were separated from each other by about 3 cm. Closed cells averaged 12 mm. in length by 8 mm. in diameter. The empty cell had the same diameter but was 16 mm. in length, thus indicating that about 4 mm. of this would be occupied by the plug when the cell is completed.

Cell contents and prey analysis: When collected, the female *P. gibbosus* was evidently accumulating bees to stock the empty terminal cell. The first prey, a female *Sphecodes* sp., was encountered at a depth of 14 cm. below ground level in the main burrow. It was on top of loose dirt 1.3 cm. above a plug made of small, rounded mud pellets packed in solid to a depth of 3 mm. The second bee, a male *Sphecodes* sp., was found just below this plug packed in loose dirt. The first cell contained 12 bees, 10 of which were still untouched, and a small *P. gibbosus* larva that was feeding on the ventral, anterior surface of the thorax of one bee, with its posterior end anchored to another. There were 2 males and one female of *H. (S.) tripartitus*, 4 males and 2 females of *L. (D.) microlepoides* and one male of *Sphecodes* sp. in this cell. The second cell, located at the bottom of this branch, was empty but evidently completed and ready for stocking. Cell number 3 contained a total of 8 bees, 2 of which were damaged in excavation, but no evidence of a wasp egg, larva or feeding damage. The 6 bees represented 3 males and one female of *L. (D.) microlepoides* and a male and a female of *Sphecodes* sp. Cell 4 contained a total of 15 bees, 12 of which had been dismembered by 2 fly larvae. The 3 whole bees represented one female of *H. (S.) tripartitus*, one female of *L. (D.) microlepoides* (Ellis) and a male *Sphecodes* sp. The fly larvae may have been those of either *Hilarella hilarella* (Zetterstedt) or of *S. (trilineata complex)* sp., the adults of which often follow the wasps as they come into the burrows. Cells 5 and 6 contained *P. gibbosus* pupal cases which were molded both inside and out and were obviously the oldest cells in the burrow. Cell 5 contained the heads of 16 bees and cell 6 the heads of 23.

This nest contained a total of 76 bees or remains of bees, 74 of which had been stored in cells. There were from 8 to 23 bees (average 14.8) in each cell. The bees represented 3 genera belonging to the family Halictidae, one of which, *Sphecodes*, is known to be parasitic on species belonging to the genus *Halictus*. The presence of these parasitic *Sphecodes* sp. among the prey may indicate that this female was doing at least part of her prey collecting at the nesting sites of *Halictus* and *Lasioglossum*.

Number four burrow: The burrow of this female was found at 11:45 A.M. on 27 June as she came in with prey. It was located out in the open about 2 m. east of the base of a small peach tree and about one m. east of the catch basin surrounding it. On 23 June water was purposely allow to overflow this basin, soaking the area on the east side out to about 6 m. in a narrow (30 cm.) band. The nest entrance was on the southern edge of this area in level, sandy soil.

Behavior: The female made several trips bringing in prey between 11:45 A.M. and 1:00 P.M. on 27 June, and her behavior pattern was similar to that given for the female in burrow 3. However, as she was coming in with prey at 1:07 P.M. she was being closely pursued by 4 flies, one of which remained within a few millimeters of her abdomen for at least 2 m. When she was within about 5 cm. of the burrow entrance she suddenly flew upward on an erratic course for about 2.5 m., with the 4 flies in hot pursuit, and landed on a leaf on the peach tree. She was observed holding the prey in the usual manner while at rest and none of the flies were bothering her in this situation. Two of them were on adjacent leaves watching the wasp and the other 2 could not be seen. At 1:08 P.M. she flew and was immediately followed by the 2 adjacent flies and all 4 were again in pursuit as she neared the nest entrance. Once again she flew away without entering the burrow but we were unable to see where she went. At 1:09 P.M. a fly entered the nest entrance for about one-half second and then landed on a nearby *Sphaeralcea* plant orienting so as to face the nest entrance. The *P. gibbosus* female was not seen again until 1:31 P.M. when she again tried unsuccessfully to get into the nest. This was repeated at 1:33 P.M. and she hadn't reappeared for another try as of 4:30 P.M.

On 28 June the burrow remained closed from within until 11:32 A.M. at which time it was opened and several clean-out trips were made by the female. It was closed from within at 12:12 P.M. and remained that way for the rest of the afternoon. The female was seen coming into the burrow several times on 29 and 30 June and was collected as she came in with prey at 11:41 A.M. on 1 July.

Burrow design: The entrance was on level ground and although slightly irregular in shape, was about 6 mm. in diameter. For most of its length the burrow was of the same diameter but there were irregularities along its course and the corners were slightly wider.

For the first 7.6 cm. the burrow went downward at about a 30° angle toward the southwest, angled abruptly downward at this point at about a 60° angle and proceeded down and toward the south for 24.1 cm. The course of the burrow was irregular so it required 31.7 cm. of burrow to reach a depth of 16.5 cm. below ground level with an offset to the south of 21 cm. At this point it angled sharply toward the east, extending slightly downward for 2.5 cm. where it again angled sharply downward and toward the south for 3.8 cm. It then angled sharply toward the west and extended for 6 mm. before making a half circle extending downward toward the southeast for 5.1 cm. The U-shaped curvature took the burrow around an elongate termite burrow. It then proceeded downward and toward the south for 2.5 cm. before curving eastward for 1.3 cm. and then in a gradual curve back toward the west for 3.8 cm. This point was 28.6 cm. below ground level, maximum depth for the burrow proper, and was offset 29.2 cm. to the south of the burrow entrance, the maximum offset. From this point the burrow was almost level for 10.2 cm. but extended roughly in a half-circle back toward the north and west. A loose dirt plug containing bees occupied 4 cm. of this portion of the burrow. At the end of this half-circle, a branch extended downward and toward the northwest for 3.0 cm. ending in an open cell. The burrow and this branch were open for their entire length of 64.5 cm. except for the plug near the bottom.

The 10 cells were located at 6 different depths below ground level and only number 6 was directly connected to the burrow. The remainder had been stocked and effectively plugged off from the burrow. The shallowest cell was number 3 at a depth of 15.2 cm. and 22.2 cm. northwest of the main burrow. Judging from its isolated position it was probably on a separate branch off the main burrow. Cells one and 2 were at a depth of 22.2 cm. and almost directly beneath cell 3. These cells were separated from each other by 1.3 cm. Cells 4 and 5 were 24.1 cm. deep, almost directly beneath cell one and were separated from each other by 6 mm. Based on position, depth and distance from the main burrow, these latter 4 cells may have been on 2 sub-branches of a branch extending off the main burrow. Cells 6, 7 and 8 were at a depth of 30.5 cm., but because of their scattered positions were probably on different branches from the burrow. Cell 9 was at a depth of 28 cm., and may have been on a side branch with these 2 cells. Cell 10 at 31.8 cm. below ground level was the deepest point in this nest.

Cell contents and prey analysis: This female was collected as she returned to the burrow carrying a female of *H. (S.) tripartitus.* The nest contained 9 cells which had been utilized and one which appeared to be complete and ready to accommodate the bees which were being accumulated in the plug. The cells averaged 12 mm. in length by 8 mm. in height and width. They were unlined and were lying horizontally on the ends of lateral branches or at the termination of the main burrow.

Cell number one contained the moldy remains of a medium sized *P. gibbosus* larva, seven bee heads and three dead female *H. (S.) tripartitus*. The second cell also had the moldy remains of a medium sized larva and 8 bee heads. Cell 3 contained a large cluster of mite eggs, some of which had hatched, on what might have been the remains of the wasp larva and 9 bee heads. Cells 4 and 5 were broken into unexpectedly but both contained living pupae and the remains of 23 bees, probably 11 in one and 12 in the other. Cell number 6 was at the end of the main burrow and although complete was still empty. The loose dirt plug in front of cell 6 contained 8 paralyzed bees of which 2 were damaged in excavating. There were 2 female *H. (S.) tripartitus*, 2 males of *Colletes tucsonensis* Cockerell, and a male and female *Sphecodes* sp. in this plug. Cell 7 contained 6 bee heads, cell 8 had 5 bee heads and in neither cell was there any indication of the wasp larva. However, between these 2 cells, in what might have been the plugged burrow, there was a pupa of the fly *S.* (*trilineata* complex) sp. whose larva was probably responsible for the destruction of the contents of these cells. Cell 9 contained a fresh pupal case of *P. gibbosus* and the heads of 8 bees. The pupal case was surrounded by a loose maze of white silken threads which were attached to the side walls of the cell and in which were entangled the exoskeletal remains of the 8 bees (Fig. 4). Within this loose outer covering, but attached to it, was the white, parchment-like cocoon that later turned a pale brown color. The cocoon was 8 mm. in length, 4.5 mm. in diameter and when opened in January contained a dried up pupa of the wasp. Cell 10 contained only the remains of 5 bees.

The 9 stocked cells and plug in this burrow contained a total of 83 bees or bee remains, including the one being brought in by the female at the time of capture which would have undoubtedly been placed in the plug. There were from 5 to 12 (average 8.3) bees per cell. The identifiable specimens belonged to 2 genera of Halictidae, one of which, *Sphecodes*, is known to be parasitic on bees belonging to the genus *Halictus* and one genus of the family Colletidae.

Predators: The 4 flies that kept the female from entering the burrow were collected and found to represent 2 different genera of sarcophagids. The largest of the 4 was *H. hilarella*, the 3 smaller specimens were *S.* (*trilineata* complex) sp. and the fly in the pupa found between cells 7 and 8 emerged on 12 July and found to represent the latter species. Both genera are known to be predators in the nests of bees and wasps where they develop on the stored materials, thus depriving the host larva of its food supply, or they actually eat the egg or young larva of the host. Adults of *Senotainia* have been observed trying to dig their way into nest entrances and to enter open burrows for a second or two but never long enough to penetrate to any depth. They may larviposite in the burrow during this brief period. However, judging from the adult habit of closely following the host wasp carrying prey, occasionally touching the prey, and then not following the female into the burrow, plus the fact that we have found the fly larvae on the bee prey as it was being carried into the burrow, it would seem that the usual method of introducing the fly larva into the nest is by laying the larva on the prey as it is being taken into the burrow. In most instances contact between the fly and the prey was made immediately in front of the burrow entrance while the wasp was part way into the burrow and the prey shifted back toward the abdominal apex.

In France *Hilarella stictica* Meigen is known to enter the burrows of *Ammophila hirsuta* Scopoli where it lays its larva alongside the egg of the host on the stored caterpillar. The fly larva consumes the host egg and then enters the body of the caterpillar to complete its development (Clausen, 1962). It may eventually be shown that *H. hilarella* enters the burrow of the host but we have no proof of this at the moment. Our single observation on the species shows that its behavior is very similar to that of *Senotainia* and we suspect that it will be found to larviposite on the prey as it is being carried toward or into the burrow.

Parasites: As mentioned previously, cells 4 and 5 contained healthy pupal cases of *P. gibbosus*. The one in cell 4 was damage in excavation but the one in cell 5 was cultured on 2 July and a female mutillid emerged from it on 17 August 1963. This has been identified as *Sphaeropthalma (Photopsis)* n. sp. (Ferguson, *in litt.* 1965). When cultured, the pupal case had no holes or breaks in it and appeared to have either a prepupa or pupa of *P. gibbosus* on the inside with the hard fecal material at the narrow end. The mutillid adult cut her way through the enlarged or head end, leaving an irregular emergence hole. According to Ferguson (1962:8) the females of

S. (P.) orestes Fox parasitize *Anthidium collectum collectum* Huard, by inserting the ovipositor through the cocoon, laying the egg inside and then plugging the hole with a dark substance. Such evidence of parasitism was not seen on the *Philanthus* cocoon but may have gone unnoticed. From all indications the same procedure may have been followed in the *Philanthus* as the larva had completed its cocoon, defecated in one end and was either a prepupa or pupa. Cell 4 contained a prepupa and since it was probably only a few days older or younger than cell 5, it would seem reasonable to assume that cell 5 also contained a prepupa when parasitized. Ferguson (1962: 64) states that *Photopsis* larvae feed as external parasites of the mature host larva, which it consumes entirely. This appears to be the first record of parasitism of the genus *Philanthus* by *Sphaeropthalma*.

Comparative Bionomics

As mentioned previously, *P. gibbosus* has been studied by Evans and Lin in New York, by Reinhard in Maryland and New York, by Peckham and Peckham in Wisconsin and by Rau and Rau in Missouri. The species is widely distributed, occurring from coast to coast, from southern Canada into Mexico, and evidently maintains its identity throughout this range since no subspecies have been described. The following is a comparison of the midwestern and eastern populations with the one studied in southeastern Arizona in various phases of their bionomics.

Environmental requirements: Climatically there is little doubt that *P. gibbosus* is tolerant of a wide range of temperature, humidity and seasonal changes as is evidenced by its extensive distribution. This is not only true of a north to south transgression of isotherms but also in the east to west transition from the moist hardwood forests to the dry desert areas of the southwest.

Edaphic requirements: Correlated with the environmental tolerance, the species, as would be expected, exhibits considerable variability in the selection of soil types in which to dig its nests. Evans and Lin found 9 of their 10 nests in the side of vertical sand banks, the tenth in flat sand. Rau and Rau found them in dirt roadside embankments and in clay banks. Reinhard studied a large colony that was nesting in an uncemented brick walk overlaying sand but also found them in hard, barren ground, hard-packed clay of a tennis court, in an open barren slope in a grove of trees, in the midst of a lawn, in the bank of a roadway and under a brick pavement. His large colony was next to a building. The 5 Arizona nests (one not studied) were located in level soil, either in open areas or near plants, and 2 of them had been started next to soaked spots. It would appear from the above that the edaphic requirements of *P. gibbosus* are not very restrictive and probably do not impose barriers to distribution. Nesting areas are probably selected in the vicinity of flowers visited by halictine bees or near their breeding colonies, irrespective of specific edaphic conditions.

Season: Evans and Lin found the species to be active from early July to late September. Rau and Rau made their observations between 23 July and 24 September. The Peckhams found them active in early August and Reinhard observed their activity from the middle of June to the middle of September. The Arizona nests were not kept under close observation over a long period but we know that the species was active from the middle of June to at least the middle of July and probably longer. It would appear therefore that the period of activity, June to September, applies in general to all of these widely separated geographical populations.

Generations per year: Evans and Lin state that there is probably only one generation a year in New York which agrees with our conclusion on the Arizona population. However, Reinhard (1922:364) states "In Maryland *Philanthus gibbosus* goes through two generations a year." He further says (p. 369) that the larva spends 8 months in the pupal case unless it belongs to the first generation, in which case it spends only a week in this condition. Males pupating in April emerged as adults 27 and 28 days later and females pupating in July required 15 and 19 days to complete their development. We feel that additional observations on this part of the life cycle are desirable before a definite conclusion can be made. The long length of time spent by the females in excavating their tortuous burrows may be confusing the issue. Very often nests are found with pupae, larvae and eggs already present while the female is still excavating and stocking cells. Rau and Rau excavated an incompleted burrow in which the female was found 30.5 cm. from the entrance at the end of the main burrow. Near the end they found a single cell containing a pupal case. This would indicate a rather erratic digging behavior on the part of this female which could extend nest building activities over a considerable period. She had been observed for about 7 days before the burrow was excavated and since it is indicated that a completed burrow probably has from 7 to 10 cells, she would probably have spent at least another month working on this nest.

Nest entrances: Evans and Lin found that 9 out of their 10 nests entered vertical banks and Rau and Rau state that this species frequently, if not usually, uses the sides of depressions, or embankments to begin their nests, but they also located several on level ground. The Peckhams found them using slopes or embankments. Reinhard, on the other hand, found most of his on a level walk or brick pavement, although he also recorded their using sloping ground and the bank of a roadway. The 5 Arizona burrows had their entrances on level ground. It would appear that the selection of the site for the nest entrance is variable and not a confining or limiting factor in that they use vertical banks, sloping ground, depressions or level ground.

Reinhard, the Peckhams, the Raus and the present writers found that entrances located on level ground or slight slopes had considerable loose tumulus on one to 3 sides of the entrance, usually fan-shaped. The Peckhams found the tumulus spread out to a distance of 14 cm. from the entrance and we found it varying from 1.3 to 6.3 cm. depending in part on the age of the burrows.

Burrow design: Evans and Lin found that nearly all of their burrows were horizontal with the ground surface or with at most a slight downward dip. Rau and Rau reported that burrows in vertical clay banks were horizontal but found a number of other designs as well. One burrow, with its entrance on level ground, descended gradually at a 30° angle to its termination which was 12.7 cm. below ground level. Another descended at a 45° angle for 12.7 cm. before leveling off to continue parallel with the surface. Of 2 burrows that had their entrances in sloping banks, one was horizontal for 5.1 cm., then proceeded at a 45° decline for 25.4 cm., ending in a vertical drop of 5.1 cm.; the other went slightly downward for 10.1 cm., then abruptly down at a 45° angle for 28 cm. where it ended in an angled chamber. The Peckhams illustrate a burrow that descended for 21.6 cm. at what appears to be about a 45° angle before leveling off to proceed 35.6 cm. parallel with the ground surface at a depth of 20.3 cm. Reinhard describes and illustrates a burrow that descended at an oblique angle (about 45°) for 15.2 cm. before leveling off horizontal to the ground surface for 38.1 cm. at a depth of about 10 to 13 cm.

In the architectural design of the eastern burrows of *P. gibbosus*, there are evidently at least 2 characters common to all and one that is exhibited in most of the nests. Their burrows all have a single, unbranched main shaft as contrasted with the old Arizona burrows which are branched at least 3 times. In all but 2 of the eastern burrows most, and sometimes all, of the main shaft is horizontal whereas the Arizona burrows are nearly vertical. Two incomplete nests excavated by Rau and Rau in Missouri were more like the western burrows in this respect but they showed no branching. In the eastern burrows all of the cells are located singly on the ends of short lateral branches off the main burrow. In the Arizona nests these short cell branches arise from near the ends of the major branches off the main burrow.

Burrow depth and length: Depth measurements are from ground level and the lengths are linear measurements along the burrow from the nest entrance to the end of the burrow. Offset figures are from the burrow entrance. Rau and Rau excavated one nest to a depth of 28 cm. and a length of 35.6 cm., and another to a depth of 12.7 cm. with a length of 30.5 cm. No depths were given on 2 others that were 30.5 cm. and 40.6 cm. in length. The Peckhams measured one with a depth of 20.3 cm. and 57.2 cm. in length. Reinhard measured the length of a 7-celled burrow at 53.3 cm., and judging from his illustration the depth was probably between 6 and 10 cm. These burrows, in various stages of construction, averaged 17.2 cm. in depth and 40.8 cm. in length. Of the 2 older Arizona burrows, one was 24.8 cm. deep and 49.9 cm. in length (main branch), with a maximum offset of 19 cm. to the east. The other was 30.5 cm. deep and 64.5 cm. in length (main branch), with a maximum offset of 29.2 cm. to the south of the burrow entrance. These 2 burrows, in different stages of construction, averaged 27.6 cm. in depth and 57.2 cm. in length. Although there appears to be a significant difference between the average figures for the east and west populations, we feel that these are probably unreliable as a basis for any conclusions because of the small sample number, the variability between the 2 Arizona nests, and the fact that all nests were not in the same stage of completion. There are no offset figures available for the eastern burrows.

The length figures given above for the Arizona burrows, however, include only the main burrow and one open branch down to the terminal cell. Accurate measurements on the length of the other 2 branches in each nest cannot be given as they had been completed and filled in back to the main burrow. Measurements taken from the terminal cell on each branch back to the nearest point on the main shaft would increase these length measurements from 49.9 to about 77.3 cm. and from 64.5 to about 101.3 cm. The latter figure may be a fair estimate of a completed burrow since this nest contained 10 cells, 3 more than any previously recorded.

Cell position: As given previously, in the eastern burrows the cells are located singly at the ends of short, lateral, burrows extending off the main shaft, whereas in the western burrows they are located at the ends of short lateral burrows extending from branches off the main burrow. Evans and Lin found the first cells at a distance of 17 to 30 cm. from the nest entrance (average 22 cm.). Each cell was on the end of short side burrows (3 to 5 cm. long) and were so spaced that they were at least 8 cm. apart. The deepest cell was 55 cm. from the nest entrance. We found the first cells from 26.3 to 44.4 cm. (average 35.4 cm.) from the nest entrance. Each cell was on the end of short side burrows of varying lengths or on the end of the branches. They were irregular in placement, the more proximate being separated by from 6 mm. to 3.8 cm. from each other. The deepest cells were from 46.2 to 64.5 cm. (average 55.4 cm.) from the burrow entrances. In depth below ground level they varied from 15.2 to 25.4 cm. (average 21.6 cm.) and from 15.2 to 31.8 cm. (average 25.9 cm.) in the 2 nests. All cells were horizontal in position.

From this it can be seen that in the western burrows the first cells were encountered at deeper average depths, their placement on burrow branches was irregular and some were found to be separated from each other by less than 8 cm. The average distance from the burrow entrance to the deepest cells is about the same for both locations.

Cell size and numbers: Evans and Lin state that the cells are broadly elliptical, about 10 by 18 mm. in size. Rau and Rau found one cell that measured 13 mm. in length. We found that open cells measured 8X16 mm. and the closed ones 8X12 mm., the extra 4 mm. being used for the plug in closed cells. Thus far, all the burrows that have been excavated have evidently been incomplete so we have no figure on the maximum or average number of cells per completed burrow. Evans and Lin found a maximum of 7 cells in a burrow that was still active and Reinhard illustrated one with 7 cells. We found 6 in one and 10 in another and both were still active nests.

Prey number and composition: Evans and Lin found that in 12 fully-provisioned cells the number of prey in each varied from 8 to 16 (average 11) and all but one specimen, a crabronid wasp, were bees belonging to the family Halictidae. Reinhard also found from 8 to 16 bees per cell, all of which belonged to the same family. However, in 2 seasons he collected 331 bee prey from *P. gibbosus*, of which 325 specimens, representing 21 species, belonged to the family Halictidae and 6 specimens, representing one species, belonged to the family Andrenidae. In our nest number 3, which contained 5 fully stocked cells, we found that each contained from 8 to 23 (average 14.8) bees of which 21 of 76 were identifiable to the family Halictidae. In nest number 4, which contained 9 fully-stocked cells and 8 bees in a plug, there were from 5 to 12 (average 8.3) bees in each cell. Out of 83 specimens, 10 were indentifiable and 8 of these were Halictidae and 2 Colletidae. The balance of the specimens were represented by heads and other body parts. None of the species are conspecific with those identified from eastern nests but all the genera have been previously recorded either by Evans and Lin or Reinhard. The variability in the number of bees per cell might be the result of the fact that *P. gibbosus* selects both medium and small sized bees, the latter requiring more per cell to supply ample food for the larva. There appears to be no overstocking as the cell with the maximum number of bees (23) contained only their remains which were entangled in the outer threads of the pupal cocoon (Fig. 4).

Excavating behavior: There seems to be general agreement that the female backs out of the burrow throwing dirt behind her with the front pair of legs when engaged in excavation activities. She also uses this pair of legs to spread the loose dirt out in front of the nest entrance. The Peckhams observed that when pebbles are encountered these are grasped with the mandibles or pushed with the front of her head and deposited on the tumulus. Our observations are in agreement with the above, but in addition the females continued to throw dirt out behind as they moved forward into the burrow entrance. Within the nest they probably use the mandibles as well as the legs and push the dirt up behind as they bring it up to the surface. They were not observed to leave the burrow head first during excavating activities. Considerable time is spent in these activities, evidently depending on what is being excavated, *i.e.*, cells, branches or the main burrow. One female spent 2 days in such activities and was probably digging in the main burrow or a branch. Other females hunted prey on successive days, gathering more than enough for one cell and thus spent relatively few hours, probably excavating a cell.

Closing activities: The Peckhams made observations on a nest in which brothers and sisters were still using the parental burrow and found that when some of these individuals flew off for varying periods of time they didn't close the entrance before departure. When single females are involved the burrow is, with few exceptions, closed before she leaves. The female faces away from the entrance and throws dirt back under her body with the anterior pair of legs until the entrance is concealed and the loose dirt is level with the surrounding ground.

The burrow remains closed for long periods while the females are in the nest. Rau and Rau believe that the plug materials are pushed up from beneath, probably with the head; an opinion with which we concur. With few exceptions, we found that it was possible to tell whether the females were at home or away by the surface configuration of the plug. When the plug had been pushed up from beneath, its surface was slightly concave and the outline of the burrow edge was faintly discernible. When closed from the outside, the surface was flat and there was no sign of the burrow. During excavation activities the entrance may be open or closed while the female is inside, but if open it is soon closed by dirt being pushed out. If closed it may remain so for long periods. The Raus and the present writers found that when the female removes the entrance plug from the inside she pulls it down into the burrow.

Exit from burrow: When the females intend to leave the burrow for hunting or feeding, they appear at the entrance head first after removing the plug. The Peckhams found that the females would often creep out and walk around the entrance 3 or 4 times before taking wing, and even then would sometimes return and land once or twice before leaving the vicinity. Evans and Lin found that they may peer out the entrance for a moment before closing and flying away. We observed the same cautious behavior, which was most pronounced on the first exit each day, and becoming less evident and of shorter duration as more and more trips were made. The female would usually stop with her face flush with the surface of the ground, then move up so the head was protruding where it would then be moved from side to side as if she were looking around. On the early trips this lasted for as much as 12 minutes before she came out, closed the entrance, oriented and flew away. On later trips the head was immediately thrust out of the entrance, moved from side to side for from 3 to 10 seconds before she closed the opening and flew off.

Orientation flight: Having closed the burrow the females orient their bodies so they are facing the entrance site and take wing. The Raus observed them calmly poised in the air swinging pendulum-like to and fro in semicircles in front of the hidden entrance. The arcs would become wider and the motions jerky until the females flew away. The Peckhams state that they circle the site before departing. In the western females we observed neither the pendulum-like motion or circling but the motions were jerky as recorded by the

Raus. The orientation flight in these females was step-like and proceeded either vertically or at a steep angle (50-60°) in front of and away from the entrance site. Each step consisted of from 2 to 4 hovering stops, one above the other at intervals of from 3 to 5 cm. At the end of each series of stops, the female then moves from side to side in almost a straight line for 5 to 10 cm. Each straight flight is at a slight angle away from the burrow. This is followed by another series of hovering stops. The side to side movements did not appear to increase in length as the females moved further away and as many as 15 steps were observed in a single flight. The maximum distance covered by a flight was 5.5 m. vertically above the nest site, and as the number of flights increase, the length, height and number of steps decrease until there is no discernible orientation. This pattern appears to be quite different from that recorded for the eastern females.

Homing flight: Evans and Lin found that when the females were bringing in prey they descended obliquely from a considerable height to the nest entrance. Reinhard reports that they descend toward the nest in a rapid, swinging, zigzag flight when bringing in prey. Usually the females have no trouble locating the entrance, but the Raus, the Peckhams and the writers have seen them making mistakes and investigating nearby spots or holes before finding the correct entrance. We found that the first return flights, with or without prey, were step-like as in the orientation flights except that the straight portion is toward the entrance and downward at a slight angle. As more return flights are made they lose their step-like character and become a gradual downward, glide-like flight beginning at a height of 2 to 3 m. and from 3 to 5 m. away from the entrance. These latter return flights are probably similar to the oblique flights recorded by Evans and Lin but no zigzag approaches as noted by Reinhard were observed.

Entering nest: Evidently the normal procedure for entering the burrow is for the female to land immediately in front of it, hurriedly pulling most of the loose dirt out of the plug with her front legs and pushing the rest down inside as she forces her way in. The prey is held in position by the middle pair of legs during this procedure. The Peckhams watched a female whose burrow had accidentally been covered with a leaf. She came in with prey, landed in the wrong place, hunted for the burrow entrance for a few minutes and then dropped the prey and flew away for a few minutes. The leaf was removed and on her return, without prey, she went immediately to the right spot and opened the entrance, during which process the bee was pushed back with the dirt. When the entrance was open she picked up the bee, brought it toward the entrance, dropped it, ran in and out of the burrow, brought the bee closer and dropped it again, entered the burrow, turned around, reached out and seized the bee in her mandibles and pulled it inside. We have watched several species of Cerceris which, if they dropped the prey in front of the entrance, would not touch it again but would start the entire collecting procedure over. Evidently *P. gibbosus* has some ability to adjust to an interruption of her normal behavior pattern and modify it to fit the circumstances.

Reinhard and the writers have observed that as the female enters the burrow in the normal fashion the bee prey is sometimes shifted toward the rear so that its abdomen projects slightly beyond hers for a very brief period. We have on a number of occasions seen the predaceous flies, *S.* (*trilineata* complex) sp., make contact with the bee prey at this point. These flies follow the females closely as they are returning to the nest and larviposite on the prey while it is being carried. Except for this second or less, the prey is somewhat inaccessible in that it is being held up close to the female's sternum and does not usually protrude beyond the apex of her abdomen. Reinhard has observed that on occasion the female will have the antennae of the bee grasped in her mandibles, a phenomenon we have not seen.

Hunting site: The Peckhams found that their females were capturing prey about 40 feet away from their nesting site at a large *Halictus* colony. Evans and Lin watched a female entering the nest of a small halictid bee, apparently stinging the bee inside the nest, then carrying it to her own nest. This action was repeated 4 times in 10 minutes. Reinhard reported seeing females of *P. gibbosus* hunting or feeding on a number of different flowers that were ordinarily patronized by halictid bees. He saw a female capture a bee from the flower of Queen Ann's Lace and attack other insects, spiders and floral parts by mistake. We were unable to find the hunting site of our females, but juding from the presence of *Sphecodes* sp. (a parasite of halictid bees) among their prey they may have been capturing them at a halictid nesting site.

Time spent collecting and storing prey: The Peckhams timed one female and found that she spent from one to 29 minutes (average 12.9 minutes) out of the nest, returning each time with a bee. She stored 13 bees in 3 hours and 9 minutes, spending only about a minute in the nest after each trip. One of our females spent from 3 to 10 minutes (average 4.6 minutes) collecting the bees, from 4 to 40 seconds (average 17 seconds) storing them in the burrow, and collected a total of 10 bees in one hour and 37 minutes. Another female spent from 3 to 19 minutes (average 11 minutes) collecting the bees, from 40 to 60 seconds (average 48 seconds) storing them, and collected a total of 8 in one hour and 14 minutes. In 2 hours and 51 minutes she collected and stored at least 12 bees. According to Reinhard the actual capture of the bee and stinging it consumed not more than 10 seconds which would indicate that most of their time is spent in hunting and on the longer trips they may have visited flowers for nectar.

Prey storage: Evans and Lin found 3 bees stored in loose soil near the end of a burrow and the writers found 9 bees stored similarly in the last 3.8 cm. of a new burrow. In burrow number 3, an older nest, 2 *Sphecodes* sp. had been stored in a loose dirt plug, 14 cm. from ground level, and an empty cell was ready for their storage. In burrow 4, also an old nest, 8 bees were found in a loose dirt plug at 28.6 cm. below ground level near a completed but empty cell. From the above it would appear that in new burrows the first prey are gathered and stored in a plug before a cell is constructed. In the older burrows the cell is completed and then the bees to fill it are accumulated in the plug.

Evans and Lin found that in several nests there was more than one cell partially filled with bees, without eggs, and suggest that perhaps more than one cell may be filled simultaneously. The Peckhams expressed no doubt that one cell is provisioned and sealed off from the burrow before another is started. In our burrows the latter procedure is indicated since each of the older nests contained only one empty cell and the bees to stock it were being accumulated in a loose dirt plug. All other cells had been stocked and sealed off from the main burrow.

Nocturnal behavior: The Peckhams watched males digging burrows and noted that they returned to these in late afternoon and spent the night inside. They also found them "sleeping" in crevices and holes in posts. Evans and Linsley (1960) found specimens of *P. gibbosus* "sleeping" as casuals on vegetation along with other wasp species at a location 5 miles southwest of the location of the present studies. These were probably males. At the Portal nesting site we observed no male activity but the females spent the night in the burrows.

Parasites and predators: Evans and Lin reported no parasites, predators or inquilines in any of the nests and saw no females being followed by miltogrammine flies. The Raus observed a "red-bellied parasite" digging in the loose sand at the entrance to a burrow which had just been plugged from within by the female *P. gibbosus*. Reinhard observed adults of the sarcophagid fly *Metropia leucocephala* Rossi as they investigated the *P. gibbosus* nests for brief periods and occasionally entered open burrows for 2 or 3 inches. He presumed that during these entries the fly larviposited in the burrow. He reared another sarcophagid, *S. trilineata*, from larvae found in cells where they were feeding on the bee prey and had evidently destroyed the *Philanthus* egg or young larva. Both species are predators. Reinhard also found 2 predators of the adult *P. gibbosus*, one a spider *(Misumena vatia)*, and the other a robber fly (*Deromyia discolor* Loew).

We made numerous observations on 2 species in 2 genera of sarcophagids as they followed the females when they returned to the burrows with prey. *H. hilarella* was found flying with *S.* (*trilineata* complex) sp. as they successfully discouraged a prey laden female from entering her burrow. The latter species was reared from a pupa found between 2 ravaged cells of *P. gibbosus* and its larvae were found on the bee prey as they were being carried into the nest. This species also investigates *P. gibbosus* burrows or tries to dig into them and will dart in and out of open nests. We have no information on whether or not they larviposite in the burrows.

No parasites have been previously recorded on *P. gibbosus* but it seems worth mentioning here that we reared a female of the mutillid *S. (P.)* n. sp. from a pupal case excavated from nest 4, cell 5. This is evidently a parasite of the prepupa of *P. gibbosus*.

BIONOMICS OF *Philanthus anna* DUNNING

Evidently nothing has been published previously concerning this species which, at least in some locations in Arizona and New Mexico, occurs in the same microhabitats with *P. gibbosus*. According to Muesebeck, Krombein and Townes, *et al.* (1951), *P. anna* has been collected in the Rocky Mountain States and Alberta and British Columbia in Canada. The following observations were made in southwestern New Mexico and southeastern Arizona, and although not as extensive as those made on *P. gibbosus*, will nevertheless contribute information on burrow design, habitat, prey, a possible parasite and a predator.

Habitat: The first 3 burrows were found in the same location, macrohabitat and ecological situation described earlier in this paper for *P. gibbosus*. The fourth female was seen starting her burrow at a location one mile north of Rodeo, New Mexico, at an elevation of about 4200 feet in the bottom of the San Simon Valley. Specimens of both species were collected in this location on 29 and 30 June as they visited the flowers of *Koeberlinia spinosa* Zucc.

Nest number one: The female was first observed on 20 June 1963 at 9:15 A.M. as she was excavating in her burrow, the entrance to which was 7 cm. below ground level in a vertical bank that we purposely left exposed from a previous digging. The site was in an open area largely devoid of vegetation and in dry, sandy soil on which no water had been applied. Her entrance was 5 cm. south of another wasp burrow entrance and entered the bank going directly west. The opening was 3 mm. in diameter.

Behavior: Excavating activities continued from 9:15 A.M. to 9:25 A.M. during which time loose dirt was occasionally pushed out of the opening. At 9:25 A.M. the entrance was closed from the inside and remained so until 10:00 A.M. when more dirt was pushed out. At 10:34 A.M. she returned with prey to her open burrow, having departed without being seen. She departed again after spending 1.5 minutes in the burrow, returning with prey at 10:52.5 A.M. or after spending 17 minutes away from the burrow. On both trips in with prey she flew slowly and each time landed on a small ragweed (*Ambrosia psilostachya* DC.) plant that was 30.5 cm. southwest of the burrow entrance. These stops were only for from 15 to 20 seconds each and she then proceeded directly into the burrow. At 10:55 A.M. her head appeared momentarily in the entrance and a minute later she closed the entrance with dirt and stayed inside until 11:24 A.M. At this time she opened the entrance, left it open and flew to the ragweed plant, landed for about 10 seconds before flying slowly away. She returned with prey at 11:35.5 A.M. and flew directly into the entrance without stopping on the plant. She came out after 2 minutes, left the burrow open, made a brief stop on the ragweed plant before flying away and returned with prey at 12:01 P.M. without stopping at the plant. She came out again at 12:03.5 P.M., left the burrow open, flew away without stopping at the plant, and came directly back into the burrow with prey at 12:29 P.M. At 12:31 P.M. she closed the entrance from the inside and it remained in this condition until 2:05 P.M. when the burrow was unsuccessfully excavated.

This female gathered 5 bee prey in an elapsed time of one hour and 55 minutes, interrupted by a 31.5 minute stay in the burrow.

The actual time would therefore be one hour and 23.5 minutes of which from 11.5 to 25.5 minutes (average 19.1 minutes) were spent in hunting and from 1.5 to 2.5 minutes (average 2 minutes) in storing the prey in the burrow. There was no external evidence that she was excavating during the 31.5 minutes that interrupted the prey collecting activities. During her absence from the burrow the entrance was left open and the early departures and returns were marked by brief stops on an adjacent ragweed plant. This may prove to be a regular feature in the orientation and return flights of this species.

Nest number two: This burrow was located on 28 June 1963 when the female was observed throwing loose dirt out of the nest entrance. It was located about one meter northeast of the catch basin surrounding a small peach tree and 40 cm. north of number 4 *P. gibbosus* burrow. On 23 June water was purposely allowed to overflow this basin and run east into the open area for about 6 m. in a narrow (30 cm.) band. The surface soil was sandy and the action of the water eroded a narrow, shallow channel (13 mm. deep) with a vertical bank along its northern margin. The nest entrance was located at the bottom of this vertical bank, 13 mm. below ground level, and was 4 mm. in diameter.

Behavior: At 11:40 A.M. on 28 June the female was throwing loose, sandy dirt out of the nest entrance in the same fashion employed by *P. gibbosus* and had created a fan-shaped tumulus pile in front of the entrance. She was still engaged in these activities at 9:12 A.M. on 29 June, but at 10:44 A.M. was seen coming into the burrow with prey. She remained in the burrow until 11:04 A.M. when she came out and was followed by a small fly as she flew away. She returned at 11:19 A.M. without prey and may have spent this 15 minutes feeding on the nectar of flowers. Between 1:41 P.M. and 3:44 P.M. (2 hours and 3 minutes) she gathered 5 bee prey and stored them in the burrow, but interrupted the collecting regularity for one hour and 11 minutes (2:21-3:32 P.M.) by closing the burrow and staying inside. On the uninterrupted trips she spent from 12 to 19 minutes (average 16 minutes) collecting prey and about 2 minutes storing them each time. She was collected on the morning of 30 June as she came in with prey and the burrow was excavated on 1 July.

Burrow design: The burrow angled downward toward the west at about a 30° angle for the first 7 cm. with a diameter of between 3 and 4 mm. It then angled sharply downward, almost vertical, and proceeded for 9.5 cm. to another sharp angle toward the west. It extended in this direction in a shallow arc downward for 5.1 cm. to an enlarged, elongate chamber. The chamber extended almost horizontally to the west for 10 mm., then angled downward at about a 45° angle for an additional 10 mm. and was 6 mm. in diameter. It contained 3 bees but did not have the shape of a cell. At a vertical depth of 9.5 cm. from this chamber, offset 4.5 cm. further to the west, there was an empty cell which was evidently ready for the bees being accumulated in the chamber. It was not, however, connected to it by an open burrow. This cell was at the maximum depth in the burrow of 25.4 cm. from ground level, was offset to the west of the nest entrance 17.8 cm. and was about 35.6 cm. in linear measurement from the entrance.

The first cell was at a depth of 10.8 cm. below ground level and was offset to the west of the burrow by 10.2 cm. Cell 2 was at a depth of 12.1 cm. and offset to the west by 8.9 cm. and cell 3 was at the same depth but offset to the west 10.2 cm. or directly beneath cell one. None of these cells were connected to the main burrow and because of their close proximity we suggest that they probably arose from a common side branch off the main burrow. The enlarged chamber was 15.9 cm. below ground level and its apex was offset 13.3 cm. to the west of the nest entrance.

Cell contents and prey analysis: The first cell contained a full-grown larva that was probably ready to spin its cocoon, as all the bees had been eaten and pulled apart. The second cell was damaged in excavating but contained a larva of undeterminable size. Cell 3 contained a small larva that had consumed 3 of the 8 bees in the cell. The 5 whole bees represented 2 females of *H. (S.) tripartitus*, one male of *L. (D.) microlepoides* and 2 males of *Sphecodes* sp. The 3 bees that were stored temporarily in the enlarged chamber represented 3 females of *H. (S.) tripartitus*, the same species (female) the *P. anna* was carrying when captured. This represents the same assortment of halictine bees recorded as prey for *P. gibbosus* from the same location and the presence of 2 male *Sphecodes* sp. might indicate that the *P. anna* was hunting at the nesting site of the bees.

Nest number three: This female was first seen on 18 July as she was excavating and throwing dirt out of the nest entrance which was in a vertical, dry bank of sandy soil, 10 cm. below ground level. This pit had been excavated several weeks earlier and purposely left open so as to expose this bank. On the evening of 18 July an army ant colony (*Neivemyrmex* sp.) raided the pit and surrounding area but we did not see them around this burrow entrance. The female was seen several time on 19 July and still seemed to be engaged in excavating activities. On the morning of 20 July she was observed departing from the burrow, leaving the entrance open, but no time records were taken. Upon her return with prey she was being closely followed by 2 small flies (probably *S.* [*trilineata* complex] sp.) and was captured as she attempted to enter the burrow.

Burrow design: The entrance was on the west bank of the pit and measured 4 mm. in diameter. The burrow descended abruptly at about a 45° angle, with a diameter of 5 mm., and followed an irregular S-shaped pattern to a depth below ground level of 34.2 cm. and an offset toward the west of about 11 cm. At this point there appeared to be a branch going toward the north but it ended a few mm. away from the main burrow and nothing was found beyond it. From this point it started back toward the east and downward and after making a rough arc ended up directly beneath the branch point, but at a depth of 48.1 cm., where a mutillid was found. It then made a sharp bend toward the east, proceeded nearly level for a short distance, angled slightly downward and appeared to end at this point, directly under the entrance at a depth of 53.2 cm. Even though a considerable area was excavated, no cells were found. The burrow was filled with loose dirt for about the first 50.6 cm., then open for about 3 cm., and closed to the end.

Prey analysis: Only the single bee was taken when the *P. anna* was collected and this was a female of *H. (S.) tripartitus*, one of the species stored by the female in nest number 2 and also by *P. gibbosus*.

Predators: As stated above, when the female was coming in she was closely followed by 2 flies. One of these seemed to maintain a distance of only about 5 or 6 mm. from the tip of her abdomen until she was within about 10 cm. of the nest entrance. At this point the fly closed the gap, appeared to rest momentarily on the tip of her abdomen, but slightly underneath, and even though the contact was brief the *P. anna* was disturbed and did not enter the nest. She flew upward, made a half circle and was headed back toward the entrance when captured. The bee was examined about 2 minutes later and 2 live, active fly larvae were found in its mouthparts. Unfortunately the adult fly was not taken and we were unable to rear the larvae through to adults. However, many adults of the sarcophagid *S.* (*trilineata* complex) sp. were active in the area and were reared from *P. gibbosus* nests so it was likely this species that was involved with *P. anna*. We found a few *H. hilarella* in the same area following

P. gibbosus. but this is a slightly larger species and although it too may infest nests of *P. anna* we are fairly certain that it wasn't the species we observed on this occasion.

Parasites: Although this cannot be called a definite parasite-host association. it seems worthy of recording that at a depth of 48.1 cm. below ground level. 38.1 cm. below the burrow entrance, we found a female of *Dasymutilla dilucida* Mickel in the burrow just above the open portion near the bottom. It was in the loose dirt and may have been directly or indirectly responsible for the burrow being closed for most of its length. Evidently no host relationships for this species of *Dasymutilla* have been recorded previously and although this is not a certain host record it does indicate the possibility.

It also seems worthy of note that in the area where the studies on *Philanthus* and other wasp genera were being made, the females of *D. dilucida* were very abundant as were the males of *Dasymutilla errabunda* Mickel (det. C. E. Mickel). On 17 June 1963, a female of *D. dilucida* that was investigating various cracks and burrows was in turn being investigated. on the wing. by a male of *D. errabunda*. The female climbed up into a small *Sphaeralcea* sp. plant and stopped as if resting or getting out of the heat. The male *D. errabunda* circled the plant 2 or 3 times. landed on it about 10 cm. above the female and moved rapidly down until they faced each other on the base of a leaf. After contacting each other for several minutes with their antennae the male moved around to the side and mounted the female. Although he was attempting to copulate, the specimens were collected before this was accomplished. The female made no move to escape or fight during this entire procedure. Although this is of course not conclusive proof that *D. errabunda* is the male of *D. dilucida* it at least indicates that such might be the case.

Nest number four: This female was evidently seen as she was just beginning her burrow. at a location one mile north of Rodeo, New Mexico. The entrance was being started in fine, loose sand at the entrance to a rodent burrow on a slope at an angle of about 5°. The female was digging like a *Bembex* wasp. scooping the sand out with her front legs and throwing it down the incline behind her. In the beginning the sand from above kept falling into her excavation, but after about 20 minutes she had a hole deep enough to insert her head and thorax. At this point she was disturbed by 7 ants who chased her away and stayed around the shallow hole for several hours. The female *P. anna* was not seen again. even though the site was checked each day for about 10 days.

SUMMARY

1. Nine out of the 23 recognized species of North American *Philanthus* are known to provision their nests primarily with bees belonging to the family Halictidae, but on occasion also use members of the families Andrenidae, Apidae and Colletidae. Several species sometimes store wasps of the families Sphecidae and Vespidae among their bee prey.

2. *P. gibbosus* in Arizona was found to use the following bees as prey: males and females of *H. (S.) tripartitus*; males and females of *L. (D.) microlepoides*; males and females of *Sphecoides* sp. and males of *C. tucsonensis*. *P. anna* was found to use the first 3 species listed above as their prey.

3. The widely distributed *P. gibbosus* is adapted to living under a variety of climatic and edaphic conditions, but within its total area is possibly restricted locally by biotic factors such as the proximity of prey nesting sites and flower visiting locations.

4. The eastern and western populations of *P. gibbosus* are similar in a number of activities, such as seasonal occurrence, excavating behavior, burrow closing, cell size and numbers, prey numbers per cell, generic composition of prey, time spent collecting and storing prey, method of carrying prey, hunting sites, behavior on leaving and entering burrow and predator groups.

5. Nest entrances in eastern populations of *P. gibbosus* were found in vertical banks, on slopes or on level ground. Only the latter was found in the Arizona nests.

6. One and 2 generations per year have been recorded for eastern populations, whereas only one appears to be indicated for the Arizona examples.

7. The eastern and western populations of *P. gibbosus* differ in burrow design, burrow length, position of cells, orientation flights, return flights and parasites.

8. The Arizona burrows have as many as 3 branches off the main shaft and the cells are located near the ends of these branches on short lateral or terminal burrows. The eastern burrows are unbranched and the cells are on short lateral burrows scattered along its length or at its termination.

9. Most of the eastern nests have a large portion of the burrow extending parallel to the ground surface. In the Arizona nests

the main burrow extended sharply downward at steep angles or at times vertically, ending with varying amounts of offset from the entrance. Some of the branch burrows were horizontal.

10. The average depth below ground level for the eastern burrows was 17.2 cm., for the Arizona nests it was 27.6 cm. In the eastern burrows the linear measurements of the main shaft averaged 40.8 cm., in the western 57.2 cm. However, when the side branches are included for the western burrows the linear distance excavated to the cell areas is increased to an average of 89.3 cm. The western females of *P. gibbosus* do considerably more digging than do the eastern ones. None of the burrows from any of the locations were complete.
11. In new *P. gibbosus* nests in Arizona the prey are stored in a loose dirt plug in the burrow before the first cell is constructed. In the older burrows the cell is completed before the prey to fill it are gathered. The latter also appears to be true of the eastern populations of this species.
12. The orientation flights in the eastern females was pendulum-like or circling whereas in the western females it was step-like with side-wise fading back motions between the steps.
13. The return flights of the eastern females was swinging, zigzag or a gradual downward glide. The early return flights of the western females was step-like, changing to a gradual downward glide as more trips were made.
14. No true parasites have been found in the eastern populations. The Arizona *P. gibbosus* is parasitized by the mutillid *S. (P.)* n. sp. and is evidently a parasite of the prepupa.
15. In both the eastern and western populations the sarcophagid fly *S.* (*trilineata* complex) sp. is a predator. In the east *M. leucocephala* and in the west *H. hilarella* are suspected predators of *P. gibbosus*. In the east the spider *M. vatia* and the robber fly *D. discolor* are adult predators.
16. Because of the given differences in behavior and nest construction between the western and eastern populations of *P. gibbosus*, it is suggested that a re-examination of the adult morphology between geographical samples might be profitable.
17. *P. anna* occurs in the same habitat as *P. gibbosus* and at the same season in Arizona. It does, however, appear to prefer vertical banks or sloping sand for its nest entrances.

18. The early departure and return flights sometimes involve a brief stop on a nearby plant within sight of the nest entrance.
19. Unlike *P. gibbosus*, *P. anna* leaves the nest entrance open while she is away.
20. The burrow design, depth and offsets appear to be similar to those of the western *P. gibbosus*.
21. The same assortment of halactine bee prey as recorded for *P. gibbosus* were collected by *P. anna*.
22. Evidently the same fly predators recorded for *P. gibbosus* also attack *P. anna*.
23. A female of the mutillid *D. dilucida* was found in a burrow and may be a parasite of *P. anna*.

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NEW *HETEROPOGON* LOEW, WITH A KEY TO THE SPECIES AND THE DESCRIPTION OF A NEW GENUS (DIPTERA: ASILIDAE)

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In a previous paper (Wilcox 1941), a key was given to the species of *Heteropogon* Loew occuring in America north of Mexico. Included was *Pycnopogon cirrhatus* Osten Sacken which was considered not to be a good *Pycnopogon*. Martin (1962) placed *Pycnopogon divisus* Coquillett from Mexico in *Heteropogon*, so the genus *Pycnopogon* is now restricted to the Palearctic Region.

Several errors or changes in status of the species have become evident since the previous paper. The specimens identified as *Heteropogon ludius* Coquillett from Washington are assigned to *senilis* Bigot now that material is available from California. *H. ludius* Coquillet is a well defined species occuring mainly in southern California; Back (1909) thought this species might be a synonym of *senilis* Bigot. The specimens previously identified as *senilis* Bigot from southeastern Oregon are placed in *martini* new species. The specimens from southern Arizona without scutellar bristles identified as *rubidus* Coquillett apparently represent a new species but are not described because of their poor condition. *Heteropogon nigripes* Jones from Nebraska is still not included as it appears to belong in *Eucyrtopogon* Curran; no *Heteropogon* have been seen from Nebraska but a *Eucyrtopogon* from there fits Jones's description quite well.

Martin (1962) has reviewed and given a key to the Mexican species. He has also called attention to the plumose hairs on these flies and has indicated that the Palearctic species can be grouped on their presence or absence. All of the Nearctic species (*rubidus* Coquillett and *phoenicurus* Loew have not been examined) have these hairs on the frons, occiput, neck, pleura, abdomen and legs. The main variation occurs on the face and mesonotum. Several species were found with smooth hairs on the upper face but usually a few plumose hairs were found laterally. Six species were found without plumose hairs dorsally on the mesonotum but a few were found laterally behind the humeri, they are: *macerinus* Loew, *rubrifasciatus* Bromley, *spatulatus* Pritchard, *paurosomus* Pritchard, *duncani*

Wilcox, and *stonei* new species. *Chiricahua* new species almost belongs in this group and has many less plumose hairs on the mesonotum than the related species, *currani* Pritchard.

Most of the Nearctic species have the male middle tibiae adorned at the middle or basal third with a dense brush of black hairs. The middle femora usually has a ventral brush of black hairs at the apical third and the dorsal apical anterior surface is covered with short dense black hairs. Species without the tibial brush are: *lautus* Loew, *johnsoni* Back, *rubrifasciatus* Bromley, *paurosomus* Pritchard, *duncani* Wilcox, and *stonei* new species. In these species the ventral brush on the femora is also absent but the short black apical hairs may be present or not.

These flies perch mainly on the tips of dead twigs of various trees and shrubs. Linsley (1960) found that *johnsoni* Back preferred grass stems and perched with the head down. He collected 83 specimens with prey and says, "they captured both flying and crawling prey, which consisted primarily of small beetles and bugs." His Plate 52 shows four individuals resting on grass stems with prey.

I am indebted to the following persons for the loan of material: Paul H. Arnaud, Jr., California Academy of Sciences (CAS); Mont A. Cazier, Arizona State University (ASU); Eric Fisher, Los Angeles (EF); A. T. McClay, University of California, Davis (UCD); J. A. Powell, University of California, Berkeley (UCB); and Lloyd Martin, Los Angeles County Museum of Natural History (LACM). Six of the new species are named for my friends and colleagues, all of whom I have had the pleasure of collecting with. The new genus is named in honor of A. Earl Pritchard in recognition of his excellent work on a number of genera of robber flies. The types of the new species are in the writer's collection unless indicated otherwise.

Pritchardomyia, new genus

Head 1½ times as broad as high; face at antennae subequal to width of one eye, moderately gibbose the gibbosity reaching antennae, face and frons but slightly widening from antennae; mystax composed of a double row of oral bristles, hairs above reaching antennae; palpi 2 segmented; proboscis in length subequal to height of head; antennal segments 1-2 subequal in length; third broadest at middle and slightly narrowed at base and apex, 1⅓ times length of segments 1-2; style slender, 2 segmented, about ⅔ length of third segment.

Thorax broad, not highly arched; mesonotum with strong lateral bristles and weak posterior dorsocentrals; scutellum pollinose, the disc with erect hairs and the posterior margin with 12-14 weak bristles.

Abdomen broad, tapering apically (slightly in male), with 8 segments, segment 1 with weak lateral bristles, hairs short erect numerous on the sides becoming shorter on the dorsum of the segments; male genitalia small, inverted (rotate), almost concealed by the eighth segment; apex of female with circlet of blunt spines.

Legs moderately stout, empodia and pulvilli present, all tibiae at apex ventrally with a row of 5 or more short straight bristles.

Wings with the marginal and 5 posterior cells broadly open, anal cell narrowly open, third vein branched well beyond the end of the discal cell.

Genotype: Anisopogon vespoides Bigot.

Most closely related to *Callinicus* Loew, differing mainly in lacking the two strong inwardly directed spines at the apex of the middle tibiae. In *Callinicus* also, the third antennal segment is rather slender and 1½ to 1 4/5 times the length of segments 1-2, the style is broad basally narrowing to apex and about ¼ length of the third segment, and the disc of the scutellum is with none or a few short hairs.

The plumose hairs and non-rotate male genitalia of *Heteropogon* will separate it from both of the above genera.

Pritchardomyia vespoides (Bigot)

Anisopogon vespoides Bigot, 1878, Ann. Soc. Ent. de France, 8:423. Type ♂, California, Hope Museum, Oxford.

Heteropogon vespoides Back, 1909, Trans. Amer. Ent. Soc., 35:329. Translation of original description.

Heteropogon vespoides Wilcox, 1941, Bull. Brooklyn Ent. Soc., 36: 52. Description of female, CAS.

In the previous description of a greased specimen the color of the pollen was not determined. Face and frons, yellowish brown; occiput, yellowish gray; mesonotum brown subshining, laterally behind suture, golden; pleura yellowish gray, subshining; scutellum golden the posterior margin subshining; ground color of abdomen black, sides of segments and apical segments reddish brown, the posterior margins expanded at the middle on apical segments bright dense yellow pollinose on male segments 1-6 and female 1-5. Length 18-26 mm.

Collected mostly on the coast north and south of San Francisco and in the Bay area. A few have been taken in the mountains to the east at elevations up to 2500 feet. Burdick (1943) found them on the cliffs above the ocean flying from six to twenty feet high and diving for their prey and resting on bare spots on the ground with their prey. Paul H. Arnaud, Jr., collected two specimens on oak foliage and F. E. Blaisdell labeled one specimen "blue tarweed." Occurs mostly in August and September, but one was collected in July.

This is the only species, but Eric Fisher has a female specimen collected in the San Jacinto Mts. in southern California which shows considerable variation and may be a second species.

Key to the Species of *Heteropogon*

1. Scutellum without marginal bristles, disc bare, marginal hairs short 2
   Scutellum with marginal bristles, sometimes obscured by the long marginal hairs 3

2. Wings brown, somewhat lighter in the anal and axillary cells; scutellum wholly pollinose; ♂ genitalia not enlarged; length 10-16 mm. (Texas, Arizona) . . . . *patruelis* (Coquillett)
   Wings with small brown clouds on the crossveins and furcations; posterior margin of scutellum subshining black, disc pollinose; ♂ genitalia enlarged; length 10-14 mm. (Colorado, Arizona, Montana, Utah) . . . . *maculinervis* James

3. Scutellum largely pollinose, sometimes thinly so and subshining black, but never polished 4
   Apical two-fifths or more of the scutellum polished black; smaller, less pilose species with the abdomen in part reddish or yellowish, especially apically 21

4. Femora reddish, sometimes only ventrally; abdomen in part reddish 5
   Femora black; abdomen usually all black 7

5. Femora black above, brownish below; abdominal segments 2-6 largely reddish brown; wings a smokey-gray; length 14-17 mm. (California) . . . . *rubidus* (Coquillett)
   Femora reddish or reddish brown; abdomen reddish apically or on the posterior margins of the segments; wings with brown clouds apically 6

6. Posterior margins of abdominal segments 2-6 and 7 entirely, reddish; male middle tibiae without brush of black hairs; wings faintly tinged with brown, darker along anterior portion of apical half; length 10-15 mm. (North Carolina, Georgia) .... *rubrifasciatus* Bromley
   Abdomen black but sometimes with lateral and posterior margins and apical segments, reddish brown; male middle tibiae with brush of black hairs; wings brown apically and basally in the costal cell; length 10-12 mm. (New Jersey, District of Columbia, Iowa, Kentucky, Maryland, New York, Pennsylvania) .... *macerinus* (Walker)
7. Wings largely brown or with brown clouds on the crossveins and furcations 8
   Wings hyaline, sometimes brown above discal cell especially in the females 12
8. Wings largely brown 9
   Wings with brown clouds on the crossveins and furcations or above and basal to discal cell 10
9. Basal half of the wings except extreme base, hyaline, apex black; style longer than third antennal segment; mesonotum white and yellowish pollinose; length 9-12 mm. (Texas) .... *phoenicurus* Loew
   Basal two-thirds of the wings brown, the apex hyaline; style three-fourths length of third antennal segment; mesonotum largely brownish pollinose; length 10-18 mm. (California) .... *ludius* (Coquillett)
10. Mystax white with a row of black oral bristles; wings brown above and around the discal cell; style subequal in length to the third antennal segment; length 10-12 mm. (California) .... *tolandi* new species
    Mystax black, a few white hairs above especially in the females; wings with small brown clouds on the crossveins and furcations 11
11. Wings hyaline apically; face, frons and mesonotum light brown pollinose; style of antennae four-fifths length of third antennal segment; length 10-14 mm. (Oklahoma) .... *currani* Pritchard
    Wings brownish-black apically; face and frons thinly golden pollinose, mesonotum largely subshining brown; style subequal in length to the third antennal segment; length 9-14 mm. (Arizona) .... *chiricahua* new species

12. Abdomen at least with small pollinose spots on the hind angles of segments 2-4 13
Abdomen bare of pollen 17

13. Abdomen with pollinose spots on the hind angles of segments 2-4 14
Abdomen largely pollinose or with anterior or posterior bands on several segments 15

14. Mystax all white; style subequal in length to the third antennal segment; hairs and bristles except a few on legs and tarsi, white; length 10-12 mm. (Arizona, New Mexico) . . *cazieri* new species
Oral bristles black, hairs above white; style two-thirds length of third antennal segment; hairs white, leg bristles largely and bristles of occiput, neck and scutellum usually, black; length 12-14 mm. (Nevada, California, Oregon) . . *martini* new species

15. Segments 1-5 of female abdomen and male wholly, whitish pollinose; mystax white; head and thorax white pollinose, bristles white except some on the tarsi, black; length 12-16 mm. (Colorado, Arizona, New Mexico) . . . . *wilcoxi* James
Anterior or posterior margins and sides or posterior corners of most abdominal segments pollinose; oral bristles black, hairs above white 16

16. Posterior corners of abdominal segments 2-4 and anterior margins of 2-5, gray pollinose; ♂ middle tibiae with brush of black hairs; length 11-16 mm. (Arizona, Utah) . . *arizonensis* Wilcox
Sides and posterior margins of male abdominal segments 2-6 and female 2-5, gray pollinose; male middle tibiae without brush of black hairs; length 9-12 mm. (Texas) . . . . *lautus* Loew

17. Abdomen dorsally with dense recumbent lighter hairs on some or all of the segments 18
Abdomen with short hairs dorsally, usually with long hairs laterally on the basal segments and sometimes on the posterior corners 20

18. Scutellum bare of pollen with dense long erect marginal and discal hairs more or less concealing the marginal bristles; abdomen with white or yellowish recumbent hairs on the posterior margins of most segments; male middle tibiae without brush of black hairs; length 10-15 mm. (Colorado, Arizona, New Mexico, Texas) . . . . *johnsoni* (Back)
Disc of scutellum pollinose and with sparse hairs, posterior mar-

gin with long or short hairs but not concealing the marginal bristles; male middle tibiae with brush of black hairs 19

19. Abdominal segments 1-7 of male, 1-5 of female, covered with dense recumbent golden hairs, fine long and sparse in some females; black bristles of mystax extend nearly half way to antennae, hairs brownish below, white above; style four-fifths length of third antennal segment; length 8-12 mm. (California, Nebraska, Oregon, Washington) . . . . . . *cirrhatus* (Osten Sacken)
Abdomen dorsally with short black hairs, posterior margins with fine white hairs, sides with long white hairs and males dorsally on segments 6-8; mystax all white; style two-thirds length of third antennal segment; length 13-17 mm. (Arizona, California) . . . . *davisi* new species

20. Abdomen dorsally with short black hairs, posterior corners of male 2-5 and female 2-4 with longer white hairs and anterior corners with short erect black hairs; male frons and female frons in part and posterior mesonotum, black haired; length 10-15 mm. (California, Oregon, Washington) . . . . *senilis* (Bigot)
Male abdomen dorsally with short black hairs and the posterior margins with short recumbent golden hairs, female segments 1-4 with short appressed yellowish white hairs, sparse erect on apical segments; frons and mesonotum white haired; length 9-11 mm. (California) . . . . *fisheri* new species

21. Second and following abdominal segments largely yellowish, male abdomen spatulate; middle femora of males with small brush of black hairs; legs vary from largely black to largely reddish; mesonotal and abdominal hairs sparse; anterior apical half of wings brown; length 9-12 mm. (Arizona; Sonora, Mexico) . . . . *spatulatus* Pritchard
Apical abdominal segments reddish, male abdomen not spatulate; male middle tibiae without brush of black hairs 22

22. Hind femora and usually middle ones, reddish below; wings dark brown, anal and basal cells lighter; 2-4 yellowish marginal scutellar bristles; length 8-9 mm. (Arizona) . . *duncani* Wilcox
Femora black except at tip; 4-6 scutellar bristles 23

23. Mystax white, sometimes with 4 slender black bristles below; wings hyaline, crossveins and furcations especially costally, clouded with brown; male fore tarsi with posterior fringe of long hairs, white on metatarsi becoming black apically; length 8-9

mm. (Arizona) . . . . *paurosomus* Pritchard

Oral bristles black and hairs brownish, hairs above white; wings brown, lighter in the basal two-fifths; male fore metatarsi with sparse white hairs dorsally, black on apical segments: length 8-9 mm. (Arizona, New Mexico, Utah) . . . . *stonei* new species

Heteropogon cazieri, new species

Male: Length 10 mm. Head black, face and frons thinly, occiput densely, gray pollinose. Mystax white (one black bristle on oral margin); face 4/5 width of one eye; frons white haired; 4 white bristles on ocellar tubercle; occipital bristles and hairs white; hairs on palpi largely black. Antennae black, thinly gray pollinose; hairs on segments 1-2 and bristle below on 2, white; 3 tapers from base to apex; segments measure 7-8-21-15.

Mesonotum black; anterior and lateral margins, narrow dorsocentral stripes and transverse suture, gray pollinose, remainder brown pollinose. Hairs white, long erect anteriorly, laterally and in dorsocentral rows. Bristles white, 3 humeral, 4-5 presutural, 5 supraalar, 2 postalar. Pleura and coxae gray pollinose, hairs white. Scutellum thinly brown pollinose, hairs white, 4 white marginal bristles.

Abdomen black, posterior angles of segments 2-4 with a gray pollinose spot. Hairs white, long and dense on sides and venter, dorsally short sparse appressed yellowish. Three white lateral bristles on segment one. Genitalia black, sparse white haired, hypandrium golden haired.

Femora black, tibiae and tarsi reddish. Hairs and bristles white, a few black bristles on outer tarsal segments and a brush of black hairs on middle femora and tibiae. Fore metatarsi with white appressed hairs dorsally, less numerous on outer segments. Claws and empodia black, pulvilli brown.

Halteres yellow, stem brown. Wings hyaline, veins light brown, anterior crossvein slightly beyond middle of discal cell.

Female: Length 10 mm. Abdominal segments 6-8 polished black, short sparse erect hairs yellowish; apical spines black.

Holotype: Male, 7 mi. E. Portal, Arizona, 23 Oct. 1962 (J. Wilcox).

Allotype: Female, same data, 18 Sept. 1962.

Paratypes: 18 ♂♂, 16 ♀♀, same data, (Itol J. and J. Wilcox); 34 ♂♂ ♀♀, 2.3 mi. N. Rodeo, New Mexico, 6 to 28 Sept. 1960 and 1.9 mi. N.W. Rodeo, New Mexico, 6 Oct. 1961 (Mont A. Cazier) on

Ephedra trifurca Torr., ASU; one ♂, 3 mi. W. Santa Rosa, Guadalupe Co., New Mexico, 17 Aug. 1962 (Eric Fisher) EF; 14 ♂♂, 11 ♀♀, one mi. N. Rodeo, New Mexico, 10 Oct. 1964 (Eric Fisher) EF. This species rests in a horizontal position and was collected on *Ephedra* along with *johnsoni* Back. The two species could be separated at quite a distance as *johnsoni* rests with its head down as reported by Linsley 1960.

Heteropogon chiricahua, new species

Male: Length 11 mm. Head black, face and frons thinly golden pollinose, occiput yellowish gray. Mystax composed of long black hairs extending to antennae with a few white intermixed above; face subequal to width of one eye. Frons with erect black and white hairs; ocellar tubercle with 3 slender black bristles and several white hairs; occipital bristles black, hairs white with a thin fringe of black ones around eyes; hairs on palpi black, on proboscis white. Antennae black, brownish pollinose, segments 1-2 black haired, 2 with a black bristle below; 3 tapering from base to apex; segments measure 9-8-20-20.

Mesonotum black, brownish pollinose, central stripe and intermediate area subshining brown, transverse suture whitish towards center. Hairs sparse erect white. Bristles black, 3 humeral, 4 presutural, 3 supraalar, 3 postalar (White). Pleura and coxae brownish pollinose, subshining, hairs white. Scutellum brown pollinose, sparse white haired, 2 black marginal bristles.

Abdomen black, small spots on posterior corners of segments 2-4, gray pollinose. Hairs white on sides and venter; dorsal hairs short black, somewhat longer and erect on sides of 2-7. Three white lateral bristles on segment one (one black). Genitalia black, sparsely white haired, hypandrium sparsely golden haired.

Femora black, tibiae and tarsi reddish. Bristles black, white posteriorly on fore and middle tibiae and fore metatarsi. Hairs white, middle femora and tibiae with brush of black hairs. Claws and empodia black, pulvilli brownish.

Halteres yellowish, base brown. Wings hyaline, crossveins and furcations and a large apical spot brownish black. Veins brown, anterior crossvein at 5/8 length of discal cell.

Female: Length 12 mm. More white hairs in upper part of mystax; frons largely white haired. One of the scutellar bristles white. Abdominal segments 6-8 shining black with sparse erect white hairs; apical spines brown.

Holotype: Male, Chiricahua National Monument, Arizona, 22 Oct. 1962 (J. Wilcox).

Allotype: Female, same data.

Paratypes: 15 ♂♂, 73 ♀♀, same data and 21 Oct. 1962 (Itol J. and J. Wilcox). Collected on dead twigs of walnut, oak, acacia and pine 6 to 8 feet or higher, at the mouth of the canyon leading in to the Monument.

Heteropogon davisi, new species

Male: Length 13 mm. Head black, densely grayish white pollinose. Mystax white extending to antennae, face 4/5 width of one eye; frons, occiput and beard white haired; occipital bristles and 4 on ocellar tubercle white; hairs on palpi in part black. Antennae black, golden pollinose; segments 1-2 white haired, 2 with a white bristle below; 3 tapers from base to apex; segments measure 7-7-30-20.

Mesonotum black, brown pollinose, the anterior and lateral areas and transverse suture, gray pollinose. Hairs white, confined mainly to anterior and lateral areas. Bristles white, 3 humeral, 6 presutural, 3-4 postalar, 3-4 supraalar, one weak dorsocentral. Pleura and coxae gray pollinose, hairs white. Scutellum grayish brown pollinose, 8 white marginal bristles plus a few hairs, disc bare.

Abdomen black; short black hairs dorsally on segments 1-5 with scattered white hairs posteriorly on 2-5 and anteriorly on 5: long erect white hairs on venter and laterally on 1-4, long appressed white hairs on sides of 4-5 and wholly on 6-8. Six white lateral bristles on one. Genitalia shining black, sparse hairs yellowish, fringe on hypandrium yellow.

Femora black, tibiae yellowish red, tarsi reddish becoming darker apically. Bristles white, on tarsi largely black. Hairs white, black brush on middle femora and tibiae. Claws and empodia black, pulvilli light brown.

Halteres yellowish red, base brown. Wings hyaline, veins yellowish brown, anterior crossvein at 6/11 length of discal cell.

Female: Length 17 mm. Two scutellar bristles (some may have been broken off). Long white hairs confined to abdominal segments 1-4, appressed white hairs on sides of 2-4 and basally on 5, the short hairs dorsally yellowish, appressed on basal segments, sparse erect apically on 5 and 6-8; apical spines brown. Wings with a light brown clouding above discal cell.

Holotype: Male, Sabino Cyn., Santa Catalina Mts., Arizona, 25 Oct. 1962 (J. Wilcox).

Allotype: Female, same data.

Paratypes: 4 ♂♂, same data, 19, 20 Oct., 1962 (J. Wilcox), 4 ♂♂, 4 ♀♀, same data, 8 Nov. 1962 (E. G. Davis); 7 ♂♂, 15 ♀♀, Pima Cyn., Santa Catalina Mts., Arizona, 10 Nov. 1962 (E. G. Davis); 4 ♂♂, 3 ♀♀, 12 mi. N. Tucson, Arizona, 9 Nov. 1962 (E. G. Davis); 4 ♂♂, 2 ♀♀, 7-8 mi. N. Tucson, Arizona, 6, 18 Oct. 1964, 8 Nov. 1962 (E. G. Davis); one ♀, Sierritas Mts., Arizona, 25 Nov. 1962 (E. G. Davis); 3 ♂, one ♀, Grey's Mdw., Independence, California, 23 Aug., 15 Sept. 1963 (J. Wilcox); ♂, 2 mi. E. Convict Lake, Mono Co., California, 13 Aug. 1959 (J. A. Chemsak) UCB; ♂ ♀, 5 mi. S. Olancha, Inyo Co., California, 9 Sept. 1956 (J. A. Chemsak) UCB; ♂, Freeman Gulch, Kern Co., California, 8 Sept. 1956 (P. D. Hurd) UCB; ♂, Bishop, Inyo Co., California, 4 Sept. 1956 (R. M. Bohart) UCD; ♀, Benton, Mono Co., California, 20 July 1950 (H. A. Hunt) UCD. Collected on mesquite 8 feet or higher in Arizona and in California on sage 3 or 4 feet high.

Some of the California specimens have 8-9 white dorsocentral bristles, 4-5 of which are anterior. Three posterior dorsocentral were the most found on Arizona specimens.

Heteropogon fisheri, new species

Male: Length 11 mm. Head black; face white pollinose with slight brownish tinge; frons brown, white laterally; occiput white, somewhat golden above. Lower fourth of mystax formed of black bristles, sparse fine white hairs above to antennae; frons white haired, black along eye margins; ocellar tubercle with 3 short white and one black bristles; occipital bristles black with numerous white hairs intermixed; beard, hairs on palpi and proboscis white. Face at antennae 37/44 width of one eye. Antennae black, golden pollinose, hairs below white, largely black above; one black bristle below on segment 2; segments measure 7-8-22-22; segment 3 tapering to apex.

Mesonotum black, brown pollinose, humeri and suture gray. Hairs dense white, semierect and as long as antennal segments 1-2; 7-8 black hairs in dorsocentral rows. Bristles black, 3-4 humeral, 2-3 post humeral, 4-6 presutural (one white), 4-5 supraalar, 4 postalar white (one black on one side). Pleura and coxae white pollinose with a golden cast, hairs white. Scutellum brown pollinose, hairs white, 8 black marginal bristles.

Abdomen dull black, sides of segment one and posterior corners of 2-4 yellowish gray pollinose. Hairs long white on sides of one, anterior corners of 2 and narrow lateral margins of all segments;

dorsum with short appressed black hairs; appressed yellowish on posterior corners of 2-4 and posterior margins of 5-7 and a very few on posterior margins of 2-4; 6-7 white lateral bristles on one. Venter grayish pollinose with dense long white hairs. Small genitalia black, proctiger brown, fringe on hypandrium golden, sparse hairs otherwise white.

Femora black, tibiae and tarsi reddish. Hairs largely white, short black dorsally on femora and in part dorsally on tarsi, middle femora and tibiae with brush of black hairs. Bristles largely black, a posterior row of white bristles on fore tibiae and metatarsi and middle tibiae with almost all white bristles. Claws and empodia black, pulvilli brown.

Halteres lemon yellow, lower stem brown. Wings hyaline, veins dark brown, anterior crossvein at 46/77 length of discal cell, anal cell narrowly open.

Female: Length 10 mm. Hairs of frons white, occipital bristles largely white. Five black marginal scutellar bristles. Posterior margins of abdominal segments 1-4 with short appressed golden hairs; anterior margins of 2-4 golden pollinose; segments 5-8 shining black with sparse short erect yellowish white hairs; apical spines black. Hairs of femora white except dorsally on fore ones; hind tibiae and metatarsi with anterior row of white bristles. Wings faintly brown at base of and above discal cell.

Holotype: Male, Beverly Glen Cyn., Santa Monica Mts., Los Angeles Co., California, 20 Sept. 1964 (Eric Fisher) LACM.

Allotype: Female, same data.

Paratypes: 13 ♂♂, 20 ♀♀, same data and 9 Sept. 1963; 10 ♂♂, 4 ♀♀, Sepulvidea Cyn., Santa Monica Mts., Los Angeles Co., California, 15 Aug. 1960, 1 Sept. 1962 (Eric Fisher); one ♂, Franklin Cyn., Santa Monica Mts., Los Angeles Co., California, 26 Sept. 1962 (Eric Fisher); one ♂, Saugus, Los Angeles Co., California, 1 Oct. 1960 (Eric Fisher) EF; 8 ♂♂, 4 ♀♀, Peralta, 4 mi. E. Olive, Orange Co., California, 19, 24 Sept. 1942 (Guy F. Toland, J. Wilcox).

Heteropogon martini, new species

Male: Length 14 mm. Head black; face and frons thinly and occiput densely, gray pollinose. Oral bristles black, white hairs above reaching antennae; face subequal in width to one eye. Hairs on frons white; 4 white bristles on ocellar tubercle; occipital bristles black, hairs white; hairs on palpi black. Antennae black; segments 1-2 with white hairs below, black above, 2 with a bristle below, white on one and black on other; 3 tapers from base to apex; segments measure 9-10-28-20.

Mesonotum black, thinly gray pollinose, the central stripe and intermediate spots brown. Hairs white, confined to anterior and lateral margins. Two black humeral bristles, 6 presutural (2 white, 4 black), 4-6 supraalar black (one white), 5 postalar white, one dorsocentral white. Pleura and coxae thinly gray pollinose, hairs white. Scutellum thinly gray pollinose, sparse white haired, 3 white marginal bristles.

Abdomen black; sides of segment one and a small spot on posterior corners of 2-4, gray pollinose. Hairs on sides and venter long white, dorsal hairs short appressed golden. Seven white lateral bristles on segment one. Genitalia black, sparse white haired, hypandrium golden haired.

Femora black, tibiae red, tarsi brown. Bristles black, a posterior row on fore tibiae and mostly on middle and hind tibiae, white. Hairs largely white, short appressed dorsally on fore tarsi; middle femora and tibiae with brush of black hairs. Claws black, empodia and pulvilli brown.

Halteres yellow, stem brown. Wings hyaline, veins brown, anterior crossvein at about ⅔ length of discal cell.

Female: Length 14 mm. Antennal and occipital bristles white. Four black scutellar bristles. Abdominal segments 5-8 shining black, sparse hairs white; apical spines brown. Wings hyaline, most of the veins margined with brown.

Holotype: Male, Montgomery Pass, Nevada, 6 July 1958 (Guy F. Toland).

Allotype: Female, same data.

Paratypes: 17 ♂♂, 22 ♀♀, same data (Dorothy and C. H. Martin, Guy F. Toland, J. Wilcox); 6 ♂♂, 7 ♀♀, 13 mi. N. Topaz Lake, Nevada, 1 July 1963 (J. Wilcox); one ♀, Topaz Lake, Mono Co., California, 17 July 1951 (A. T. McClay) UCD, 4 ♂♂, 7 ♀♀, same locality, 26 June 1957 (J. W. MacSwain, A. E. Pritchard) UCB. Collected mostly on sage three to six feet high. Several were collected on pine foliage where they had apparently gone to consume their prey.

Specimens not in paratype series, 3 ♂♂, ♀, Virginia Vly., 30 mi. of Follyfarm, Oregon, 3 July 1927 (H. A. Scullen).

Heteropogon tolandi, new species

Male: Length 10 mm. Head black; gray pollinose, the vertex brown. Oral bristles black, long sparse hairs above white; frons white haired; ocellar tubercle with 4 white bristles; occipital bristles and hairs white; hairs on palpi and proboscis black. Face 7/9 width of one eye. Antennae black, segments 1-2 white haired below, black above; 2 with a black bristle below; 3 tapering from base to apex; segments measure 7-8-21-20.

Mesonotum black, subshining brown pollinose, laterally and anteriorly thinly gray pollinose. Hairs white, confined to lateral and anterior areas. Bristles: 2-3 humeral, 4 supraalar and 3 dorsocentral black; 4 presutural and 3 postalar white. Pleura and coxae yellowish gray pollinose, hairs white. Scutellum brown pollinose, posterior margin centrally subshining black; 4 black marginal bristles and a few white hairs, disc bare.

Abdomen black; hairs white and long laterally on tergites 1-3 and on venter, short appressed black dorsally, sides of segments 2-5 and dorsum 6-8 appressed golden. About 7 white lateral bristles on one. Genitalia black and brown, hypandrium with a golden fringe.

Femora black, tibiae and tarsi reddish. Bristles black, a posterior row on fore and middle tibiae white. Hairs white; brush of black hairs on middle femora and tibiae. Claws and empodia black, pulvilli brown.

Halteres yellow, base brown. Wings hyaline with an anterior brown cloud above the basal half of the discal cell; veins brown, anterior crossvein at 5/9 length of discal; anal cell closed at margin.

Female: Length 12 mm. Abdominal segments 5-8 more shining than basal segments with fine sparse erect yellowish hairs; apical spines brown. Brown of the wings more extensive, bordering the veins around the discal and posterior cells 4-5; anal cell open.

Holotype: Male, Pinyon Flat, Riverside Co., California, 17 Sept. 1948 (J. Wilcox).

Allotype: Female, same data.

Paratypes: 10 ♂♂, 9 ♀♀, same data (Guy F. Toland, J. Wilcox).

Heteropogon stonei, new species

Male: Length 8 mm. Head black, densely gray pollinose. Mystax with a row of oral bristles and two above, black; oral hairs brownish those above white; hairs on frons white; 4 white bristles on ocellar tubercle; occipital bristles white centrally, black laterally; occipital hairs white, of palpi black. Face ¾ width of one eye. Antennae black, brownish pollinose, first two segments black haired, second with a black bristle below, third slightly tapering apically, segments measure 6-8-22-11.

Mesonotum black; transverse suture, dorsocentral lines, all margins and central part anteriorly, gray pollinose; central stripe posteriorly and intermediate spots subshining, brownish pollinose. Hairs white, sparse, confined to anterior and lateral margins, and to dorsocentral and central stripes. Humeral bristles black, 2-3; remainder yellowish white, 5 presutural, 3-4 supraalar, 4-5 postalar, 4-5 posterior dorsocentral becoming weaker anteriorly. Pleura and coxae gray pollinose, hairs white. Apical 2/5 of scutellum polished black, base and narrow posterior margin, gray pollinose, 6 yellowish white marginal bristles.

Abdomen black, posterior margin of segments 5-6 and 7-8 wholly, reddish brown; posterior corners of 2-4 with small gray pollinose spots. Hairs white, long and dense laterally on 1-4, short sparse recumbent dorsally, long sparse ventrally. Bristles white, 3-5 laterally on one and some shorter ones anteriorly. Venter gray pollinose. Genitalia black, reddish brown at tip, sparse hairs yellowish, hypandrium with black fringe.

Femora black, reddish brown at tip, tibiae and tarsi reddish brown becoming darker apically. Hairs largely white, bristles largely black; fore tibiae with anterior, middle tibiae with anterior and posterior, and hind tibiae with anterior and dorsal rows of white bristles. Claws and empodia black, pulvilli brownish black.

Halteres light yellow, base brown. Wings brown, lighter in basal 2/5, veins brown, anterior crossvein at ⅔ length of discal cell.

Female: Length 9 mm. Dorsocentral and central hairs black; 2-3 dorsocentral bristles black, one on each side white. Four scutellar bristles. Posterior margin of abdominal segment 4, apical half of 5, and 6-7 wholly, reddish brown; segment 8 and apical spines, black.

Holotype: Male, Hualapai Mts., Arizona, 6000′, 4 June 1962 (J. Wilcox).

Allotype: Female, same data.

Paratypes: one ♂, same data; 18 ♂♂, 17 ♀♀, Mingus Mt., Arizona, 17 June 1948, 3 July 1949 (M. W. Stone, J. Wilcox, Jr., J. Wilcox); one ♀, Grand Canyon, Arizona, 4 June 1963 (J. Wilcox); one ♂, Grants Co., New Mexico, 11 June 1937 (R. T. Kellogg); one ♀, Silver City, New Mexico, 30 June 1933 (R. T. Kellogg); one ♀, Beaver Cyn., Utah, 11 June 1946 (R. M. Bohart) UCD.

This species belongs in a group of rather small flies which are found in the southwest and are apparently related to *rejectus* Williston from Mexico, known only from a female specimen. The other Nearctic species found only in Arizona to date, are *duncani* Wilcox (April) and *paurosomus* Pritchard (August to October).

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REPRODUCTIVE BIOLOGY IN THE CHITON *MOPALIA MUSCOSA*

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In recent years there has been considerable interest and work on the reproductive biology of Pacific Coast invertebrates. Studies include work on a wide variety of molluscs, echinoderms, and arthropods (notably the decapoda). Detailed accounts for these groups can be obtained from the recent review by Giese (1959).

Time of spawning is an important aspect of these studies. It is difficult to pin-point the factor or factors which incite spawning in a natural population. In many cases there is uncertainty as to whether spawning is exogenously or endogenously controlled.

It is the objective of this paper to present data concerning reproductive activity of three populations of the chiton *Mopalia muscosa* inhabiting Santa Monica Bay. It will be shown here that without knowledge of unusual conditions at a particular site, conclusions regarding spawning time in this chiton could have been erroneous.

Three separate populations of *M. muscosa* were selected from Flat Rock Point, Latigo Point, and Sunset Point, all of which are in Santa Monica Bay, California.

Fifteen mature specimens collected randomly from each site per month, for one year, were taken to the laboratory. The animals were measured for wet weight, length, and width; and sex was determined (Tables 1 and 2).

The gonad was removed and its volume determined by placing it in a graduated cylinder filled with a known volume of water. The ratio of gonad volume to wet weight times 100 yielded the gonad index (Lasker and Giese, 1954).

The gonad index plotted against months of the year reveals changes in the mass of gonadal tissue; when the gonad is small, the ratio is low, and when the gonad is large, the ratio is high. Hence one may infer that changes in the gonad ratio reflect reproductive activity.

The three populations are separated by relatively long stretches of sand. Wherever small rock outcrops occur, this chiton may usually be found. Although sandy stretches may constitute a geographic

TABLE 1.

Summary of measurements made for each of three California populations of the chiton *Mopalia muscosa.*

	Mean	*Minimum*	*Maximum*
FLAT ROCK POINT			
weight (gm.)	12.85	5.48	25.00
length (mm.)	5.09	3.00	7.80
width (mm.)	3.32	2.50	4.60
LATIGO POINT			
weight	14.00	4.53	39.92
length	5.35	3.00	7.80
width	3.58	1.80	4.80
SUNSET POINT			
weight	13.46	4.32	28.69
length	5.12	3.70	6.80
width	3.46	2.50	4.90

TABLE 2.

Number of males and females at each of three California study sites for the chiton *Mopalia muscosa.*

	Males	*Females*
FLAT ROCK POINT	100	80
LATIGO POINT	94	86
SUNSET POINT	89	91

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barrier preventing the three populations from interbreeding, the fact that this species discharges gametes into the sea, and fertilization is external, makes interbreeding possible.

Temperature variations among the three sites were not more than 1.3°C during the period that determinations were made. Wave action was more or less constant at the three sites. It is likely that only minor variations existed in the amount and nutritive value of the food supply among the sites.

Reproductive cycles of the three populations are shown in Figure 1. Histological observations made on small preserved sections of gonads, which indicated the degree of gonadal maturity, paralled closely the changes in the gonad index for all three populations. Data indicate the existence of two distinct cycles for each population, although the cycles from Sunset Point are somewhat obscured.

The Flat Rock population showed a rapid increase in the gonad index from August to November, followed by a slight drop in mid-December. An increase was noted in January, however a great decline was apparent in February to March. Again, there was a sharp rise in April, almost as great as in October and January. For May, June, and July, the gonad index was at a low level.

The Latigo Point population showed a decrease in gonad index from August to September, followed by a sharp rise to peak activity in December. There was a steady decrease from December to March. As was shown for the Flat Rock population, between March and May, a sharp peak occurred, followed by a drop and leveling off.

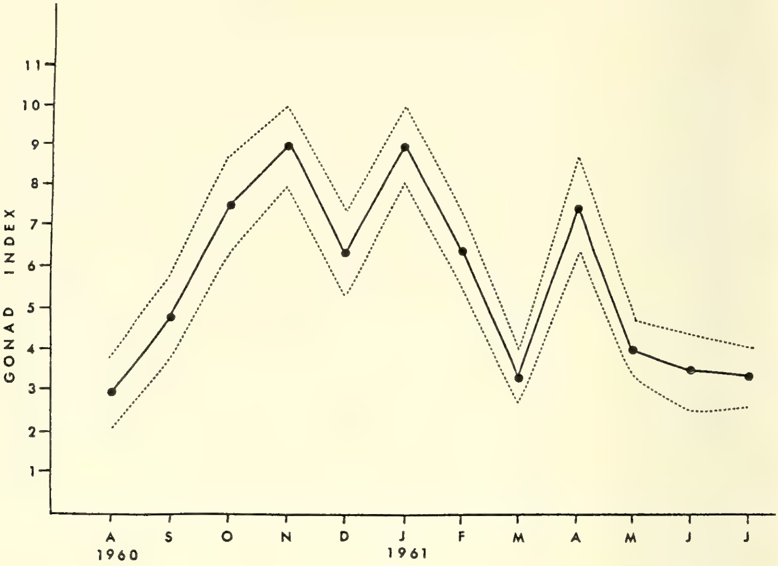
To summarize, the differences between the Flat Rock and Latigo Point populations are: (1) the gonad index of the former started from a low point and the latter from a high point, (2) in December the Flat Rock population showed a drop, whereas the Latigo Point population was at its peak. Nevertheless, when the two curves are superimposed, similarities become obvious.

The Sunset Point population appeared to start off the same as did the Latigo Point population. This is not surprising since these two localities are in close proximity. Local hydrographic conditions between these two localities are more similar to each other than to the Flat Rock population, which is about 20 miles south of the other two sites (Flat Rock forms the Southern boundary of Santa Monica Bay).

Surprisingly, a precipitous drop in the gonad index occurred from November to December at Sunset Point, yet the other two populations maintained a consistently high gonad index. From January through April there was a gradual rise, followed by a gradual decline. Between January and July, April was the highest point, as in the other two populations.

Temperature has long been considered to be singularly the most important environmental factor inciting spawning (Giese 1959). Examination of temperature data indicated that from the high gonad index period (maximum sexual maturity) to the low gonad index period (the spent organism), a temperature difference of only 2°C occurred in Santa Monica Bay. It does not seem likely that this small temperature difference alone could bring about the spawnout as seen in Figure 1. Furthermore, the gonad index of the Sunset Point population dropped three months earlier than did that of the Latigo Point and Flat Rock populations, which suggests that temperature alone did not bring about the changes noted above.

In a study of this kind it is desirable, if not imperative, to observe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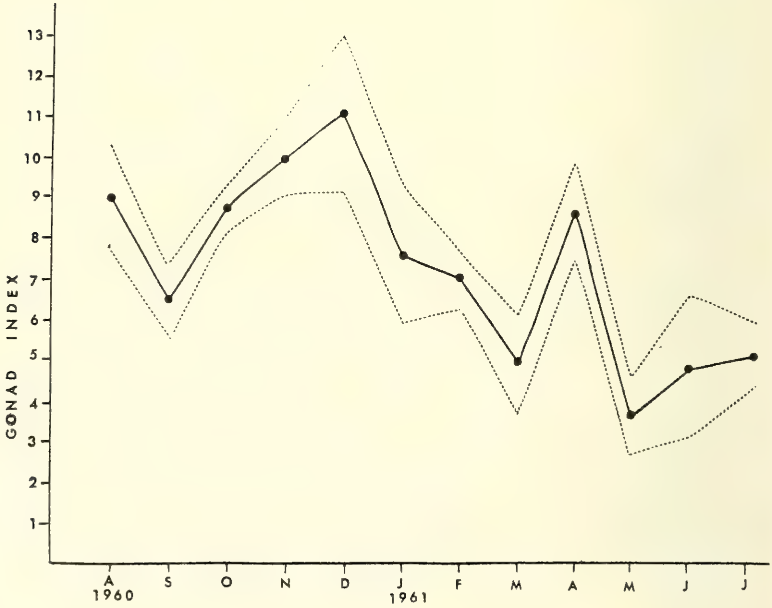
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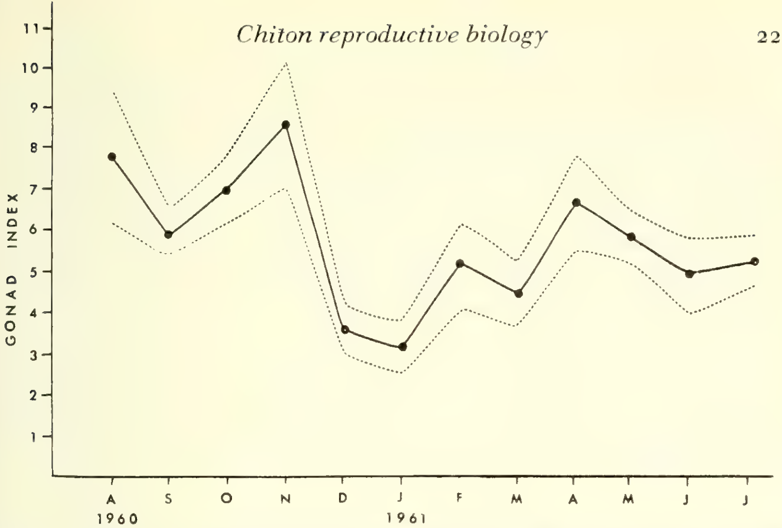

Figure 1. Annual reproductive cycles of *Mopalia muscosa* from three localities in Santa Monica Bay, California, 1960 to 1961. The points are the mean values, the bands represent the 95% confidence limits. *(Opposite page, above)* from Flat Rock Point; *(Opposite page, below)* from Latigo Point; *(This page, above)* from Sunset Point.

collecting sites with view towards any new environmental change. At Sunset Point, the California Department of Parks dumped tons of sand and rock, as a deterrent to wave erosion. This was removed by wave action over a five week period. But this environmental stress apparently either induced the chitons to spawn earlier than the Latigo Point and Flat Rock populations, or else the animals could not feed properly and resorption of the gonads took place. Histologically, the evidence suggested that the Sunset Point chitons resorbed the gonadal tissues rather than spawning out.

It has been shown by Tucker and Giese (1962) for *Cryptochiton stelleri* and by Giese and Araki (1962) for *Katherina tunicata* and *Mopalia hindsii* that changes in lipid, protein, and glycogen content of the gonad and other tissues occur during the course of the reproductive cycle. Although no biochemical measurements were made during the course of this study, it would have been interesting to have done so. These data would have permitted broader but more critical interpretations leading to a better understanding of the reproductive biology of *M. muscosa.*

Nevertheless, the precipitous drop seen in the Sunset population, between November and December, was unquestionably earlier than the other two populations. The dumping of sand and rock was probably a sufficient physical stress to bring about this condition.

Limited as this study was, it underscores the importance of such parameters as local hydrographic conditions. Such data, taken collectively with histological sections, biochemical measurements, and controlled laboratory experiments, provide a good background for a more precise understanding, both descriptively and experimentally, of reproductive biology.

Additional remarks on reproductive behavior in California chitons were provided by Thorpe (1962).

ACKNOWLEDGMENT

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A DEEPLY-BURIED HUMAN SKULL AND RECENT STRATIGRAPHY AT THE PRESENT MOUTH OF THE SAN GABRIEL RIVER, SEAL BEACH, CALIFORNIA

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On 21 December 1960, a human calvarium was found during some construction activities north of Seal Beach, California. It was reported to have been embedded in a layer of old marine deposits which is now 16 feet, 3 inches below sea level, and 32 feet below present ground surface. No other skeletal remains or cultural materials have been found in association with the calvarium.

The site (Archaeological Survey No. LAn-272) is in SW¼ of Sec. 11, T. 5 S., R. 12 W., Los Angeles County. The site is about 100 feet west of the Pacific Coast Highway, between the south bank of the present channel of the San Gabriel River and the northern boundary of Orange County. The present coastline is about half a mile to the southwest.

The skull rested on a layer of clayed silt in the bottom portion of an 18-inch layer of shells, which in turn is overlain by one of several thin layers of peat. The strata overlying the skull on the east face of the pit were only 4 feet thick because the rest had been removed during the construction activity; however, the strata still remaining were unbroken and were continuous with an undisturbed vertical section about 4 feet north of the skull. The complete stratigraphic sequence is displayed in Figure 1.

The strata indicate that conditions of deposition were similar to those existing today behind the sand bar at Sunset Beach, a few miles south of Seal Beach. The fauna and flora are largely an estuarine assemblage. The whole of the exposed layers below recent fill show that after deposition of the skull, there was eustatic rise in sea level, coastal subsidence, or both, of at least 26 feet, accompanied by deposition; the character of the accumulating strata varied from

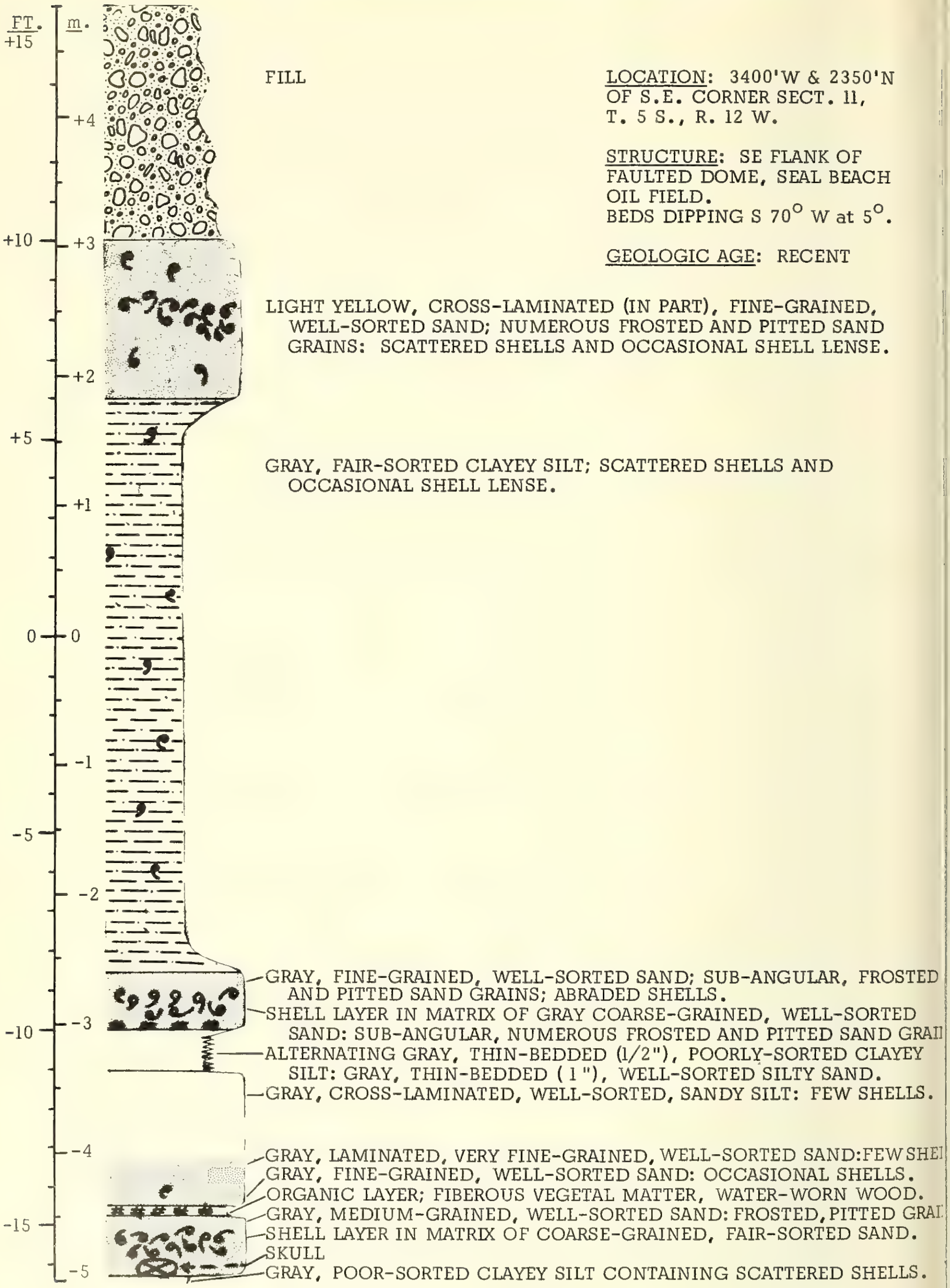

Figure 1. Stratigraphic section of site LAn-272. Scale at left is in feet and meters; 0 = present sea-level. (Conrey)

estuarine-lagunal muds to sands as the result of a shifting sand-bar. Deposition was interrupted at least twice by erosion which is identified by disconformities in sand layers and by extensive lenses of vegetal matter. Finally, the site was elevated at least 10 feet. A 5° tilt in the beds suggests that the last vertical shift of the site represents crustal movement rather than a eustatic fall in sea level.

It was not the depth of the skull, of course, but rather the evidence of considerable crustal movement subsequent to the skull's deposition that made this find of more than usual interest. While we expected the skull to date within the last 10,000 years or so of man's known occupancy of the Southern California coast, it was felt that the age might be at least two thousand years rather than more recent.

While the find was thought to be of little direct significance for archaeology, analysis of the skull by a physical anthropologist was considered worthwhile because it was well preserved and published details on the Indian population dating before 1000 A.D. are relatively rare for Southern California. In addition, the skull, or rather the stratigraphic sequence above it in this unusually good exposure, was significant in problems of local coastal geology.

It was clear, therefore, that the find merited the application of Carbon-14 dating, which of course was necessary before its full significance could be assessed. Through the courtesy of Dr. Carl L. Hubbs of Scripps Institution of Oceanography, La Jolla, chione shell excavated near the skull was submitted to Dr. Willard F. Libby of the Institute of Geophysics and Planetary Physics, University of California, Los Angeles. The result was a Carbon-14 date of 980 ± 80 B.P. (UCLA-119; see Ferguson and Libby, 1962:13).

The dating of the stratum in which the skull was embedded at about 1000 A.D. proved to be something of a surprise, though certainly not unacceptable, and as a consequence, the significance of the skull and the stratigraphy has shifted for the three disciplines, assuming the date is correct.

Archaeologists will note the unusual rapidity of deposition and of the extensive vertical movement of the local crustal area in the past thousand years. This crustal instability emphasizes the need for caution in any problems that involve analysis of terrace remnants, sea margin sites, or of deposition and erosion in this section of the coast.

For the physical anthropologist, the skull's recent date is consistent with its matching the general physical characteristics of the late Indian population; however, the unusual nasal and palatal breadths make the specimen important—especially for the comparison with the as yet undated La Brea skull, as discussed by Brooks, below.

CALVARIUM ANALYSIS

The calvarium described here (Figs. 2-5) is that of a female between 35 and 40 years of age at the time of death. The musculature and brow-ridge developments are slight, although the lateral por-

Figure 2. A deeply-buried human skull from Seal Beach, California. Frontal view.

tions of the nuchal lines of the occipital are somewhat more pronounced than in many female skulls of California Indian derivation (Gifford, 1926). The mastoids confirm the opinion that this is a female, since they are quite small. None of the cranial sutures had closed, except the basilar suture which usually is closed by 20 to 25 years of age. Since cranial suture closure is considered an unreliable age indicator, especially in females (Singer, 1953), tooth attrition was used as a factor in deciding the age at death.

The calvarium is complete except for some of the more delicate structures of the face and of the base of the skull which have been broken away. The right and left upper medial incisors and the right upper third molar were lost post-mortem. There is no artificial deformation nor any other culturally induced change of the natural features of this individual.

The cranial index of the skull is within the lower limits of dolichocrania, almost hyper-dolichocranic. The long headedness is related in part to a narrow breadth of the skull, as well as to the

Figure 3. A deeply-buried human skull from Seal Beach, California. Lateral view.

extension of the cranial length measurement by an occipital bun. The relationship of head length to head height, both basion-bregma height and auricular height, indicates a skull which is within the upper range of medium head height, orthocranic. The breadth-

Figure 1. A deeply-buried human skull from Seal Beach, California. Vertical view.

Figure 5. A deeply-buried human skull from Seal Beach, California. Basal view.

height index is acrocranic for both auricular and basion-bregma height, and appears to be a reflection of the slightly narrow cranial breadth, in relation to the length, rather than an unusually high skull. As there is no mandible, the facial measurements are based only on the upper facial measurements. The upper facial index is in the middle range of the mesen index, although the orbits are narrow for their height, being hypsiconchic. In profile, the face has little or no prognathism; the gnathic index confirms this, as it is within the lower limits of mesognathy.

The most noticeable feature of the facial area is the nasal and palatal region. Neither the nasal height nor breadth measurement are unusual themselves, but each in combination with the other is rare in California and the nasal index, which is within the hyperchamaerrhine range, is rare for the whole of North America. The external palatal index is also very broad, brachyuranic, and the breadth of the palate emphasizes the breadth of the face in the maxillary area. The medium index for the upper facial breadth is based on the upper facial height and the bizygomatic breadth and does not reflect the breadth of the nasal, maxillary, and palatal regions. Nasal breadth is apparent in the measurement for the upper nasalia, 18 mm., which is almost as broad as the interorbital breadth, 22 mm. There is no nasal depression and the nasal bones (those remaining) extend from the base of the nose with no convexity. The bridge of the nose is broad and low and in life would not have shown much nasal relief.

In observing the general appearance of the calvarium, the contrasting features are the very slight development of the frontal region and the strongly muscled occipital region. The frontal region has no brow ridge projection and only a very slight bulge at glabella. The occipital region, on the contrary, shows a crest which is strong for a female, running just below the occipital bun, and the entire area of nuchal muscle attachment is roughened and irregular. The mastoids are small and feminine, although the supramastoid crest, as well as the lateral occipital crests, are larger than is common among California Indian women. At the juncture of the sagittal and lambdoid sutures is a large wurmian bone, and there are two more medium-sized and one small wurmian bone in the lambdoid suture.

One of the left nasal conchae is swollen and enlarged both anterior-posteriorly and laterally to at least 10 mm. thickness, almost filling the nasal cavity. The external appearance of this swelling is porous and resembles an exostosis.

TABLE 1.

Tooth wear patterns in a deeply-buried human skull from Seal Beach, California.

Right and left incisor 1	Missing
Right and left incisor 2	Medium shovel-shape, heavy wear, dentine exposed
Right and left canine	Excessive wear, dentine completely exposed
Right and left premolar 1 and 2	Enamel of the cusps is worn through to the dentine, but enamel is still present in the valleys
Right and left molar 1	Lingual wear heavy, with exposed dentine; enamel is present on the occlusal surface of the posterior buccal region
Right and left molar 2	Lingual wear heavy with exposed dentine; enamel of the buccal half of the tooth is still present
Right molar 3	Missing
Left molar 3	Two caries in the center of the occlusal surface; enamel worn, but no dentine exposed.

There are no dental abcesses and few dental caries. The major tooth problem was extensive wear (Table 1). The wear pattern follows that considered usual for California Indians (Leith, 1928). All teeth except the upper third left molar are worn down through the enamel to the dentine. This is generally attributed to abrasive content in food due to the grinding of the food in stone mortars or metates, the leaching of acorns in sand, and the cooking of food by stone boiling. The lateral incisors (the medial ones were lost postmortem) were shovel-shaped on the lingual surface, although the wear pattern has almost eliminated this trait.

The unique breadth of the nasal and palatal regions has created some problems in seeking comparative material. Birdsell (1951) has compared Santa Catalina Island archaeological crania, measured by Carr, with Murrayians from Australia. The indices for the crania from Santa Catalina Island approximate those of the calvarium being considered. Among the Santa Catalina cranial characteristics are a "nose concave in profile and of unusual breadth" (Birdsell, 1951:36). These also exhibit a "nasion depression deeper . . . than is usual in American groups," as well as a lower vault. In these latter two respects the calvarium diverges from this description, although in photographs of the living individuals, especially the California Indians, the profiles appear to be orthognathous, which is similar to the profile of this calvarium. These comparisons are not intended to support the Amurian theory, but to compare the Seal Beach and Catalina Island crania.

Kennedy (1959) measured a series of both male and female crania from the collections at the University of California Museum of Anthropology, derived from archaeological collections of the Great Basin area of Nevada. The calvarium being described falls within the range of this series for all the female cranial measurements, except those of upper nasalia breadth, external palatal length and breadth, and for several of the indices. Kennedy does state that many of the female nasal indices are in the platyrrhinic classification and that the nasion depression is of medium size and the root and bridge height are also medium, which to some extent agrees with the description of this calvarium.

Some years ago Brooks made a survey of nasal measurements and indices of archaeological crania and living individuals north of Mexico and west of the 100th meridian. Although in this survey many of the groups might have one or other of the nasal measurements, a nasal index of 58.8 does not occur as a mean in any of the series. Several groups approach this index, such as the Paiute female crania nasal mean of 56.5, the Apache female crania nasal mean of 54.5, and the Maidu female crania nasal mean of 54.7. It is interesting that in this series of over 90 tribes and 30 archaeological horizons within these geographical limits, only the Paiute approach closely in their mean the nasal index of the Seal Beach skull.

There are two archaeologically-recovered series of skeletons from Zuma Creek in Los Angeles County and San Nicolas Island (Littlewood, 1960; Rootenberg, 1960). In general there are some resemblances with one or another of their measurements, but there is no basic similarity. The nasal index and upper nasalia breadth is comparable to one of the Zuma Creek females, but the remainder of the measurements of this skull are different. For the San Nicolas Island material, also, some of the measurements show an occasional similarity, although there is no overall conformity. If the series were larger it is possible the calvarium discussed here might fall within the female ranges.

At the Los Angeles County Museum, the cranium found in the La Brea tar pits (Pit 10) was made available for comparison and measurement (the skull has also been measured by A. L. Kroeber, 1962). This cranium is of dubious antiquity because of its position in the tar pit collections. The cranium is that of a woman, also within the same age range as the Seal Beach calvarium, about 35 years of age. The majority of cranial and facial measurements could be taken even though the left section of the frontal bone and the nasal-malar region had been reconstructed (workmanship was so excellent that it was only possible to determine the extent of the repair by very careful examination). The skull is much smaller and more delicate in appearance than the Seal Beach calvarium, the evidence of muscular attachments being non-existant; despite this, there are similarities. Both skulls are precisely the same width; although the Seal Beach calvarium is more dolichocephalic, both skulls show moderate occipital buns. The La Brea skull's nasal opening is broad, but not quite as broad as that of the Seal Beach skull. Also the fragment of the nasal portion of the La Brea skull had no nasion depression apparent at the root of the nose and was similar in this feature to the Seal Beach skull.

The palatal sections of these two skulls differed widely. The La Brea palate is small and the tooth area is crowded, with the lower first left molar placed sideways in the socket so that the wear facets are on the posterior surface of the tooth. In contrast, the Seal Beach skull has a wide, large, high, and uncrowded palate.

The La Brea cranium has several small wurmian bones in the line of the lambdoid suture, similar to the Seal Beach calvarium.

Summary

The descriptions of the Paiute, Nevadan, Santa Catalinan, and Southern California skeletal remains from archaeological sites correlate with many of the measurements and morphological observations of the Seal Beach calvarium, despite the hyper-chaemerrine nasal index and the broad palate. This broad nasal and palatal region is not far outside the normal range of some of the female crania from these series. In the survey of nasal measurements also, the means approximating most closely that of this calvarium are those of the Paiute females. Further, the teeth wear patterns are consisent with Leith's conclusions regarding attrition based on the California Indian type of food preparation.

The most interesting correlation is that with the La Brea skull, also a female, and still of undetermined antiquity. Despite the more rugged cast of the Seal Beach calvarium, many of the metric and morphological observations made from both skulls are similar. The La Brea cranium, although small and delicate, also is in agreement with descriptions of female cranial series from Southern California.

The Seal Beach female calvarium, though displaying certain extreme features, can be placed within the range of variability displayed by the skeletal populations recovered archaeologically from sites in Southern California and Nevada.

Acknowledgements

The authors wish to thank the following people for their aid in this project: Mr. Dan Burris (who found and reported the skull); the R. A. Wattson Co. (which facilitated access for field studies); Detective Al Chafe of the Seal Beach Police Department, who examined the skull and notified the Anthropology Department at California State College, Long Beach; Dr. Ethel E. Ewing, Dr. W. J. Wallace, Mr. Charles Case, and other members of the Archaeological Research Associates who made preliminary examinations of the site; Prof. Albert L. Ehrreich of the Geology Department, CSCLB (who aided in preliminary stratigraphic analysis); Dr. Carl L. Hubbs, Scripps Institution of Oceanography, and Dr. Willard F. Libby, Institute of Geophysics and Planetary Physics, UCLA, for their kind cooperation in analyzing shell and obtaining the Carbon-14 date; Mr. Armando Solis of the Los Angeles County Museum of Natural History who photographed the skull; and Dr. Theodore Downs and Mr. Leonard Bessom of the Los Angeles County Museum of Natural History who made the La Brea skull available for study.

Brooks wrote the calvarium analysis. The first section of the paper was written by Conrey, who made the stratigraphic analysis, and by Dixon. We wish to express our appreciation for the comments of colleagues who read earlier drafts.

A preliminary version was given at the Annual Meeting of the Southern California Academy of Sciences, May 19, 1961.

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AN ANOMALOUS COLOR PATTERN ON A PACIFIC STRIPED DOLPHIN

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The Pacific striped dolphin, *Lagenorhynchus obliquidens* Gill, is one of the most common dolphins found in Californian waters (Brown and Norris, 1956:311; Brownell, 1964; Houck, *in litt.*, 1965). The color pattern of this dolphin has been described and illustrated most notably by Scheffer (1950). Numerous other authors have published notes on this species, but only Brown and Norris (1956:313) have reported a sighting with an anomalous color pattern. They described an animal that was unpigmented except for a mottled gray area running dorsally from the snout onto the tail stock.

On 4 July 1963, just outside the Farallon Islands, off San Francisco Bay, California (37° 41′ N, 123° 45′ W), I was an observer aboard the whale catcher "Sioux City." On this day we were pursuing a Sei whale, *Balaenoptera borealis* Lesson. This whale was accompanied by approximately fifteen Pacific striped dolphins and three Dall porpoises, *Phocoenoides dalli* (True). Figure 1 shows two of the striped dolphins, both of adult size. The dolphin on the left, com-

Figure 1. Wild Pacific striped dolphins showing normal (left) and anomalous (right) color patterns.

pletely out of water, shows the normal color pattern for this species. The dolphin on the right, only partly out of water, shows an anomalous pattern; namely, a large lateral thoracic black area and, between this and the dorsal black, a white line that is very distinct and higher on the body than normal. The strong anterior white extension over the eye should also be noted as being unusual.

Pigment anomalies of this extent are rare in cetaceans, and to my knowledge this is the first anomalously-colored dolphin of its species to be illustrated.

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THE DISTRIBUTION OF PELAGIC TUNICATES, FAMILY SALPIDAE IN ANTARCTIC AND SUBANTARCTIC WATERS

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INTRODUCTION

Since 1962 the United States Antarctic Research Program of the National Science Foundation has maintained a research vessel, the USNS *Eltanin*, in Antarctic and Subantarctic waters to collect oceanographic, hydrographic, meterological and biological data. The Department of Biological Sciences and Allan Hancock Foundation of the University of Southern California has had prime responsibility for the biological sampling program aboard.

The *Eltanin* collections contain extensive material of pelagic tunicates, family Salpidae. The present report is based on materials of this group from *Eltanin* cruises 4 to 15, from waters off southern South America and in the Pacific Antarctic.

During these cruises, from July 5, 1962, through November 31, 1964, the ship worked an area from approximately 32° south to 67° south. The Atlantic sector of the Southern Ocean was worked from the Drake Passage east to 22° west longitude and from the Drake Passage west to about 178° east longitude. By far the greatest amount of work was concentrated in the Drake Passage or closely adjacent areas. An indication of the areas sampled may be obtained from the distribution chart (Fig. 1).

As Cruises 1 through 3 were made in areas other than Antarctic and Subantarctic waters, none of the Salpidae taken on these cruises are considered unless they relate directly to those found in the southern cold waters.

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[1] Also Research Associate, Los Angeles County Museum of Natural History.

MATERIALS AND METHODS

Salps were collected primarily by the Isaacs-Kidd midwater trawl (Isaacs and Kidd, 1953), which was usually towed at fishing depth for two hours. In addition, specimens were taken by ½-meter plankton net, Clarke-Bumpus net, Indian Ocean Standard net (Currie, 1963), five-foot Blake trawl, ten-foot beam trawl, forty-foot otter trawl, Menzies trawl (Menzies, 1962:84, Fig. 1; Menzies, 1964:97, Fig. 9), and dip net. Opening and closing nets are only now being used aboard the *Eltanin* and depth data should be examined with this in mind. The greatest depth that the net reached while fishing is here recorded as the depth of capture and over a two or three hour fishing period actual depth may vary as much as 100 meters.

In order to arrive at water temperature at point of capture, it was assumed that the specimen was captured at the fishing depth of the tow. Temperatures are interpolated from between the two nearest hydrographic stations, from temperature readings at the depths most closely approximating the depths of the tow. If hydrographic stations were not made within one or two degrees of our collection, or if temperature data was not available within approximately 200 meters, no temperature data are included.

Hydrographic data were taken on Cruise 3 by the A & M College of Texas (Hood, *et al.*, 1963). Lamont Geological Observatory (LGO) has handled hydrographic work on Cruises 4 to 15 (Friedman, 1964, and unpublished data furnished by E. M. Williams of LGO).

Measurements were made with calipers calibrated to the nearest 1/10 millimeter and rounded off to the nearest millimeter. Except for measurements of *Iasis zonaria* (Pallas), which has a strong rigid test, an error of two to three mm. can be expected in specimens measuring over approximately 20 mm. The flaccid nature of all but *Iasis* makes more accurate measurements impossible. Measurements are expressed in terms of body length, the distance between the mouth and the atrial opening (Foxton, 1961:5). Identifications were made following Yount (1954), except for specimens in the *S. fusiformis* group that are now separated into four species (Foxton, 1961). The two southerly species of this group, *Salpa thompsoni* and *Salpa gerlachei*, are distinguished chiefly on muscle fiber counts.

Salps pass through two different phases in their life cycle, with the solitary form producing chains or stolons with chains of fifty to several hundred aggregates. The aggregate stage in turn produces one or more of the solitary forms (Berrill, 1961:153). As the phases may

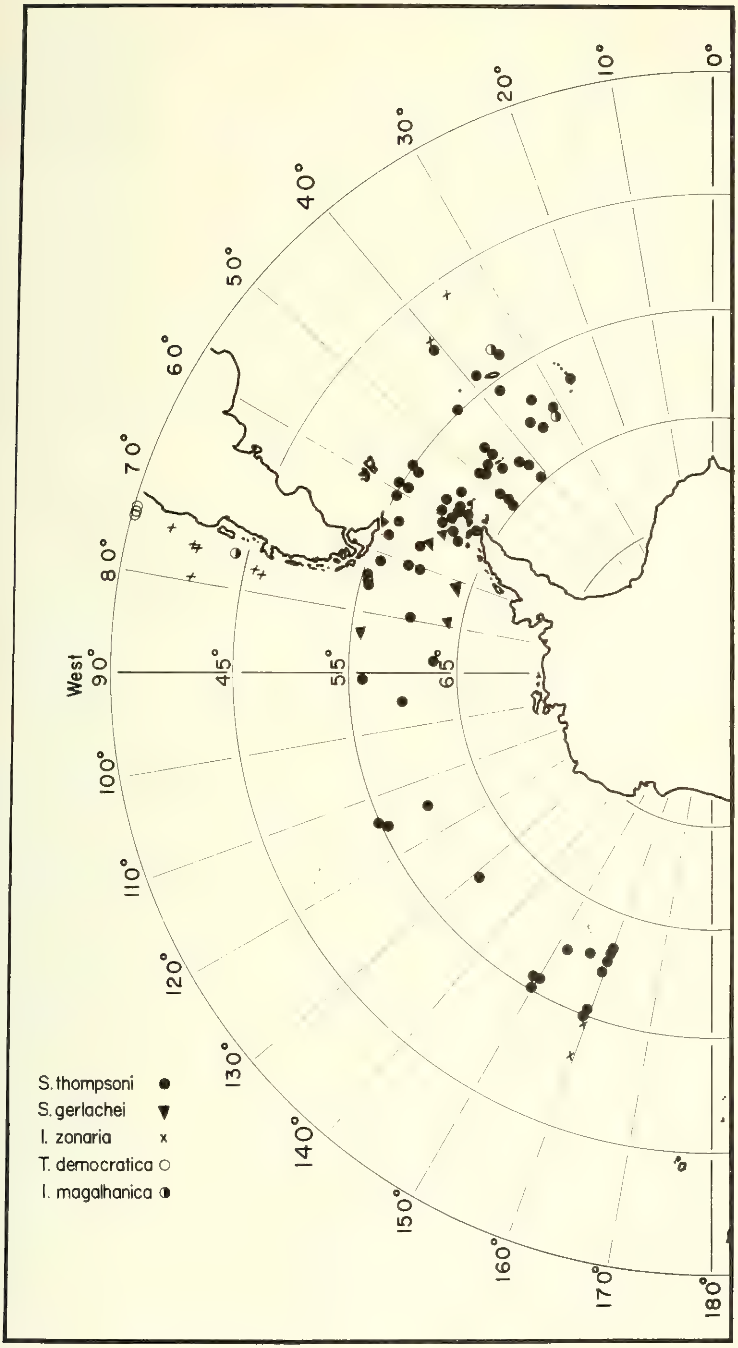

Figure 1. Distribution of five species of Salpidae collected by the USNS *Eltanin* in Antarctic and Subantarctic waters.

have different ecological requirements they are considered separately.

Species and number of times collected are: *Salpa thompsoni* (87), *Iasis zonaria* (13), *Thalia democratica* (9), *Salpa gerlachei* (7), and *Ihlea magalhanica* (3).

ANNOTATED LIST OF SPECIES

Salpa thompsoni Foxton

All of the 87 stations where this species was collected (Fig. 1), fall within the geographic range indicated by Foxton (1961, text-fig. 10). *Solitary form*: Found in 46 of the 87 collections, 17 times in combination with the aggregate of the same species. Their size ranged from 19 to 102 mm. Specimens were taken from July through February with a peak in August (Fig. 2).

Solitary forms were taken at depths varying from the surface to 3320 meters (Fig. 3). Temperatures at points of capture ranged from —1.6° to 3.8°C.

A list of intestinal contents, listed in order of times encountered, consisted of: unidentified material, diatoms, radiolarians, invertebrate eggs and gastropods. The body cavities contained copepods, invertebrate eggs, euphausids, ostracods and amphipods in the order listed.

A rudimentary stolon is present in even the smallest specimen, *i.e.*, 19 mm., and larger specimens carry progressively longer stolons.

The number of fibers in the fourth muscle (M. IV) was counted on 56 specimens, and a range of 63 to 105 was obtained with a mean of 80.5. These values are lower than those obtained by Foxton (1961: 15) who recorded a range of 70 to 130 and a mean of 93.2 in his specimens. Six of my specimens had a count of 70 (the area of overlap that Foxton encountered between *S. thompsoni* and *S. gerlachei*), or lower. They were identified as *S. thompsoni* on the basis of the typically greater width of the muscle and the higher counts of muscle fibers in other than M. IV.

Aggregate form: Found in 58 of 87 collections of *S. thompsoni*. They were taken in every month except June and July, with a peak from December through March. Size ranged from 9.0 to 57 mm. The depths of capture ranged from the surface to 3950 meters. Temperatures at points of capture ranged from —1.1° to 3.3° C.

Intestinal contents, listed in descending order of times encountered, were: unidentified material, diatoms, copepods and gastropods.

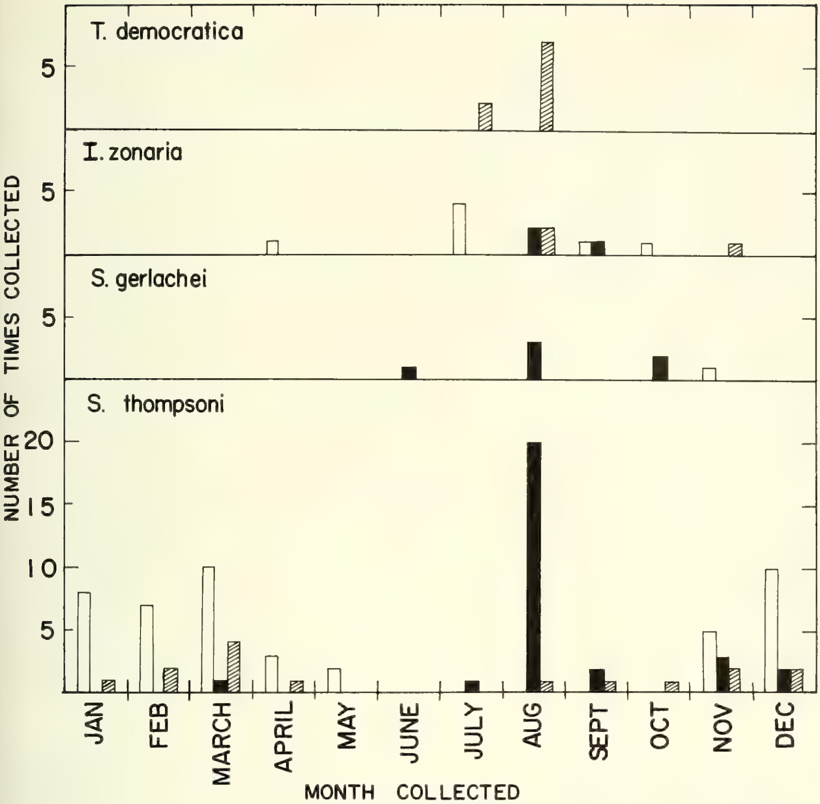

Figure 2. Number of times collected by month of four species of Salpidae. Solitary form, solid bars; aggregate form, open bars; both forms in same collection, diagonally crossed bars.

The body cavities contained copepods, amphipods, ostracods and fish scales. One of the amphipods found in the body cavity of a 38-mm. specimen measured 18 mm. and was the largest item encountered relative to body size.

No more than one embryo was found in any specimen and there was no correlation between the size of the specimen and that of the embryo. The largest embryo measured 2.8 mm. and was found in a small 17-mm. specimen. Conversely one of the largest specimens, 48 mm., contained a one-mm. embryo, and many of the intermediate and large aggregates were devoid of recognizable embryos. It seems probable that several solitary individuals develop and are released singly during the life of an aggregate form.

As in the solitary form, the aggregates of this species have lower muscle counts than those cited by Foxton for his specimens. Total fiber counts for muscles I to VI inclusive, ranged from 137 to 207 in 144 specimens, with a mean of 162.0. Foxton (1961) reports counts of 140 to 235 with a mean of 177.7 (p. 17). In my specimens, therefore, counts of 137 to 159 represent an area of overlap between *S. thompsoni* and *S. gerlachei*, and 56 of 144 counts or 39% fall into this overlap range.

The specimens are regarded as *S. thompsoni* because the muscles are relatively wide and the muscle fiber counts in the individual muscles run higher than in *S. gerlachei*.

In view of the considerable overlap in the main distinguishing character for these two closely related species, the question arises as to their validity. Foxton (1961:20f.) plotted fiber counts of M. IV in the solitary form in relation to degrees south at point of capture. He obtained a complete scatter throughout the range. Inasmuch as I found an even greater overlap in the aggregate form, a similar graph of total fiber counts for M. I to VI in relation to latitude of capture was plotted. No correlation in number of fibers to latitude is seen for the aggregate form. The subject of species validity is taken up in more detail in the Summary and Discussion section below.

Salpa gerlachei Foxton

Salpa gerlachei was collected only seven times. Its scarcity can be attributed to the fact that the *Eltanin* has made few collections within the expected geographical range of the species.

Solitary form: This form was taken in six of the seven collections of the species. Four of these collections are either from the Drake Passage or closely adjacent areas (Fig. 1), localities from which this species has not been reported previously.

A collection of ten solitary forms of the *S. fusiformis* group was taken from the Peru-Chile trench at a depth of 6010 meters. The specimens ranged from 16 to 21 mm. Muscle fiber counts of M. IV were possible on only three of the specimens and read 48, 34, and 50. The tests are serrate and the eighth and ninth muscles laterally joined. The specimens are identified as *S. gerlachei*, although they were taken at 8° 10.5′ S., 81° 08.1′W., far north of the expected geographic range of the species.

The size range of this form is 18 to 41 mm. It was collected at depths from 185 to 6010 meters (Fig. 3), and temperatures at points of capture varied from 0.6° to 1.9° C.

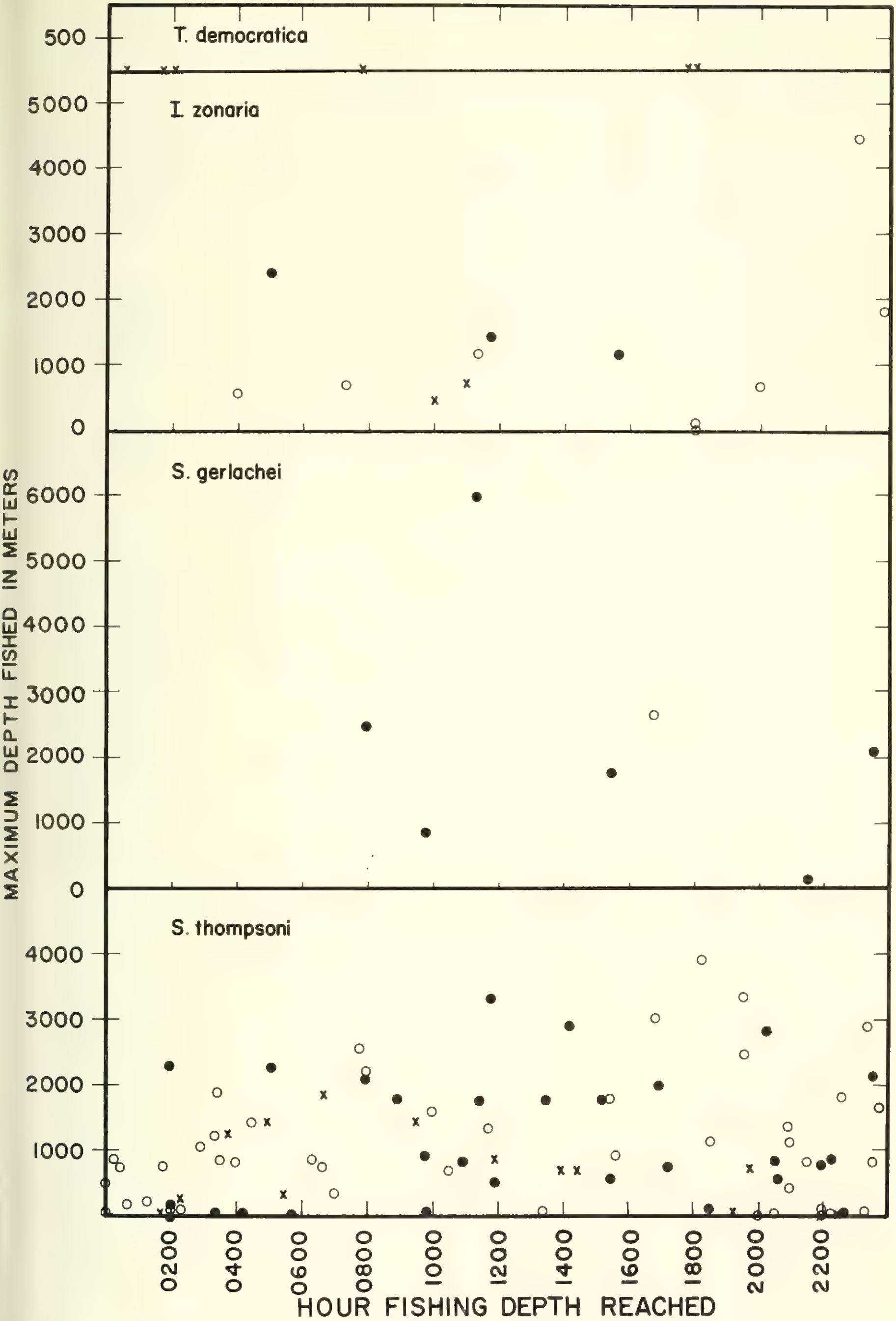

Figure 3. Depth of capture in relation to hour collected for four species of Salpidae. Solitary form, closed circle; aggregate form, open circle; both forms collected in same tow, large X.

Intestinal contents were examined on only two specimens and both were negative. Copepods were the only items found in the body cavities in three of the 23 specimens examined.

Stolons were present in all specimens, but rudimentary in the smaller ones.

Muscle fiber counts for this species, as opposed to those of *S. thompsoni*, agree very closely with those given by Foxton (1961:17). M. IV has a fiber count range of 34 to 58, with a mean of 47.4 for twenty specimens. Foxton recorded a mean of 48.8.

Aggregate: Only one specimen of this form was identified. It was taken at 2700 meters in November and measured 24 mm. Temperature at point of capture was 1.1° C. No embryo was observed and the body cavity is empty.

The total number of muscle fibers for the M. I to VI inclusive is 129, and corresponds to Foxton's mean of 128.8.

Iasis zonaria (Pallas)

Solitary form: Eight specimens were collected at six stations, with the sizes ranging from 43 to 100 mm. The species was collected only in the cold months (Fig. 2). The depths of collection varied from 240 to 1200 meters (Fig. 3), and temperatures at points of capture ranged from 2.0° to 4.9° C. No intestinal contents were examined. All specimens have well developed stolons.

Aggregate form: Seventy-five specimens were identified from ten collections. Sizes ranged from 10 to 43 mm. The species was taken at depths extending from the surface to 4590 meters. Although Thompson (1948:135) regarded this as a surface or near surface species in Australian waters, in our collections they were taken 44% of the time at depths exceeding 1000 meters (Fig. 3).

This form was collected once in April, and then from July to November (Fig. 3). Temperatures at points of capture varied from 0.5° to 10.2° C.

All of the specimens contained from three to five embryos; five was the number most frequently encountered. The largest embryo measured 22 mm. and was found in 52-mm. specimen. The embryo appears fully developed. Intestinal contents were not examined but body cavity contents listed in order of times encountered were copepods, invertebrate eggs, ostracods, radiolarians and fish scales.

Thalia democratica (Forskål)

Thalia democratica was taken in nine collections, most of them from north of the 35th parallel, and consequently is not shown on the distribution chart which extends only to 35°S. Examples not shown (Fig. 1) were taken between 32 and 35°S. off the coast of Chile. As both the solitary and aggregate forms were taken in each tow they are not considered separately.

The solitary form represented from three to twelve percent of the entire sample. The two extremes are from samples taken near the surface and simultaneously with one net slightly below the other. Precise depth data were not recorded as this collection was made during a preliminary shakedown cruise, but the tow with the larger percentage of solitary forms was at the shallower depth. This confirms somewhat other data indicating that the solitary form tends to mass closer to the surface than does the aggregate form (Russell and Colman, 1935:216).

The temperature range at points of capture varied only slightly, from 12.5° to 13°C. Although this represents approximately the minimum temperatures at which the species is able to exist, swarms were taken at this temperature, indicating a sharp demarkation point between success and failure for the species. Thompson (1948:143) and Bary (1960:117) recorded similar low extremes of temperature for the species, *i.e.*, 11.5° and 12.5°C.

This was the only species taken exclusively in the uppermost layers, since it ranged only to a depth of 32 meters. Sewell (1953:39) identified this species from depths up to 2000 meters in the Indian Ocean, but concluded from their condition that they were dead when captured.

Thalia democratica is a small species of salp. Solitary forms ranged from one to 10 mm., aggregates from one to eight mm. These examples are smaller than those collected in New Zealand waters where the solitary form reaches 27 mm. and the aggregate attains 16.5 mm. (Bary, 1960:109). They are also smaller than those found off the coast of South Africa (van Zyl, 1960:24). Bomford (1913:244), however, reported the smaller type in the Bay of Bengal and recognized that they were not as large as those taken in English waters. The size discrepancy may reflect locality differences, or it may be a reflection of time of year collected. Van Zyl (1960:24) found that specimens of both forms collected in winter, when our collections were made, were smaller than those collected in the same locality in summer.

The largest embryo found in an aggregate measured two mm. No intestinal contents were examined.

Ihlea magalhanica (Apstein)

Ihlea magalhanica was taken only three times. (Fig. 1).

Solitary form: Represented by two specimens taken in different tows. One is a 67-mm. specimen taken in November at a depth of 540 meters at a temperature of 1.8°C. Another measured 57 mm. and was taken at 490 meters and a temperature of 0.4°C. It was taken in April.

Aggregate form: Seven specimens were collected in one tow in much warmer waters than the two solitary specimens, 13.6°C. They range from 9 to 18 mm. in length, and were collected at the surface in November. The smallest specimen contains seven embryos.

Summary and Discussion

Taxonomic separation of S. thompsoni and S. gerlachei: The two closely related species, *S. thompsoni* and *S. gerlachei*, are a problem in attempted identification in a great many individuals. For positive identification the muscles must be in sufficiently good condition for fiber counts. Because of the fragility of the specimens in this group, this is frequently not the case. Although Foxton uses proportional measurements of body length and muscle width to distinguish between the two species, he noted that these measurements are of doubtful value in separating the aggregate forms. The aggregate forms were most difficult to identify in the *Eltanin* materials. For these reasons, 44 collections of the *S. fusiformis* group cannot be referred to either species.

In addition, in our collections are four samples containing the aggregate form on which counts are possible but which I cannot identify. They were all taken in or east of the Drake passage. The counts run consistently low for *S. thompsoni* but not low enough for *S. gerlachei*.

The difficulty in separating these two species does not make their recognition invalid. The difference in the fiber counts are most pronounced in specimens in the area of geographic overlap between the two forms. When solitary forms of the two species were taken in the same tow they were easily distinguishable in general appearance.

Geographic distribution: Foxton (1961: text-fig. 10), indicated a circumpolar distribution of *S. thompsoni* that extends north to approximately 40° S. or the subtropical convergence. In the east longitudes, the primary area worked by the *Eltanin* through Cruise 15, our data on geographic range agree closely with Foxton's.

Foxton (1961:29, text-fig. 10) indicated a limited range for *S. gerlachei* restricted to the Pacific sector roughly between 65°S. and the ice edge, and between 175°E. and 80°W. Our collections extend the known range eastward into the Drake Passage as far as 62°W., and indicate a possible population in the Peru-Chile trench at great depths.

I. zonaria is a widely distributed species found in the Atlantic from 40°S. to Iceland and the coast of Greenland (Thompson, 1948:134). In the Atlantic sector the *Eltanin* collected one solitary specimen at 48°13′ S. Herdman (1888:111) reported the species as far south as 52°45′ around the southern end of South America. The farthest south in the Pacific sector that the species was collected by the *Eltanin* is 54°56′ S. where nine specimens were taken in one trawl.

I. magalhanica was regarded by Thompson (1948:165) as a cold water form but Bary (1960:117) found a predominance of specimens in warmer waters and postulated a subtropical origin for the species. As the *Eltanin* collected this species only three times, it can only be noted that the species is rare in the areas that we have worked but that single specimens were collected twice in waters in which temperatures were 0.4° and 1.8° C. Apstein (1906a:188) also reported this species at sub-zero temperatures. The third *Eltanin* collection of seven aggregates was made at 13.6°C.

T. democratica is typically a tropical and temperate water species (Thompson, 1948:142). In our collections this species was not collected south of 35°17′S.

Fagetti (1959) indicated an absence of *S. maxima* off the north and central coasts of Chile, with which the findings of our collections agree. The species was collected only once at 7°48′S., 81°23′W.

Vertical distribution: With the exception of *T. democratica*, all of the salps taken by the *Eltanin* appear at great depths. *S. thompsoni* is the only species taken a sufficient number of times to attempt any generalizations in regard to vertical migration, a debated subject in the Salpidae. Fraser (1949), working with one of the *S. fusiformis* group in Scottish waters at depths of only 100 meters, found evidence of nocturnal migration toward the surface. Mackintosh (1934:94, fig. 18) working with Antarctic material of the same group and down to depths of 200 meters, indicated the same phenomenon. Yount (1958:118) and Apstein (1906b:277ff.), however, did not find evidence of diurnal migration.

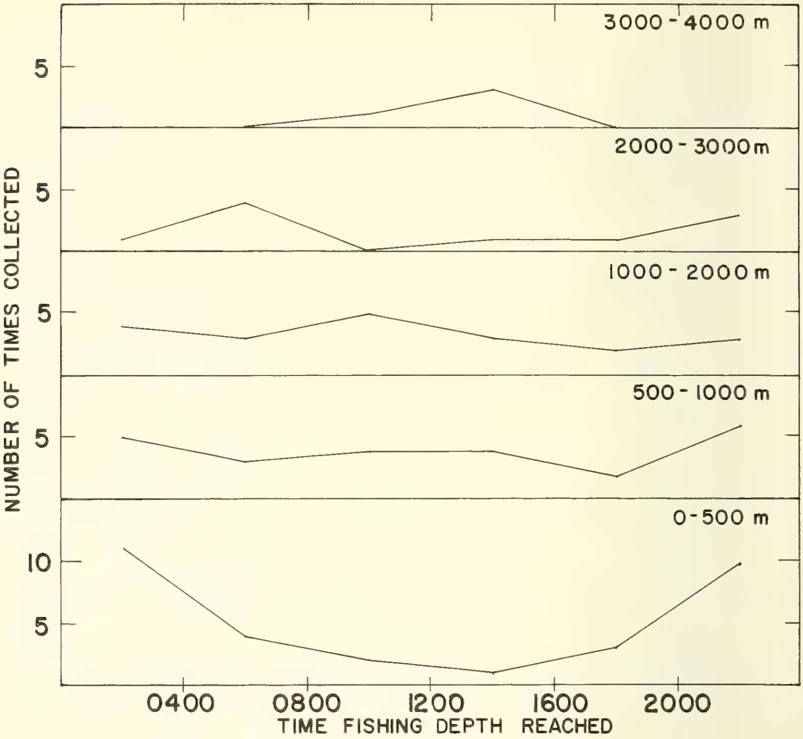

Figure 4. Number of times collected in relation to four-hour groupings of time of day collected of *Salpa thompsoni.*

The data from our collections of *S. thompsoni* suggest that in the upper layers (down to 500 meters) there is a diurnal migration with the animals approaching the surface in the hours of darkness. Below 500 meters there is little or no tendency to migrate. These data correspond with what would be expected if the species is negatively phototrophic. The values in Figure 4 were obtained by counting the number of times collected in four-hour periods. If there were a tendency to use any one type of gear at certain times of day, the depth figures would be influenced by this, but cruise leaders state that all types of gear are used throughout a 24-hour period, with no tendency to use any one type of gear at a given time. These depth data, therefore, are probably a true reflection of what occurs. Counts of number of specimens were disregarded because of the tendency for the species to swarm and also because of the widely divergent collecting methods used; if the species was collected either singly or in swarms a unit of one was assigned to the collection.

Our collections of *S. thompsoni* do not bear out the suggestion (van Zyl, 1960: 13) that the solitary form is found in deep water and the aggregate in surface or subsurface waters (Fig. 3). Again, although Macintosh (1937) found that many plankters descended to greater depths in the winter in the Antarctic, correlation tables plotted for *S. thompsoni* showed no seasonal trend for depths of capture.

As opening and closing nets were not used, doubt may be cast on the existence of salps at the depths recorded. However, the number of times at which captures were made at these depths and the number of specimens taken lend credence to the depth records. In addition, a salp was photographed resting near but not on the bottom at a depth of 4905 meters (Fig. 5). The distance of the shadow from the animal shows that the specimen is not on the bottom and furthermore it appears in good condition. It seems to be the solitary form of one of the *S. fusiformis* group and was taken at 56°58′S., 89°28′W.

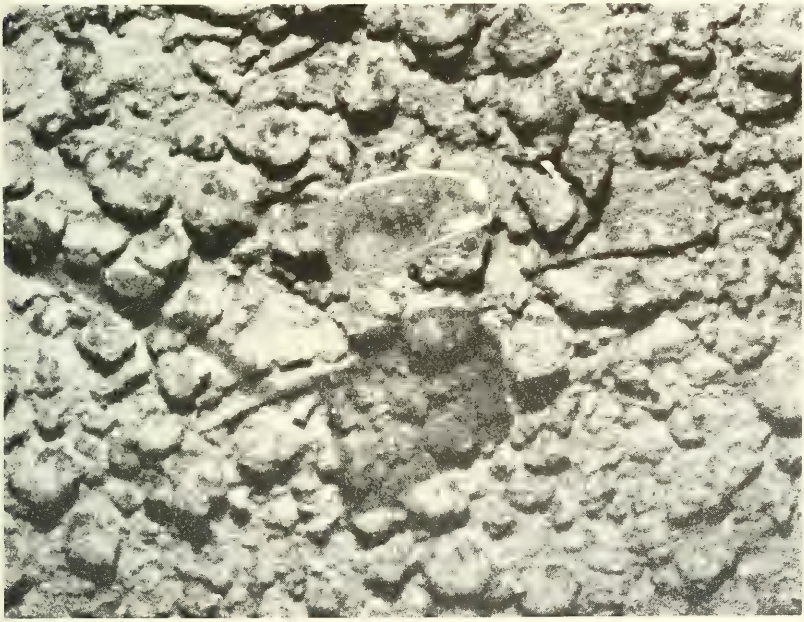

Figure 5. Photograph of unidentified salp made at depth of 4905 meters at 56°58′ S., 89°28′W. Print of Armando Solis, Los Angeles County Museum of Natural History, from a negative furnished by the National Science Foundation.

Feeding: There was nothing in the examination of the intestinal or body cavity contents to indicate that any of the species are other than random filter feeders. This has been stated most recently by Yount (1958:127). The presence of fish scales in the body cavities of two specimens further bears out the lack of any selective feeding mechanism. The only dietary limitation appears to be the size of the oral aperture. One salp contained an amphipod that was 44% of the body length, but normally the ingested material is much smaller, with diatoms largely predominating.

The contents of the body cavity and the intestine have been listed separately, however, as there is no certainty that all of the material in the body cavity of preserved specimens is a normal constituent of the diet. Material may be ingested during capture and preservation that is not normally a part of the diet. Also, there is a possibility that extraneous material may be rejected in some manner following ingestion. Thirdly, some of the amphipods, and possibly members of the other groups may be commensal in the body cavity.

Seasonal distribution: Records on seasonal distribution must be viewed with the following facts in mind. There has been no systematic attempt to survey any one area at different times of the year using any one type of gear for comparative purposes. The multiplicity of purposes and the preliminary nature of these first cruises has not made this possible. A certain amount of positive information is available, which shows that a designated species is capable of living in a designated habitat at a specific time.

S. thompsoni has been collected a sufficient number of times to indicate that it is present in the Antarctic year-round and that there is a blooming of the solitary form in August. From December through March the aggregate form appears in great numbers (Fig. 2).

The only generalization that can be made in regard to *T. democratica*, *I. zonaria* and *S. gerlachei* is that they are present in the coldest months of the year.

Acknowledgments

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REDISCOVERY OF *HYLA PICTIPES* COPE, WITH DESCRIPTION OF A NEW MONTANE STREAM *HYLA* FROM COSTA RICA

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In 1957 during my first field work in Costa Rica, I collected two distinctive species of stream-breeding hylids, from the Cordillera Central, that did not agree with any of the specimens available to Taylor (1952, 1954, 1958) for his review. In subsequent years, workers from the University of Southern California and I accumulated additional material of these forms from the Costa Rican ranges. One species appears to represent *Hyla pictipes* Cope, originally described in 1875 and not rediscovered since. The second form proves to be an undescribed species related to *H. pictipes*.

The series referred to *Hyla pictipes* is from the slopes of the volcans: Poás, Barba, Irazú and Turrialba in the Cordillera Central and from the north and south slopes of the Cerro de la Muerte, Cordillera de Talamanca. All specimens were taken in the immediate vicinity of torrential streams at altitudes between 6500 to 8200 feet (1980 to 2500 meters). In life there was marked color variation in these frogs. Some were deep black in dorsal ground color, others dull green and a few chocolate brown. The color differences are not geographically constant nor do they correlate with differences in structural characters. On Volcán Poás and Volcán Barba two or more color variants were collected together. A number of specimens kept alive did not exhibit any ability to change individual ground color under different circumstances.

Hyla pictipes Cope, 1875

Figures 1, 2 and 3A

Hyla punctariola pictipes Cope, 1875: (Costa Rica: Provincia de Limón: Pico Blanco, in error for Cerro Utyum, 5000-7000 feet).

Hyla punctariola moesta Cope, 1875.

Hyla punctariola monticola Cope, 1875.

Diagnosis: Distinguished from other montane stream hylas by the following combination of characters: Small tympanum with heavy fold over it; dark groin with yellow spots; fingers ¼ webbed, toes 5/6 webbed; a series of white tubercles on forearm and foot. It is easily separated from its close relatives *H. rivularis* and *H. debilis* in lacking the acute snout shape and from *H. tica* by having tympanum less than 20% of head length. *H. pictipes* might possibly be confused with *H. pseudopuma* which occurs at high elevations but is not a stream breeding frog. It is easily separated from this species in having less webbing on the hand and foot and a much smaller tympanum.

General Description: CRE 274: Adult male with snout-vent length 39.0 mm., head length 11.0 mm., head width 12.6 mm., interorbital

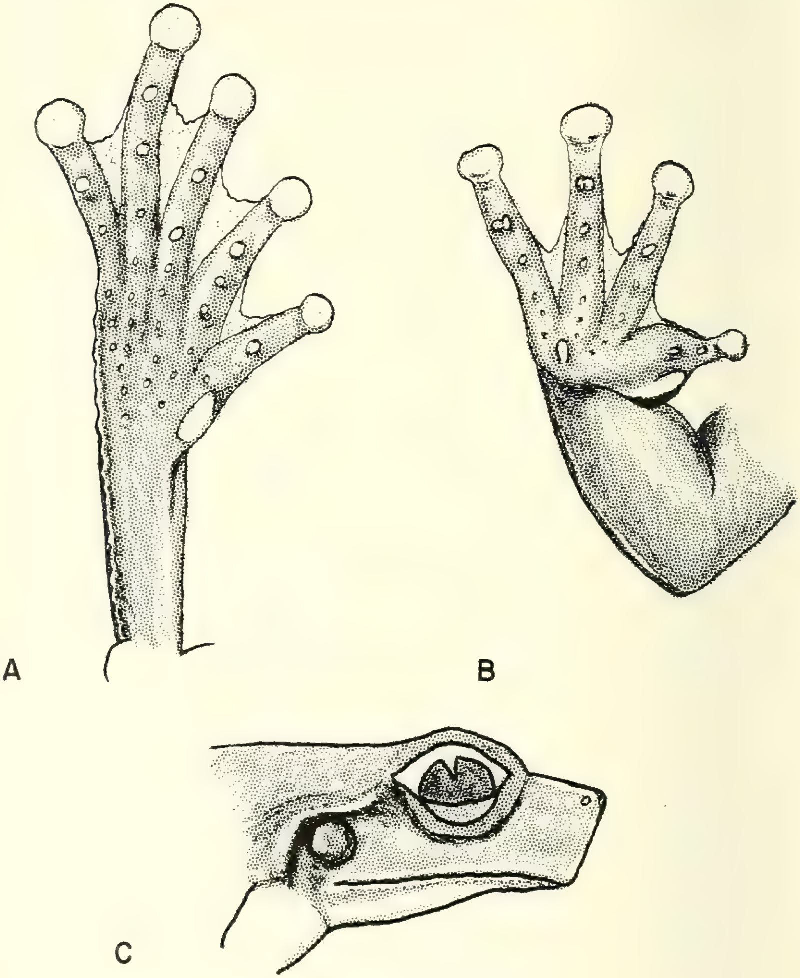

Figure 1. Hyla pictipes. A. Ventral view of foot. B. Ventral view of hand of male. C. Lateral view of head.

distance 4.0 mm., internarial distance 3.3 mm., width of eyelid 3.3 mm., tympanum 1.7 mm. Snout blunt, nostril equidistant between eye and snout, canthus distinct, loreal region concave, nostrils slightly protuberant; a heavy fold extending from eye over tympanum to shoulder (Fig. 1C). No external vocal sac but vocal slits present. Length of forearm 19.4 mm., a series of white tubercles on ventrolateral edge of forearm extending onto outer finger; thumb greatly enlarged and covered with black horny excrescences; vestige of web between thumb and first finger, other fingers ¼ webbed; distal subarticular tubercle divided on outer finger, many supernumerary tubercles on fingers and palm of hand, inner palmar tubercle oval, outer palmar tubercle tripartite, discs of outer fingers larger than tympanum (Fig. 1B). Heel reaches to nostril when leg is extended forward; foot webbed about 5/6, no inner tarsal fold, ridge consisting of tubercles extending from heel to outer toe (Fig. 1A). Scattered tubercles below vent.

A radiograph of this frog reveals the absence of the quadratojugal

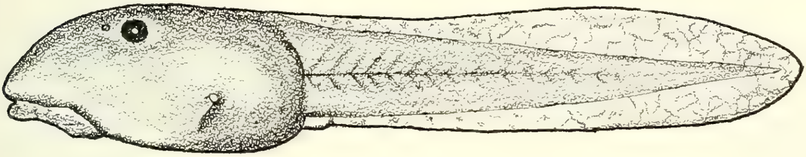

Figure 2. Lateral view of tadpole of *Hyla pictipes.*

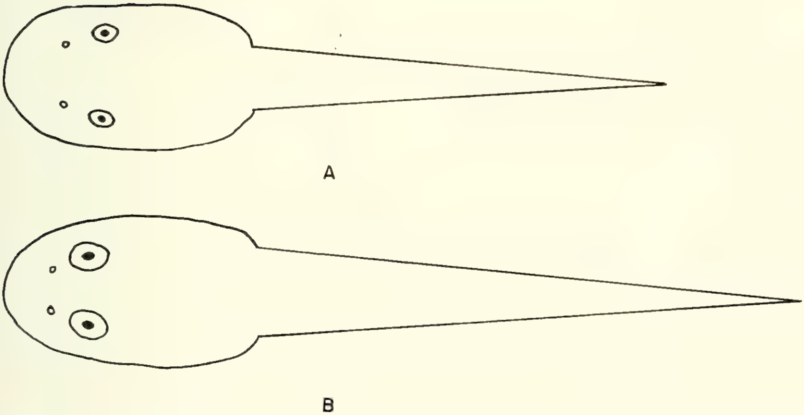

Figure 3. Diagrammatic dorsal views of the tadpoles of *Hyla pictipes* (A), and *Hyla rivularis* (B), with proportions based on the same body length.

bone as do radiographs of specimens from other localities. A cleared and stained specimen (CRE 6198) has a very much reduced quadratojugal.

Coloration: In life, back mottled black and gray, sides and groin black with few yellow spots; feet and rear of tibia and femur black with few yellow spots. Throat almost entirely mottled with dark, belly almost entirely black, cheeks gray. The extremes of color variation are represented by the above description and a female from Volcán Turrialba with the following color in life: Back uniform green, throat and venter bright yellow, sides mottled yellow and dark brown; yellow spots on front and rear of femur, shank, foot and arm. Many specimens are mottled dorsally with gray and black with the groin and rear of thigh black with yellow spots. The belly is light with variable amounts of dark mottling. The area below the eye is often green. The most consistent color character is the dark groin and femur with the light yellow spots. A light ridge on the arm and foot is present although variable in extent. White tubercles below the vent are always present.

Larvae: Tadpoles were collected along with adult *H. pictipes* at Rancho Redondo and Volcán Barba. None could be reared to metamorphosis but it is extremely likely that they represent the tadpole of *H. pictipes*. In general, they resemble the tadpoles of *H. rivularis* but the two can be distinguished (Starrett, 1960).

Description of Tadpole: (CRE 528 and CRE 6194) Maximum total length, 36.2 mm.; body depressed, tail about 1.6 of body length; tail fin low, not extending onto body, tail musculature not extending to rounded tip. Eyes dorsal, small and situated rather posteriorly. Spiracle sinistral with opening about 9/13 of way back on body. Anal tube dextral. Body color uniformly dark brown; tail fins and musculature also dark brown, tail fins speckled with brown dots and reticulations (Fig. 2). Mouth very large, ventral, about width of body, entirely surrounded by wide lips bordered with three or four rows of papillae. Mouth with lateral indentations which lack papillae. Tooth rows 2/3, complete, all about same width; denticles well developed; beaks pigmented and weakly serrated; upper beak bow-shaped.

The mouth parts of this tadpole are very similar to those of *H. rivularis*. The tadpole of *H. pictipes* lacks papillae on the lateral indentations of the mouth, while that of *H. rivularis* has papillae on these indentations. In color, the tadpole of *H. pictipes* is differentiated by the uniformly brown body and tail. A comparison with *H. rivularis* shows that those of *H. pictipes* have relatively shorter tails, smaller eyes and the width of the tail is less at the base, making a sharp demarcation between body and tail and less tapering in dorsal profile. Figure 3 compares the two tadpoles diagrammatically.

Remarks: In 1875 Cope described three frogs, *Hyla punctariola pictipes, H. p. moesta, H. p. monticola* from Pico Blanco, 5000 to 7000 feet, in Costa Rica. Although named as subspecies of *Hyla punctariola* Peters, Dunn (1940) has subsequently shown this species to be an *Eleutherodactylus.* Cope considered the three hylids as subspecies although he mentioned the possibility of their being three distinct species. His descriptions were brief and the differences mentioned were in color pattern. The color pattern of *H. p. moesta* "Above brownish-black, sides and femora, except above and below, deep black. Some white spots on sides behind axillae, and some small yellow ones near groin. A few minute white points on front and back of femur, and upper surfaces of feet. Otherwise the limbs and hands, except the thumb, are black. Lower surfaces thickly black spotted except on breast and tibia, where the white predominates," is very similar to that of frogs reported here from both the Cordilleras de Talamanca and Central. The color pattern described for *H. p. pictipes* is very similar to that of the frogs collected in Irazú, Poás and Barba. The color pattern of *H. p. monticola* is somewhat different. Cope describes a series of brown spots on the back forming transverse bars. The USNM types of these frogs, examined by me in December, 1961, were in poor condition. *H. p. moesta* (USNM 30660) is dried up and shriveled. From radiographs and examination of the specimen it appears there is no quadratojugal. The snout shape, amount of webbing and large pre-pollex are all similar to these characters in my series of Costa Rican frogs.

The syntypes of *H. p. pictipes* (USNM 30652 and 30631) are soft. The foot webbing is like that in the recent series. Both have a large pre-pollex. Traces of color pattern can be discerned. The typical light spots in the groin and on the rear of the femur are present as well as a white line on the tarsus. The quadratojugal appears to be absent in the radiographs.

The holotype of *H. p. monticola* (USNM 30661) is very shriveled. The webbing on the foot is similar to the other Cope types and probably no quadratojugal is present. It seems apparent that Cope was dealing with one variable species. The types of *H. p. moesta* and *H. p. pictipes* seem definitely conspecific with the recent series of Costa Rican frogs described above. The type of *H. p. monticola* is referred to the same form. The few anatomical characters visible apply, but the color pattern as described by Cope is different from available fresh material. This may not be significant because there is such variation in color pattern in the species. Taylor (1958) described a frog that fits Cope's color pattern description of *H. p. monticola.* An examination of that specimen (KU 36764) reveals that it is *Smilisca sordida* Peters (includes *Smilisca gabbi* Cope, 1875). The transverse bars are not uncommon in other specimens of *S. sordida* from Costa Rica.

It seems best to use the name *Hyla pictipes* for these montane frogs because the types of *H. pictipes* are in fairly good condition and more characteristics of the species can be seen. I hereby designate USNM 30652 as the lectotype of *Hyla pictipes* Cope.

The specimens of this frog which were collected at dusk or after dark were found either sitting partially submerged on rocks in the streams or on leaves of relatively low plants close by the water; those taken during the day were all in wet situations; either on rocks or sticks in the streams or on rocks along the water's edge which were constantly showered with spray. Males were heard calling only for a short time starting at dusk, and the individuals which were located by call were all sitting partially submerged in moving water. The call of *H. pictipes* is a rather weak, low and somewhat drawn out

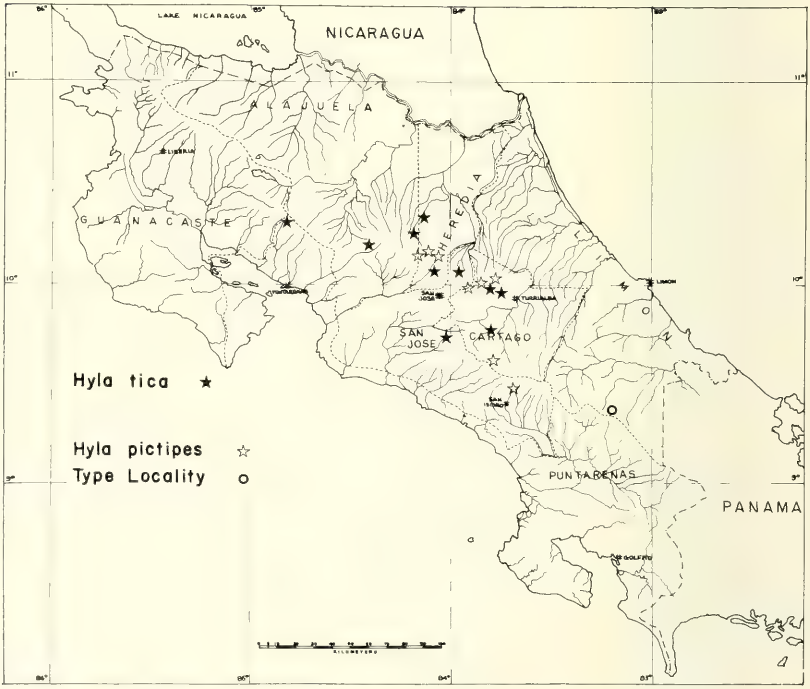

Figure 4. Distribution of *Hyla pictipes* and *Hyla tica.*

single "brraw," with long intervals of silence between calls. Calling males were usually difficult to locate because of the ventriloquistic nature of the call, emphasized by the preference of the frogs for calling sites which were located beneath fallen tree trunks or in other similarly concealed locations.

The distribution in Costa Rica is shown (Fig. 4).

The new form also occurs along fast-moving streams in the central and Talamanca ranges in Costa Rica, but at lower elevations, 3700 to 5400 feet (1130 to 1650 m.), than *H. pictipes*. Because the new form is from Costa Rica and since the local name used for inhabitants of that country is "tico," the new form will be called

Hyla tica, new species

Figure 5

Holotype: UMMZ 122482 from a stream, 4500 feet, on Volcán Turrialba, Cartago Province, Costa Rica; collected on July 25, 1957 by Andrew and Priscilla Starrett and Thomas M. Uzzell, Jr.

Paratypes: 36 specimens from various localities. (Table 1)

Diagnosis: A moderately small hyla (male 29 to 34 mm., female 34 to 38 mm.) with short legs, heel when extended forward reaching to eye. No distinct inner tarsal fold, outer tarsal fold consisting of series of tubercles. Fingers about ⅓ webbed, toes about 4/5 webbed. Snout short and rounded; diameter of eye larger than distance from eye to nostril. Diameter of tympanum about ½ that of eye.

Color tan with brown and black splotches on back, groin and rear of thigh yellow, dark bars on dorsal area of femur, belly granular with scattered black dots. Back with scattered pustules.

This frog can be distinguished from other Costa Rican hylids by the following combination of characters: rounded not sharply projecting snout; fingers about ⅓ webbed, toes about 4/5 webbed, tympanum about ½ eye, dark bars on femur, belly light with dark flecks, eyes not red.

Description of Holotype: Adult male with snout-vent length 30.5 mm.; length of head from angle of jaw 9.0 mm.; head width 9.3 mm., interorbital distance 3.5 mm.; internarial distance 3.1 mm., width of eyelid 2.0 mm., diameter of tympanum 1.9 mm. Snout rounded in profile, nostril closer to eye than to middle of upper lip, canthus rounded, loreal region sloping, a slightly concave area around nostrils; a fold extending from eye over tympanum. Vocal sac median, external.

Vestige of web between thumb and first finger, outer fingers about ⅓ webbed, distal subarticular tubercle divided on all fingers, a

Figure 5. Dorsal view of *Hyla tica*, new species.

rounded palmar tubercle at base of thumb, outer palmar tubercle bifid, disc of 3 outer fingers slightly smaller than tympanum. Length of forearm 14.7 mm., a series of white tubercles on ventro-lateral edge of forearm, thumb slightly swollen and finely shagreened.

Length of femur 14.7 mm., tibia 17.0 mm., foot 23.0 mm. No inner tarsal fold, a few small white tubercles on outer tarsal edge. An oval inner metatarsal tubercle and a very small round outer tubercle. Many supernumerary subarticular tubercles, distal divided on outer toes. Discs about same size as those of fingers. Foot about 4/5 webbed.

Anus with small anal flap, white tubercles present below opening; vomerine teeth present 5-5, larger than choanae, extending beyond posterior edge of choanae. Tongue rounded, not notched posteriorly. Belly granular; back and legs covered with pustules.

Coloration: When collected, frogs appeared very dark in contrast with other hylas in same region. Back appeared warty with pustules. Dark brown above with slight bronze and greenish tints; brown spots on sides, brown bars on thigh. Yellow in groin and on rear of thigh; few black flecks on venter. Eye color grayish brown.

Color in alcohol: Back and head bronze with dark brown spots and reticulations; dorsal part of femur tan with indistinct dark bars; rear of thigh brown and white; tibia brown with darker brown bars, few white pustules on foot; white mottling on upper lip; chin and belly cream, white with dark flecks on lower lip; scattered black spots on belly; sides brown with white reticulations; anterior femur flesh color; arm tan with a dark bar extending onto two outer fingers (Fig. 5).

The amount of dark mottling on the back is variable; it is absent in some specimens and one female has a dark hourglass marking extending from the eyes to the middle of the back. The dark bars on the thigh are prominent on some specimens and rather obscure on others. Most specimens have dark flecks on the belly. A dark area often extends from the rear of thighs onto the ventral part of the thighs. This dark area is dotted with white tubercles. The chin is white anteriorly with a few dark flecks.

Remarks: Variation in measurements are summarized in Table 2. The vomerine teeth are absent on the right side in one female. The choanae are slightly larger than the vomerine teeth in all the paratypes.

The frogs on Volcán Turrialba were collected during a light rain in a mixed chorus with *Hyla rivularis.* They were calling from the vegetation above a small rocky stream. The call of the male was a

TABLE 1. Locality data for paratypes of *Hyla tica* sp. n.

Museum No.	No. of Specimens	Date	Elevation (feet)	Province	Locality
UMMZ 118474 (CD 7612-7617)	4	July 25, 1957	4500	Cartago	Type locality
UMMZ 118475	1		5000	Heredia	San José de la Montaña
UMMZ 118476	1		4500	Alajuela	E slope Volcán Poás, 13.3 mi. N Vara Blanca
CRE 7017	10	Sept. 27, 1963	3900-4000	Cartago	Tapantí, along Río Quiri
CRE 7095	1	Dec. 19, 1963	4300-4600	Cartago	1 km. N Tapantí
CRE 7037	1	Oct. 16, 1963	4500	Puntarenas	0.5 mi. W Monteverde, tributary to Río Guacimal
CRE 7043	4	Oct. 19, 1963	4700-4900	Puntarenas	0.5 mi. NE Monteverde
CRE 7211	1		4800	Puntarenas	0.5 mi. NE Monteverde
CRE 7048	8	Oct. 30-31, 1963	3700-3900	San José	0.25 mi., above and 0.5 mi. below junction of Río Claro and Río La Hondura
CRE 7062	1	Nov. 29, 1963	4700	San José	1 km. S San Cristóbal Sur in Río Tarrazú
CRE 7157	1	Feb. 20, 1964	4200	Alajuela	1 mi. S Zapote on Zarcero-Quesada rd.
CRE 7056	4	Nov. 20, 1963	5400	Cartago	Río Playas where it crosses Pacayas-Santa Cruz rd.

TABLE 2. Measurements of *Hyla pictipes* and *H. tica* sp. n.

Species	No. of Specimens	Sex	Snout-Vent Length/Head Length (Mean)	Snout-Vent Length/Leg Length (Mean)	Head Width/Head Length (Mean)	Tympanum/Head Length (Mean)	Snout-Vent Length (Mean)	Snout-Vent Length (Range)
H. tica	28	♂	3.3	.61	1.00	.23	31.1	29.0–34.0
H. tica	9	♀	3.4	.62	1.00	.21	35.8	34.3–37.6
H. pictipes	35	♂	3.2	.61	1.02	.15	34.2	30.9–39.9
H. pictipes	17	♀	3.4	.61	1.06	.15	39.1	33.4–45.0

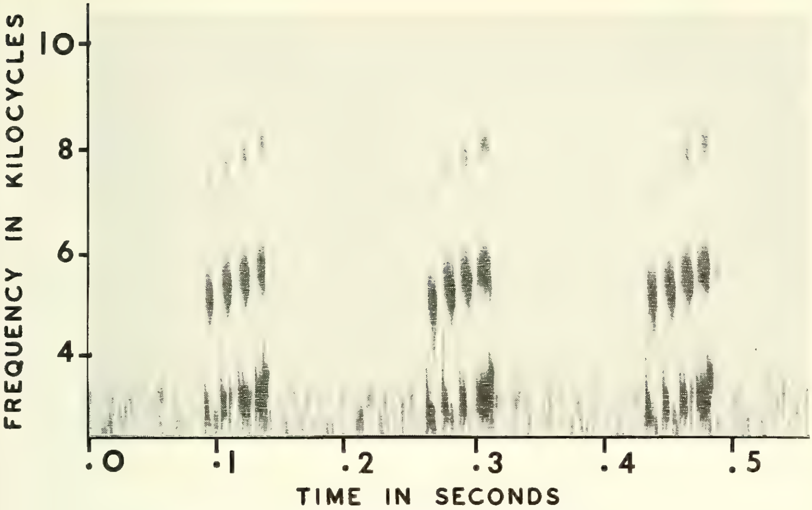

Figure 6. Sound spectrograph of *Hyla tica*, new species.

weak repeated sequence of three notes, each one consisting of a short series of crepitations lower in pitch than the continuous cricket-like call of *H. rivularis*. William E. Duellman made a sound-spectrograph of this species (KU 65132) at Río Maria-Aguilar, 3 kilometers west of Cariblanco, Alajuela Province; April 18, 1961 (Fig. 6). The call consists of 3 notes, each note having 4 pulses. The pulse rate is 80 pulses per second. The duration of the call for the 3 notes is 0.4 seconds. The first pulse has a fundamental frequency of 2600 cycles per second, the dominant frequency of 5000 c.p.s. and the third harmonic of 6200 c.p.s. The fourth pulse has a fundamental of 3100 c.p.s., dominant 5600 c.p.s. and third harmonic 7100 c.p.s.

The females contained large (2 mm.) unpigmented eggs suggesting the possibility of the eggs being deposited in streams under rocks.

Hyla tica can readily be distinguished from *Hyla debilis* and *H. rivularis* by the round instead of sloping snout and more webbing on the hands and feet. However, this frog appears to be related to a group of stream breeding tree frogs which includes *Hyla rivularis*, *H. debilis*, *H. pictipes* and possibly the red-eyed hylas, *H. uranochroa*, *H. rufioculis* and *H. legleri*. Two cleared and stained specimens of *H. tica*, UMMZ 118474 (CD 7615) and CRE 7017, and radiographs of other *H. tica* reveal the presence of a slightly reduced quadratojugal bone. The bone is slender and does not quite reach the maxilla. The quadratojugal is even more reduced in *H. rivularis* and *H. debilis*, occurring as a tiny bone at the base of the squamosal. This bone is either very small or completely absent in *H. pictipes*. The quadratojugal in the red-eyed frog, *H. rufioculis*, is reduced and similar to the condition in *H. rivularis* and *H. debilis*. In *H. uranochroa* and *H. legleri* the quadratojugal is not reduced and makes contact with the maxilla. This group of frogs lives near small streams, and as far as is known they are stream breeders. The females lay large unpigmented eggs. The tadpoles of *H. rivularis*, *H. pictipes* and *H. uranochroa* have large sucking mouthparts and low dorsal tail fins, and are adapted for stream life. The similarity in the tadpoles is more evidence supporting the close relationship between *Hyla pictipes* and *Hyla rivularis*. The distribution of *H. tica* in Costa Rica is shown in Figure 4. The altitudinal distribution of *H. tica* (3700 to 5400 feet) overlaps that of *H. rivularis* (4125 to 6800 feet) which in turn overlaps that of *H. pictipes* (6500 to 8200 feet).

ACKNOWLEDGMENTS

I am indebted to Charles F. Walker and Jay M. Savage for the use of the material. William E. Duellman kindly offered the soundspectrograph of *Hyla tica*. I am also grateful to Dr. Savage and Andrew Starrett for helpful suggestions and advice concerning the manuscript. Thanks are due to Naomi Zinkow for typing the manuscript.

For loan of comparative material acknowledgment is made to the authorities in charge of the herpetological collections of the University of Michigan Museum of Zoology (UMMZ), the University of Kansas Museum of Natural History (KU), the United States National Museum (USNM) and University of Southern California (CRE).

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XEROGRAPHY IN THE LABELING AND PROCESSING OF LARGE BIOLOGICAL COLLECTIONS—A PROGRESS REPORT

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Labeling large biological collections by traditional pen and India Ink methods consumes an enormous amount of time and drudgery, leading to inaccuracy due to carelessness and/or fatigue. Furthermore, the resulting labels often contain only minimal information, necessitating further time to be spent by the investigator, checking log and data books.

During 1962 and 1963 we faced this problem with the large U.S. Antarctic Research Project collections made from the USNS *Eltanin* in Antarctic waters. Automation, of some sort, was obviously the answer.

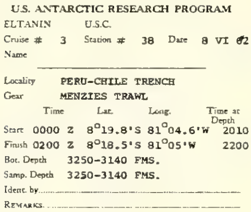
Commercial printing of completed labels is uneconomical; batch or lot size varies, some having few specimens or needing few containers while others may necessitate several hundred. It also increases probability of error because sorting and production of labels are separate and uncoordinated.

Stamp-pad or portable moveable-type label devices were rejected because no ink yet developed for them will hold up in standard biological preservatives. India Ink may be used but smear tendency severely limits print size and the amount of information per label.

Electric typewriters, equipped with "Flexo-writer" tapes and special ribbons, are presently being investigated elsewhere (Beatrice Burch, *in litt.*). These constitute a short step in solving the problem. Speed, however, is not increased by more than a factor of three; the labels are subject to at least considerable initial fading and the method is subject to mechanical error.

We therefore considered Xerography, essentially an electrostatic photographic process. A dry, powdered, charged thermoplastic "toner" (ink) image is transferred from a light-sensitive, selenium coated, aluminum plate (film) to any paper (cloth or other material) by applying an attractive charge to the paper. The toner image is then fused *into* the paper by means of heat or special solvent vapor (Byers, 1958).

Ordinary paper test strips in formalin, alcohol, acetic alcohol and



U.S. ANTARCTIC RESEARCH PROGRAM
ELTANIN U.S.C.
Cruise # 3 Station # 38 Date 8 VI 62
Name
Locality PERU-CHILE TRENCH
Gear MENZIES TRAWL

	Time	Lat.	Long.	Time at Depth
Start	0000 Z	8°19.8'S	81°04.6'W	2010
Finish	0200 Z	8°18.5'S	81°05'W	2200

Bot. Depth 3250-3140 FMS.
Samp. Depth 3250-3140 FMS.
Ident. by
REMARKS.

Figure 1. Vial-size label, actual size, *i.e.*, 35% of original Master size.

Bouin's Fixative up to 32 months indicate that the image does not fade and that the paper will disintegrate first.

Using the manually operated Xerox No. 4 camera, Processor D and Heat Fuser, we typed the information on ordinary bond, printed, Master label sets (8 per legal size paper) and photographically reduced them to 50% size to produce three submaster sheets on bond paper. The submasters were then placed side by side on the easel and "shot" onto 110 lb. Resistall index paper (Brown's Resistall Index Bristol 220 M, sub. 110, L. L. Brown Paper Co., Adams, Massachusetts) at 100% (jar labels) or 70% (Fig. 1. vial labels), yielding 24 identical, legible labels every three or four minutes.

Unfortunately, as with any new procedure, a few difficulties soon arose. First, quality and sharpness of the original Master, as well as distinctly different shapes of individual digits in entries, are important. Qualitative deficiencies in the Master are accentuated in photoreduction and similar shape caused difficulty in distinguishing between 3's and 5's in some of our vial labels. Use of the proper electric typewriter with carbon ribbon eliminated the probem.

Second, on *some* of the final labels in solution, the Xerox image was seen to fade or "lift off" the heavy, dense 100% rag, specially treated Resistall paper. There was no correlation with solution. The phenomenon was not uniform, most from any one sheet holding up well. These "sluffed" areas appeared within a few days and occurred as streaks of fading, etc., across the sheet, often affecting several labels. They even occurred on test sheets that had been "baked" up to two minutes.

Microscopic examination of various combinations of heat and/or vapor fused material indicated that the denseness of our particular stock of Resistall paper resulted in poor penetration of the fused toner. At best, it penetrated only the superficial layers, even when both vapor and heat fusing were used.

Correspondence with Xerox personnel in Rochester, New York yielded information that the toner is swelled and softened in formalin, alcohol, etc., but is not "... soluble in them in the strict sense...." (J. Dessauer, *in litt.*, D. L. Clarke, *in litt.*)

Non-solubility of toner in these solutions was further demonstrated by two facts. None of the liquid in our test bottles was ever discolored and the "sluffed" toner from faded areas can be found as particulate matter in the bottom of the bottles.

Qualitative tests on original and subsequent test strips and sheets in solution indicate that there is excellent resistance to smearing and abrasion with unfaded labels. The scale used was excellent, good, fair and poor. Abrasion tests were done by placing individual labels from our stock of (wet) test sheets in solution in jars about one-third full of a mixture of soil, sand and gravel, and shaking vigorously for five minutes.

These results indicate that the problem was not one of "solubility" of toner. It was instead probably due to a combination of two factors. These are: moisture spots in the paper which may adversely affect attraction and adhesion of the hydrophobic toner, resulting in fusion *on* hydrophilic areas of the paper rather than *in* and around the fibers (M.A. Insalaco, *in litt.*); and non-porosity of this particular heavy Resistall paper, significantly contributing to the net effect. Further, swelling of the paper itself in solution may actually "push off" poorly fused toner, the few superficial fibers around which it is fused being broken in the process (L. V. Nevis, pers. comm.).

Swelling and softening of toner in standard biological preservatives is complete in, at most, a few hours. Therefore, stable images may be expected from fused toner which is well embedded in the fibers and cannot be smeared by gentle rubbing even after prolonged immersion (M. A. Insalaco, *in litt.*).

Ultraviolet will not affect significantly because ". . . the toner is pigmented with carbon black, . . . only the organic portions of the toner would be affected by UV exposure over a long period of time, but these effects should be approximately equal to the effects on the organic portions of India Ink. . . ." (M. A. Insalaco, *in litt.*).

The solution to the problem therefore seems obvious: Vapor Fusion, in order that the toner is partially dissolved and better plasticized to permit better penetration *into* the paper; followed by Heat Fusion, to insure initial hardness by driving off any traces of fusing solvent; and use of a more porous and/or lighter Resistall type paper.

However, because the toner contains thermoplastic polymers, it will tend to soften and become plastic at higher temperatures, dry toner soon showing some tackiness at 140°F. In the presence of a poor solvent, possibly acting as a partial plasticizer, the thermal stability of the toner might be reduced (M.A. Insalaco, *in litt.*). Xerox Corporation Research and Development personnel therefore restrict any tentative recommendation of this application, using their commercially available toners, to temperatures below 100°F (M. A. Insalaco, *in litt.*).

The application of xerography to the labeling and processing of large biological collections would result in initial savings in labor of at least 30 to 40%, even with the relatively slow No. 4 camera, which enables photo-reduction. Labeling procedures would be immensely more accurate and, as a by-product, each label could contain all necessary and important information without appreciably increasing time or cost, resulting in even further time saving to individual investigators.

This qualitative report is necessary because of the nature of the problem itself. It is hoped that the method will be quantitatively tested in the future, as well as refined and accelerated as new equipment becomes available.

Acknowledgments

Grateful acknowledgment is made for assistance and cooperation extended by both sales and technical personnel of the Xerox Corporation, and to members of the Allan Hancock Foundation who contributed significantly to the results, especially H. H. DeWitt and S. R. Farkas who suggested the abrasion test and handled most of the technical detail.

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1958. Individual identification labels for pinned insect specimens. *Entomological News*, 69(5): 113-116. [This paper mentions "photo-offset printing" in preparation of such labels. Xerography may be used in making the master for such labels but the labels themselves are printed. In any event, the labels were for *dry* specimens and any "permanent" photo process would serve as well.—F. J. L., Jr.]

A NEW GENUS AND SPECIES OF SPONGE FROM SOUTHERN CALIFORNIA

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During 1959 four bizarre specimens were collected by two Campbell grabs from the ship R/V Velero IV. They were tentatively identified as large gastropod egg cases (Hartman, 1963: 84). Credit is due to Robert Given who later recognized them as Porifera. Examination of the sponges indicated that they were members of the curious family Coelospheridae, Order Poecilosclerida, and constitute a new genus and species, the first representatives of this family from the Pacific coast of the United States.

Coelosphericon, new genus

Characterized by possessing subtylotes, anchorate isochelas, toxas, and a body wall consisting of two contiguous layers of subtylotes. This genus appears to be most closely related to *Coelosphaera* Thomson and *Coelosphaerella* De Laubenfels from which it differs by containing anchorate isochelas. The type species of the new genus is *Coelosphericon hatchi*, n. sp.

Coelosphericon hatchi, new species

Figure 1

Holotype: Allan Hancock Foundation, 1965—14; collected off Gull Island, Santa Cruz Channel, California (33° 56′ 06″ N, 118° 52′ 17″ W) on 22 December 1959. Depth, 221 m.; substratum, rocks and green coarse sand; R/V Velero IV station 6806-59.

Paratypes: Allan Hancock Foundation, 1965—14, United States National Museum 23747, and British Museum of Natural History 1965. 6.17.1; all collected off Gull Island, Santa Cruz Channel, California (33° 56′ 03″ N, 119° 52′ 03″ W) on 22 December 1959. Depth, 218 m; substratum, rocks and some green sand; R/V Velero IV station 6805-59.

The name *Coelosphericon* refers to the sponge having the likeness of a hollow sphere.

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[1] Allan Hancock Foundation Contribution No. 283.

Description: *Coelospherhicon hatchi* is approximately egg-shaped (Fig. 1a) and measures up to 18 mm. in diameter across the base and 35 mm. in height (excluding the apical osculum). Two of the four specimens are firmly attached to rock; the remaining sponges were torn from their substratum. From 6 to 13 subapical fistules arise from the upper half of each of the specimens. The holotype contains a symmetrical but atypical subapical rosette of 6 fistules (Fig. 1a). In addition, each specimen contains an apical osculum. The fistules measure up to 8 mm. and the oscula up to 10 mm. in length.

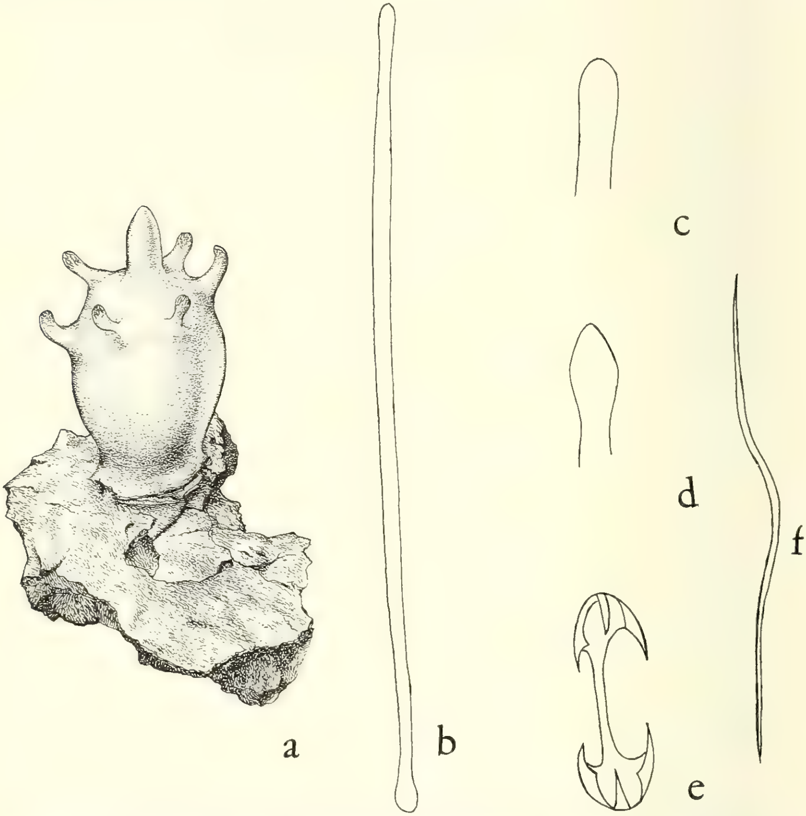

Figure 1. (a) Drawing of the holotype of *Coelospherhicon hatchi* (height, excluding osculum, 27 mm.; basal diameter, 18 mm.) attached to a rock; from Hartman (1963:82). Note the 6 fistules and the apical osculum. (b) Camera lucida drawing of a typical subtylote. Length, 869 μ; diameter, 17 μ. (c) Stylote end of the subtylote spicule. (d) Another variation in the end of a subtylote. (e) Anchorate isochela. Length, 39μ. (f) Toxa. Length, 133 μ; diameter, 2.5 μ.

The color in alcohol is white to cream, the latter shade due to the presence of the dermal membrane. The body surface is smooth, the texture slightly crusty, and the body wall exceptionally tough. Fistules, occurring on the midbody and the subapex, arise as a hollow cylinder of subtylotes. Near the apex of the fistules columns of subtylotes originate and proceed to the end where they arch around and become congruent with other similar columns. The columns of subtylotes measure up to 250 μ in diameter. Between them lie spaces which are occupied by dermal membrane and pores. Pores measure from 50 to 200 μ in greatest diameter. The central apical osculum contains an orifice measuring roughly one mm. in diameter in preserved specimens. Since the apex of the osculum has a folded wall, the size of the opening presumably is larger in live specimens.

The dermal membrane is thin and contains numerous anchorate isochelas (Fig. 1e); it appears to lack pores except in the apical portions of the fistules. The body wall measures up to 2 mm. in thickness. It consists of an outer layer of subtylotes (Fig. 1b) that lie approximately at right angles to a second layer of subtylotes. This

TABLE 1. Spicule dimensions of *Coelosphericon hatchi*, new genus and species.[1]

SUBTYLOTE	Holotype *AHF* *1965-14*	Paratype *USNM* *23747*	Paratype *BMNH* *1965.6.17.1*
a. length (range and mean)	535-770-970	525 878-1010	
b. standard error of mean length	770 ± 24	878 ± 20	
c. confidence limits for length at 95% level	722 to 817	839 to 916	
d. diameter	12-17-22	15-17-20	
e. standard error of mean diameter	17 ± 0.1	17 ± 0.3	
f. confidence limits for diameter at 95% level	16.8 to 17.2	16.2 to 17.2	
ANCHORATE ISOCHELA			
a. length (range and mean)	32-38-42	30-38-42	
b. standard error of mean length	38 ± 0.4	38 ± 0.5	
c. confidence limits for length at 95% level	37.0 to 38.6	35.6 to 39.5	
TOXA			
a. length (range and mean)			111-134-162
b. standard error of mean length			134 ± 2
c. confidence limits for length at 95% level			130 to 138

[1] Based on 35 measurements for each character; all data expressed in microns.

seems to confer considerable strength to the sponge. Beneath the two layers occurs a capacious spongocoel that is either empty or it contains a small basal mass of pulpy mesenchyme or a few small patches of mesenchyme adhering to the body wall. The mesenchyme contains numerous subtylotes arranged in apparent confusion although there is a tendency for the subtylotes to occur in groups of 8 to 10 units. Toxas (Fig. 1f) and anchorate isochelas are abundant. Histological sections of the mesenchyme from the paratype AHF 1965–14 indicate that the sponge was undergoing spermatogenesis in December. Numerous "cysts" measuring from 40 to 121 μ in largest diameter were observed. Many contained spermatocytes, and a few, apparently mature spermatozoa. The choanocyte chambers measure up to 37 μ in diameter.

Spicules are shown in Figures 1b to f and dimensions presented in Table 1. Subtylotes and anchorate isochelas are abundant in the body wall and mesenchyme. Toxas, with few exceptions, are restricted to the mesenchyme. It is not uncommon for the subtylotes to have various modifications of one or both ends (Figs. 1c, d). The anchorate isochelas tend to approach the arcuate configuration. The one acanthostyle and one sigma observed in spicule slide preparations are considered to be contaminants.

Remarks: It gives me great pleasure to name *Coelosphericon hatchi* in honor of Professor Melville Hatch, Department of Zoology, University of Washington. Dr. Hatch is recognized as the authority on beetles of the Pacific Northwest United States. He also served as a member of my dissertation committee for which I am grateful.

Acknowledgments: I would like to thank the following persons at the Allan Hancock Foundation, University of Southern California: Robert Given for calling my attention to the occurrence of these specimens, Dr. Olga Hartman for making the specimens available for study and for a drawing of the holotype by Anker Petersen, Amada Alvarez for spicule measurements and camera lucida drawings, and Drs. Olga Hartman and Willard D. Hartman, the latter of the Peabody Museum of Natural History, Yale University, for a critical review of the manuscript.

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THE FEMALE OF *EUCRYPTOCERUS PLACIDUS* (F. Smith) (Hymenoptera: Formicidae)

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When Kempf (1951) revised the genus *Eucryptocerus*, he had available to him fewer than 20 specimens (all workers) representing the four species recognized then. A fifth species, *E. serraticeps* (F. Smith), described from a single female, was included provisionally; this species was unknown to Kempf, except by the very inadequate original description. At this time, the sexual forms of *Eucryptocerus* were unknown.

A few years later Kempf (1959), after examining the male type of *Cephalotes placidus* (F. Smith), removed this species to the genus *Eucryptocerus* and placed *E. opacus* (F. Smith) in synonymy with it. Kempf redescribed the male specimen and provided the first adequate concept of what the sexual forms are like.

While examining a series of ants from Amazonian Peru, I discovered a series of 40 workers of *E. placidus*; associated with the workers was a single alate female cephalotine which bore a strong superficial resemblance to the females of the related genus *Cephalotes*. There can be little doubt that this is the previously undescribed female of *placidus*, and in order to assist others working with Neotropical ants, it seems advisable to describe it at this time.

This specimen has been checked against Smith's description of *E. serraticeps*, and there can be little doubt that the two species are distinct from one another. Smith described his species as having the abdomen "... very smooth and shining, with scattered delicate punctures; the apical segments roughened, with their margins smooth and shining." In the female of *E. placidus* the abdomen is distinctly marked with fine, transverse striae, imparting a rather dull appearance; the abdominal punctures are more obscure than fine, and are mostly separated by only two or three times a puncture diameter. The wings differ in color from Smith's description since the entire wing, except the submarginal cell, is infuscated with brownish. The wing agrees closely with the description and figures of Kempf (1959), except that the marginal cell is somewhat longer.

The following description should prove to be of assistance in recognizing additional female specimens of this species:

Alate female (Fig. 1): Total length, 11.4 mm.; forewing, 10.9 mm.; maximum head width, 3.0 mm.; maximum head length (from anterior margin of lateral lobes), 2.9 mm.; maximum thoracic width, 3.0 mm. Integument dull black, except the dark reddish-brown apical tarsal segments.

Head, excluding mandibles, very slightly longer than wide; mandibles strongly rugose; clypeus about as broad as long, triangular; frontal carinae slightly convergent anteriorly, margin of lower one-third slightly crenulate, with a few clavate setae; occiput with a pair of low, pointed tubercules immediately above posterior ocelli; a low pointed tubercule on each side above eyes, with a similar tubercule immediately behind; front distinctly convex when viewed from above; occipital emargination rather deep; cheeks very broad, almost one-third as broad as head is long.

Pronotum nearly vertical anteriorly; humeral angles projecting forward as a narrow spine when viewed from above, pronotal crest strong laterally, absent medially, carinate, the carina raised on each side of median line as a pair of low humps, entire carina slightly crenulate; mesopleura with small spine above mid coxae; epinotum narrow, with a pair of spines directed caudad, the spines about as long as distance between their bases.

Petiole short, about twice as broad as long, anterior face vertical; postpetiole not swollen dorsally, only slightly swollen laterally; petiole and postpetiole without ventral projections; gaster more elongate than in worker, about one-third longer than broad, first tergite emarginate basally, disc with very fine striae which converge medially, anterior carina of first tergite distinct as far back as spiracle; remaining tergites discally roughened, all tergites with a narrow, dull, impunctate marginal band; first ventrite dull, sparsely punctate with a few irregular striae laterally; remaining ventrites roughened discally; all ventrites with narrow, impunctate apical margins which are slightly more shiny than those of tergites.

Integument generally dull, subopaque, mesoscutum, scutellum and abdomen somewhat shinier. Punctures of front moderate in size, separated by about a puncture diameter, becoming a little finer and sparser below, somewhat less distinct on pronotal lobes; punctures of occiput coarser than those of front, separated by a puncture diameter or less; cheeks rugoso-punctate; punctures of anterior and upper faces of pronotum equal to those of occiput, sparser medially, of lateral face coarse, rather close; punctures of mesoscutum slightly elongated, separated by a puncture diameter or less, becoming sparser

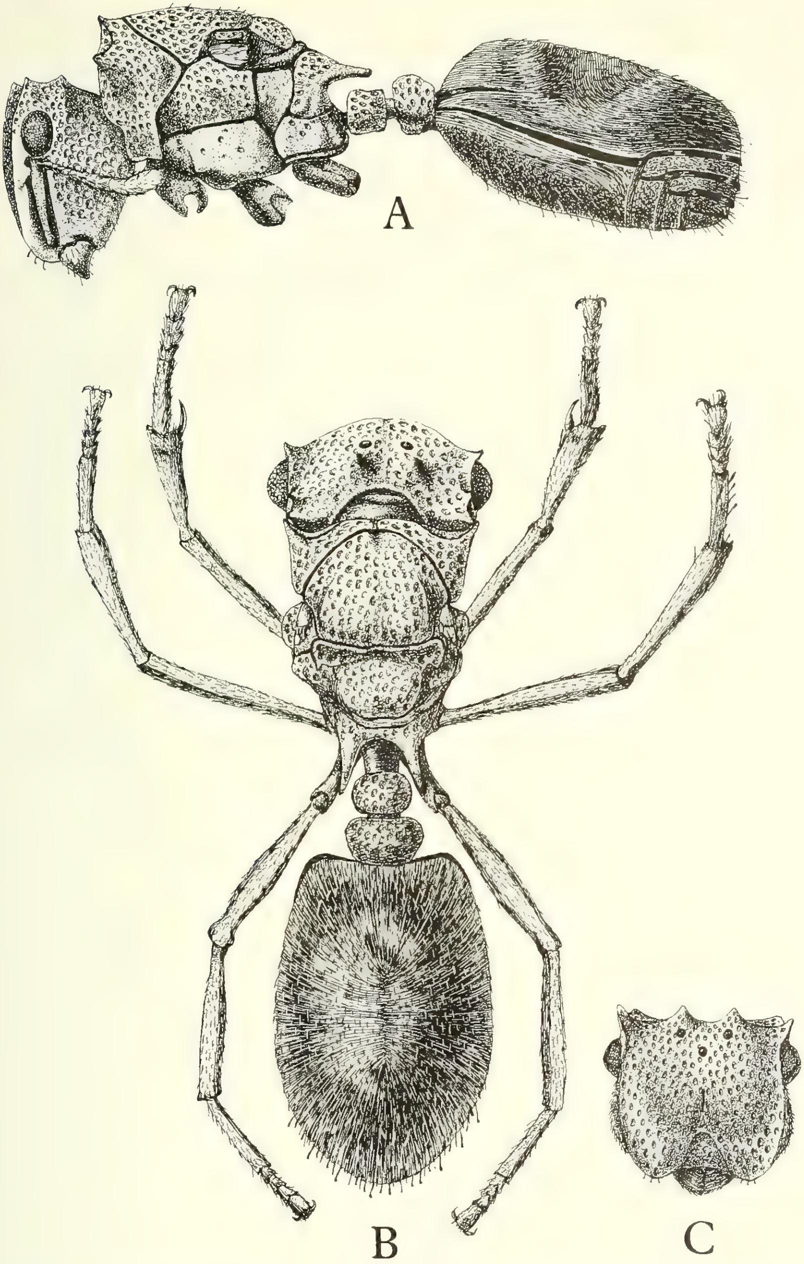

Figure 1. Eucryptocerus placidus (F. Smith), alate female. A. lateral view, legs and wings removed; B. dorsal view, wings removed; C. frontal aspect of head only.

and fainter laterad; those of disc about equal to those of occiput; punctures of upper mesopleural plate slightly finer than those of adjacent portion of pronotum, separated by slightly less than a puncture diameter; punctures of lower half of mesopleura, entire metapleura, lateral and posterior faces of epinotum obscure, scattered, the integument opaque, minutely granulose; punctures of scutellum slightly elongate, equal to those of mesoscutum, separated by a puncture diameter or less, the integument slightly more shiny than elsewhere; punctures of basal face of epinotum coarse, deep, subcontiguous.

Wings fuscous infuscate, except for clear submarginal cell; marginal cell closed and appendiculate apically, about 3.5 times as long as wide; submarginal cell about three-fourths as long as marginal; otherwise as figured by Kempf (1959:93) for the male.

Described from a single alate female, associated with forty workers, from Pucallpa, Loreto, Peru, alt. 200 m., collected November 11-20, 1964 by J. Schunke. All specimens in the collection of the Los Angeles County Museum.

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ON THE BIOLOGY OF THE PELAGIC CRUSTACEAN *NEBALIOPSIS TYPICA* G. O. SARS

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Studies of the rare bathypelagic leptostracan *Nebaliopsis typica* G. O. Sars (Cannon, 1931, 1946; Linder, 1943) discussed the variation in the ratio of carapace to body length and noted the absence of embryonic forms in known collections. Specimens of this species, which add to the existing information on these topics, have recently been collected by biologists on the U.S. Antarctic Research Program vessel USNS *Eltanin.*

Most of the collections used in this study are from the area bounded by 38° and 70° south latitude and 59° and 115° west longitude (Fig. 1). In addition three specimens are included in the station list (Table 1) which were caught as the USNS *Eltanin* began working between Chile and New Zealand, beyond the primary survey area. Also included is a most interesting record, from the research vessel of the University of Southern California, *Velero IV*, of an individual collected in the North Pacific Ocean. All of the specimens were caught with a three-meter Isaacs-Kidd Midwater Trawl (Isaacs and Kidd, 1953) which trawled at a given depth for several hours (most often two) before being towed, open, to the surface.

Measurements were made of the total length and carapace length. Total length was measured from the most anterior part of the rostrum to the distal edge of the caudal furca. The length of the carapace was taken from the most anterior to the most posterior points. The ratio of the two lengths, for the specimens caught between South America and Antarctica, is shown in Figure 2. The variation is of the sort that might be expected in a species. A correlation is indicated between the length of the whole animal and the carapace, which had been questioned by Cannon (1931, 1946) and Linder (1943).

Two of the specimens, from station 1288, were males and the remainder were females. The size range for the species is extended, although the "Mancoidstadien" described by Linder (1943) were not represented. Three of the females were found with developing eggs, which they shed from under the carapace when placed in fixative. They were apparently held in the basket formed by the large and

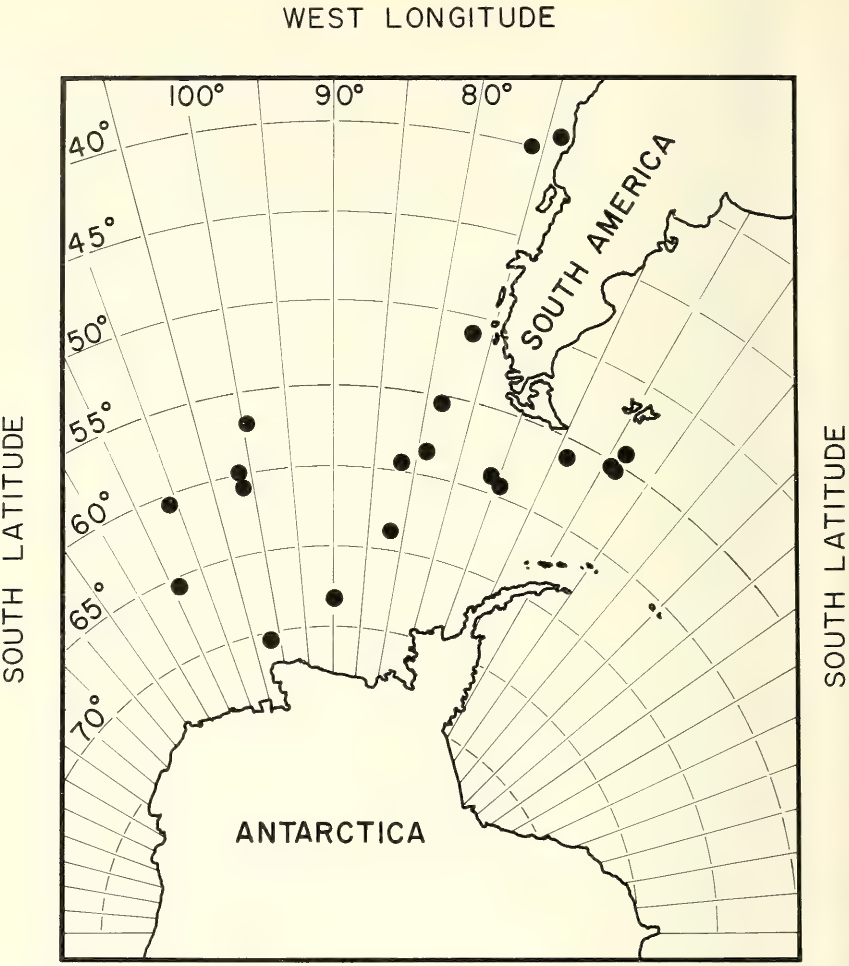

Figure 1. Distribution of *Nebaliopsis typica* collected from the USNS *Eltanin* between South America and Antarctica.

setose posterior pair of thoracic appendages, that extend anteriad to the area of the mouth parts. These were found at stations 354, 778, and 1288.

The nine from station 778 are very near to becoming free-swimming and are quite similar to the embryonic *Nebalia bipes* figured by Manton (1934: fig. 41). They differ from Manton's figure in that both antennae are longer and contain more segments. The abdominal appendages are also longer in these specimens than in

TABLE 1

Stations at which *Nebaliopsis typica* was found. All stations except final one made by USNS *Eltanin*.

Station Number	Number of Specimens	Date	Latitude	Longitude (*West*)	Bottom Depth (*Meters*)	Sampling Depth Range (*Meters*)	Time of Tow (*Local*)
USNS *Eltanin*							
99	2	12 VII 62	51°30′S	77°35′	3848	1208-	1020
			51°43′S	77°36′	——	1219	1415
154	1	16-17 VIII 62	56°43′S	64°28′	2928	2105	1753
			56°36′S	63°20′	3999		0300
253	1	7 X 62	59°05′S	69°28′	3843	961	1720
	(fragment)		59°04′S	69°43′	——		2035
310	1	3 XI 62	58°59′S	70°37′	4209	1416	0325
			58°44′S	70°19′	3138		0735
326	1	25 XI 62	38°09′S	74°31′	3715	1691-	0940
			38°30′S	74°37′	——	2072	1450
348	1	4 XII 62	54°40′S	58°58′	2306	644	1125
			55°06′S	59°05′	2635		1445
354	3	5 XII 62	55°25′S	58°51′	3880	1812-	1715
			55°44′S	58°53′	4118	2145	2135
355	1	5-6 XII 62	55°43′S	58°53′	4150	2363-	2146
			56°08′S	58°55′	4502	3025	0315
778	1	19 X 63	59°32′S	82°33′	4959	1251-	0115
			59°38′S	82°28′	4959	1691	0430
793	2	25-26 X 63	64°11′S	82°46′	4374	3294	2130
			64°22′S	82°27′	4410		0340
868	1	25 XI 63	57°06′S	78°56′	4758	997-	1755
			56°57′S	78°37′	——	1230	2150
877	2	29-30 XI 63	55°22′S	78°08′	4282	1940	2040
			55°24′S	78°24′	——		0035

TABLE 1 (*continued*)
Stations at which *Nebaliopsis typica* was found. All stations except final one made by USNS *Eltanin*

Station Number	Number of Specimens	Date	Latitude	Longitude (*West*)	Bottom Depth (*Meters*)	Sampling Depth Range (*Meters*)	Time of Tow (*Local*)
915	1	13 I 64	65°54′S	114°34′	4740	2059	1520
			66°16′S	113°39′	4873		2150
936	1	21 I 64	70°08′S	101°36′	3825	2379	1200
			70°06′S	100°55′	——		1650
946	1	26 I 64	67°47′S	90°28′	4154	1711	1820
			67°31′S	90°26′	——		2155
1288	6	3 X 64	40°00′S	76°06′	3971	2855-	1730
			40°22′S	76°20′	——	2507	2320
1303	1	18-19 X 64	59°59′S	101°18′	4575	1281-	2400
			60°11′S	101°16′	5124	970	0200
1304	1	19 X 64	60°12′S	101°16′	5033	864-	0305
			60°23′S	101°14′	5087	586	0619
1320	2	26 X 64	60°17′S	110°15′	5033	2379-	1330
			60°26′S	110°38′	5047	2288	1805
1380	2	17-18 XI 64	54°01′S	145°02′	3623	842-	2332
			53°53′S	145°13′	3697	686	0132
1396	1	26 XI 64	49°57′S	169°01′	4904	3111-	0535
			49°48′S	169°17′	5124	2507	0735
1488	2	7 VI 65	57°00′S	99°35′	4568	1830	1502
			57°05′S	99°17′	——		2025
R/V *Velero IV*							
10659	1	25 VIII 65	32°35′N	120°47′	3660	991	0240
			32°04′N	120°29′	——		1108

Manton's as the third abdominal appendages extend to the telson. They are similar in that the terminal dactyl is absent in both. Thus, the appendages are no more differentiated than are those of *N. bipes* even though those for *N. typica* are longer. As the carapace was distinctly defined at this stage these specimens have been included in Figure 2.

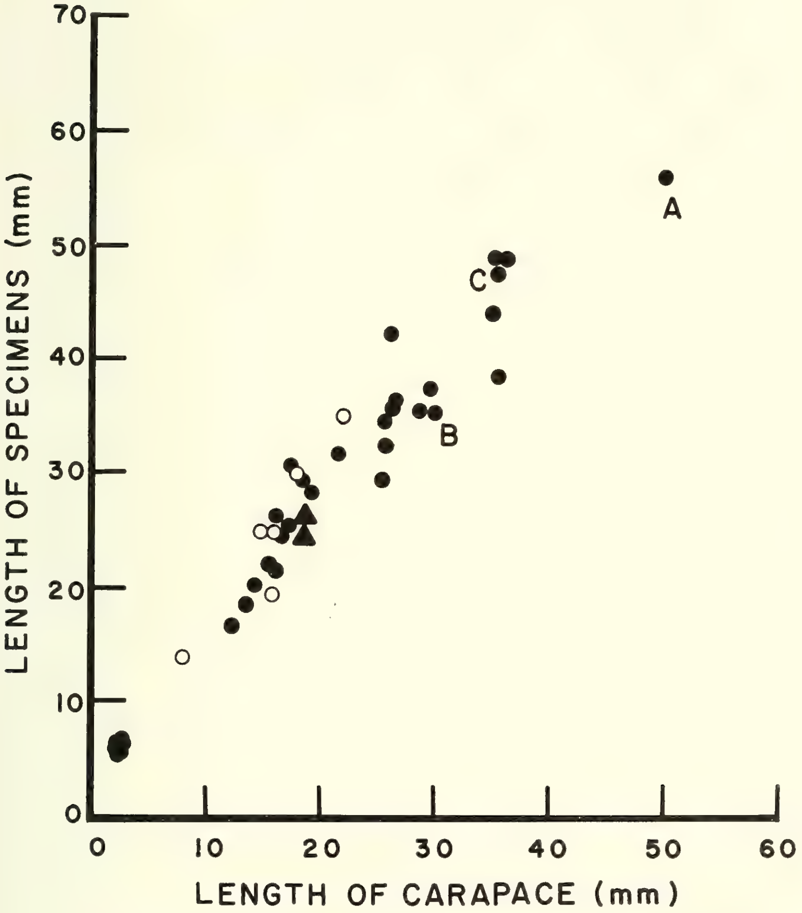

Figure 2. Ratio of the length of the carapace to the length of the entire animal in *Nebaliopsis typica.* Open circles—*Discovery* specimens; darkened symbols—USNS *Eltanin* specimens; circles—females and triangles—males. A indicates an adult that carried 163 embryos; B indicates an adult that carried 9 embryos; C indicates an adult that carried 86 eggs.

The largest specimen (taken at station 354) shed 163 individuals. These embryos were at an earlier stage of development than those of station 778 and they differed in more aspects from the development of *N. bipes* at a comparable stage described by Manton (1934) than did those of station 778. The appendages are as differentiated as "stage G" of Manton. The eye is less differentiated than in "stage G" and is closer to the optic rudiment in the stage just prior to hatching *N. bipes.* The rostrum is also rudimentary and in a comparable stage of development with that of the eyes. The yolk, comprising at least half the body mass, is more extensive than that of a similar stage of *N. bipes.* The embryos still retain the embryonic cuticle, which would place them at the same stage as figure 3E, of Manton (1934). The appendages, however, are considerably more differentiated than in the stage of *N. bipes* pictured in Manton's figure 3E.

An adult female from station 1288 released 86 eggs. Rudiments of the appendages were not visible in external examination.

It is hoped that as more specimens of this widely distributed, but not very abundant, species are observed that further details of its life history will be worked out.

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ADDITIONAL RECORDS OF THE SCYPHOZOAN *STEPHANOSCYPHUS SIMPLEX* KIRKPATRICK

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Biologists working in this laboratory have collected additional specimens of the scyphozoan *Stephanoscyphus simplex* Kirkpatrick since an earlier report (Brahm and Mohr, 1962). These constitute the first records of this species from the Peru-Chile Trench as well as additional records from the Arctic, North Atlantic, and the Antarctic Oceans.

Collections were made in the Arctic Ocean from the ice floe ARLIS 1 (Arctic Research Laboratory Ice Station), the ice island ARLIS 2, and the United States Coast Guard ice breaker USNS *Burton Island.* In the Peru-Chile Trench and the Antarctic Ocean, collections were made from the United States Antarctic Research Program vessel USNS *Eltanin.*

Several different types of collecting gear were used in obtaining these samples. The collections made from ARLIS 1 were usually obtained with an orange peel bucket (OPB), but *S. simplex* were also obtained with a #20 mesh, ½-meter closing net which hit the bottom, and with an improvised dredge. All bottom samples taken from ARLIS 2 were obtained with an improvised dredge. The samples taken aboard the USNS *Burton Island* en route to ARLIS 1 were collected with an orange peel bucket. Aboard the USNS *Eltanin* a one-meter trawl or Menzies trawl (Menzies, 1962) was most frequently used for benthic sampling. However, a modified ten-foot double beam trawl or Blake Trawl (Menzies, 1964), a Benthic Trawl, a Petersen Grab, and a Campbell Grab were also used in collecting bottom samples and were successful in obtaining *S. simplex*. Because of this great diversity of collecting gear, any quantitative analysis, or comparison of numbers of specimens in different regions is impossible.

The specimens all agree with the description of Kramp (1959) in both internal and external characteristics. The identification was based solely on the sessile stages. Most of the specimens still retained their pedal discs and none of the polyps contained medusae.

The stations at which *S. simplex* Kirkpatrick was collected are shown in Table 1 and Figure 1.

Figure 1. New locations of *Stephanoscyphus simplex* Kirkpatrick.

Most of the specimens were not attached when studied. However, some of the specimens were still attached to different substrates. One specimen taken from ARLIS 1 (Sta. 265) and another taken from ARLIS 2 (Sta. 416) were attached to mollusc shell fragments. One specimen from the Arctic was found on a rock (Sta. 446) and three were found on *S. simplex* polyps (Sta. 360, 396, and 446). In the Antarctic and Peru-Chile Trench, most of specimens were also unattached but fourteen were found attached to small pieces of wood (Sta. 25, 50, 127 and 333), sixty-two were found attached to stalks of

TABLE 1

A list of stations in which *Stephanoscyphus simplex* Kirkpatrick was found

Station Number	Number of Specimens	Collecting Instrument	Latitude	Longitude	Sample Depth (Meters)	Date
USNS *Eltanin*						
13	3	Beam Trawl	56°20′N 56°26′N	51°58′W 51°52′W	3488- 3492	29. 3. 62
18	14	Benthic Trawl	58°15′N 58°15′N	48°36′W 48°37′W	3404- 3422	3. 4. 62
25	27	Menzies Trawl	4°53′N 4°51′N	80°28′W 80°27′W	2489 ——	2. 6. 62
30	28	Menzies Trawl	0°01′S 0°01′S	81°44′W 81°44′W	1171- 1180	4. 6. 62
37	62	Blake Trawl	8°11′S 8°10′S	81°08′W 81°10′W	6006	8. 6. 62
38	4	Menzies Trawl	8°05′S 8°00′S	81°09′W 81°07′W	5746- 5948	8. 6. 62
40	11	Menzies Trawl	13°10′S 13°07′S	77°57′W 77°57′W	3404- 3495	11. 6. 62
43	3	Menzies Trawl	13°19′S 13°14′S	78°04′W 78°07′W	5234- 5314	12. 6. 62
50	49	Menzies Trawl	16°12′S 16°10′S	74°41′W 74°41′W	2599- 2858	15. 6. 62
67	54	Menzies Trawl	25°42′S ——	71°22′W ——	5783- 5797	22. 6.62
76	18	Menzies Trawl	31°13′S 31°14′S	72°20′W 72°21′W	3541 ——	25. 6. 62
84	3	Petersen Grab	31°55′S 31°54′S	72°55′W 72°44′W	4634 ——	5. 7. 62
127	109	Menzies Trawl	61°45′S ——	61°14′W ——	4758 ——	1. 8. 62
129	1	Menzies Trawl	61°46′S 61°48′S	61°35′W 61°25′W	3678- 3816	2. 8. 62

TABLE 1 (*continued*)

A list of stations in which *Stephanoscyphus simplex* Kirkpatrick was found.

Station Number	Number of Specimens	Collecting Instrument	Latitude	Longitude	Sample Depth (Meters)	Date
155	1	Menzies Trawl	56°34′S	63°18′W	3927	17. 8. 62
			56°29′S	63°13′W	——	
208	7	Campbell Grab	37°29′S	73°55′W	957	11. 9. 62
			37°30′S	73°55′W	——	
333	41	Campbell Grab	42°56′S	75°36′W	3655-	27. 11. 62
			42°56′S	75°34′W	3651	
853	*	Blake Trawl	64°03′S	79°15′W	4264	16. 11. 63
			63°58′S	79°16′W	——	
875	*	Rock Dredge	56°24′S	78°51′W	4301	28. 11. 63
			56°18′S	78°56′W	——	
884	*	Blake Trawl	56°54′S	115°10′W	1743	31. 12. 63
			56°57′S	115°12′W	——	
USNS *Burton Island*						
——	1	OPB	73°43.2′N	126°40.7′W	110	6. 9. 60
——	1	OPB	74°19.8′N	127°21.2′W	375	7. 9. 60
ARLIS 1						
265	1	#20 closing net	74.6°N	155.5°W	1145	22. 12. 60
360	4	Dredge	74.5°N	163.9°W	747	16. 1. 61
396	3	OPB	74.8°N	165.6°W	411	26. 1. 61
446	6	Dredge	74.8°N	165.6°W	419	9-10. 2. 61
460	2	OPB	74.9°N	165.9°W	436	17. 2. 61
459a	1	OPB	74.9°N	165.9°W	427	17. 2. 61
474	1	OPB	74.7°N	166.3°W	407	2. 3. 61
ARLIS 2						
383	3	Dredge	77°26′N	178°41.5′E	1350	20. 12. 61
416	2	Dredge	77°20′N	179°34.5′E	1260	30. 12. 61
408	1	Dredge	77°18′N	179°23.5′E	1260	27. 12. 61
460	2	Dredge	77°47′N	178°35′E	1440	10. 1. 62

*Identified in field; not currently available.

seaweed (Sta. 37), twenty were found on foraminiferans (Sta. 40, 50, 76 and 127), and twenty-five were embedded in gravel (Sta. 127 and 129). Notations made by J. F. Tibbs indicate that *S. simplex* was one of the few benthic organisms collected in the vicinity of manganese nodules.

This species appears to have a broad distribution (Kramp, 1959; Hartman and Barnard, 1960; Brahm and Mohr, 1962). Of thirty-two bottom samples from the Arctic Ocean, *S. simplex* was present in fifteen. The depth varied from 110 meters to 1440 meters. Seven of the negative stations were from depths of over 1800 meters while the species was present in fifteen of the remaining twenty-five samples. This would suggest that *S. simplex* is found in shallower depths in the Arctic Ocean than elsewhere, as noted for echinoderms by Hofsten (1915). The specimens in the Antarctic were found to 6000 meters. This follows a trend of species being in deeper waters in the Antarctic than the Arctic which was noted by Menzies (1963).

The distribution of the species along the Peru-Chile Trench and past the Antarctic Convergence is also of note; Menzies (1962) has found that this is not the usual distribution for the isopods of the bottom and work in progress suggests this is also not usual for bryozoans (Bullivant, *pers. comm.*, 1965). Ekman (1953) also notes a large number of echinoderm species endemic to the Antarctic.

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ANTARCTIC SCOPELARCHIDAE: A NEW FISH OF THE GENUS *BENTHALBELLA* AND THE DISTRIBUTION OF *B. ELONGATA* (NORMAN)

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The new Antarctic species described here was collected by members of the Department of Biological Sciences and Allan Hancock Foundation of the University of Southern California aboard the USNS *Eltanin* while engaged in an ecologic study of the marine biota of the Antarctic Seas. The study is supported by the United States Antarctic Research Program of the National Science Foundation (G-19497). The type series is represented by 30 *Eltanin* specimens (67.7-221 mm. standard length) and one specimen from the southwestern Pacific that was kindly loaned by Richard H. Rosenblatt of the Scripps Institution of Oceanography. All specimens were taken by 10-foot Isaacs-Kidd midwater trawls.

The new *Benthalbella* resembles its congeners in the forward position of the ventral fins (in advance of the dorsal origin), the elongate body and the high vertebral count (60-63).

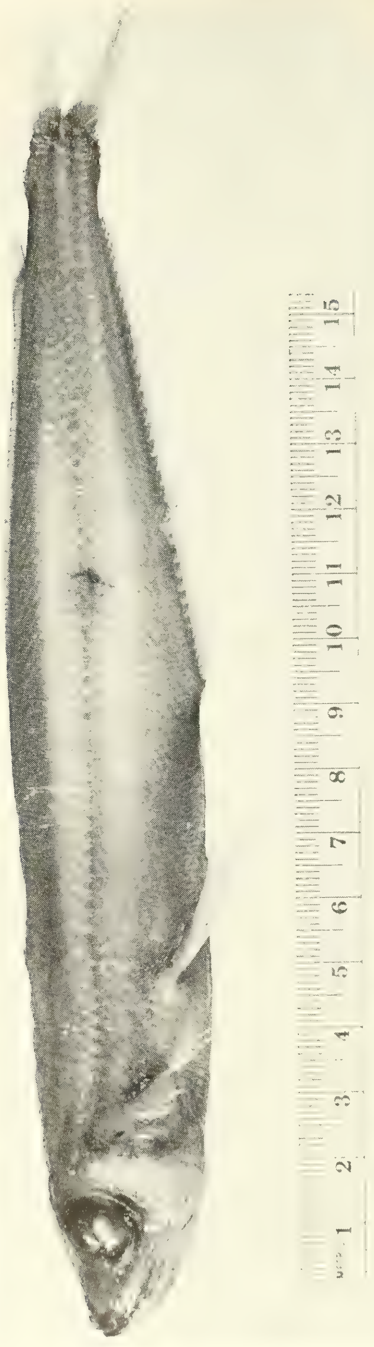
Specimens have been deposited at the Los Angeles County Museum (LACM), Scripps Institution of Oceanography (SIO), U.S. National Museum (USNM) and the British Museum of Natural History (BMNH).

We wish to thank all persons responsible for making the collections and Robert J. Lavenberg, John R. Paxton and Jay M. Savage for critical reviews of the manuscript.

Benthalbella macropinna, new species

Figure 1

Holotype. LACM 10118; 209 mm. standard length (SL); *Eltanin* station (Elt. Sta.) 359, Scotia Sea, 56°17′S, 58°09′W; 6-7 December 1962. Collected by an Isaacs-Kidd 10-foot midwater trawl towed between the surface and 840 meters over a bottom of 3960-3990 meters.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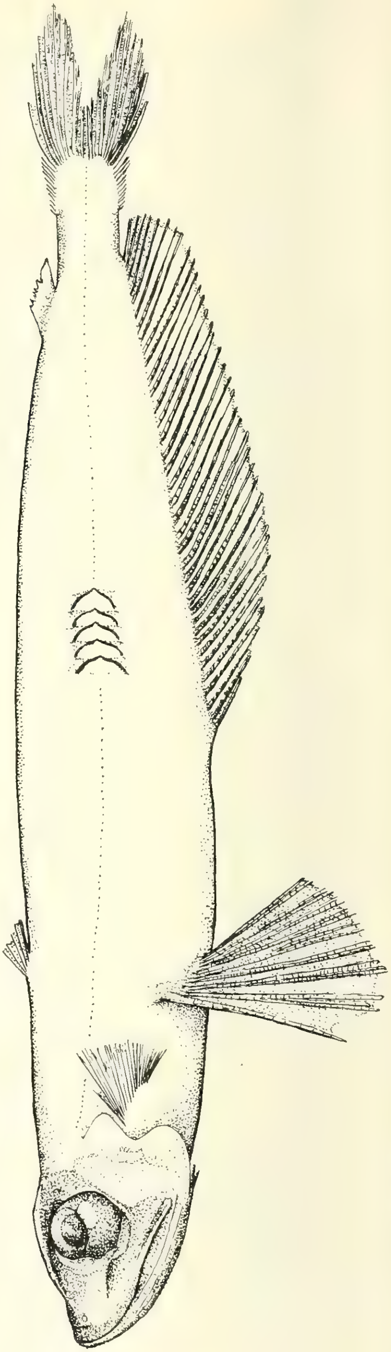

Paratypes. LACM 10119; 1, 117 mm. SL; Elt. Sta. 141, 60°19′S, 65°08′W. LACM 10120; 1, 118 mm. SL; Elt. Sta. 143, 60°05′S, 65°11′W. LACM 10121; 1, 114 mm. SL; Elt. Sta. 148, 59°10′S, 65°04′W. LACM 10122; 1, 175 mm. SL; Elt. Sta. 285, 65°58′S, 70°35′W. LACM 10123; 1, 163 mm. SL; Elt. Sta. 396, 59°02′S, 56°05′W. LACM 10124; 1, 126 mm. SL; Elt. Sta. 397, 59°11′S, 56°12′W. LACM 10125; 1, 221 mm. SL; Elt. Sta. 563, 48°13′S, 20°26′W. LACM 10126; 1, 192 mm. SL; Elt. Sta. 738, 53°06′S, 37°43′W. LACM 10127; 1, 108 mm. SL; Elt. Sta. 802, 66°08′S, 82°32′W. LACM 10128; 1, 94 mm. SL; Elt. Sta. 836, 61°52′S, 75°14′W. LACM 10129; 1, 138 mm. SL; Elt. Sta. 839, 61°05′S, 74°59′W. LACM 10130; 1, 140 mm. SL; Elt. Sta. 854, 63°57′S, 79°25′W. LACM 10131; 1, 218 mm. SL; Elt. Sta. 866, 59°45′S, 78°35′W. LACM 10132; 1, 94 mm. SL; Elt. Sta. 882, 55°10′S, 114°15′W. LACM 10133; 1, 125 mm. SL; Elt. Sta. 890, 59°45′S, 114°50′W. LACM 10134; 1, 156 mm. SL; Elt. Sta. 900, 62°03′S, 115°07′W. LACM 10135; 1, 179 mm. SL; Elt. Sta. 949, 65°47′S, 88°48′W. LACM 10136; 1, 137 mm. SL; Elt. Sta. 952, 63°39′S, 86°54′W. LACM 10137; 1, 190 mm. SL; Elt. Sta. 1099, 57°00′S, 89°09′W. LACM 10138; 1, 132 mm. SL; Elt. Sta. 1121, 62°14′S, 89°55′W. LACM 10139; 1, 111 mm. SL; Elt. Sta. 1162, 59°35′S, 130°25′W. LACM 10140; 1, 140 mm. SL; Elt. Sta. 1163, 60°02′S, 130°32′W. LACM 10141; 1, 90 mm. SL; Elt. Sta. 1204, 55°57′S, 159°22′W. LACM 10142; 1, 150 mm. SL; Elt. Sta. 1324, 58°37′S, 108°50′W. LACM 10143, 1, 155 mm. SL; Elt. Sta. 1342, 56°12′S, 120°07′W. LACM 10144; 1, 125 mm. SL; Elt. Sta. 1358, 57°44′S, 137°51′W. SIO 61-42-25A; 1, 188 mm. SL; 57°55.8′S, 168°53.2′E. USNM 260173-F1; 1, 207 mm. SL; Elt. Sta. 396. USNM 260173-F2; 1, 135 mm. SL; Elt. Sta. 1162. BMNH 1965.5.26.4; 1, 198 mm. SL; Elt. Sta. 143.

Diagnosis. Benthalbella macropinna is distinguished from all other species of *Benthalbella* by its high anal ray count, 35-37 (17-30 in other species); low dorsal ray count, 5-6 (6-10 in other species) and anterior insertion of the dorsal fin, predorsal length 27.8-32.8 per cent of SL (ca. 38-43 per cent of SL in other species).

Description. Body elongate; dorsal margin posterior to head nearly straight; ventral margin tapering gradually from head to deepest point of body (at anal origin); anal fin base extending in straight line to caudal peduncle. Head and body compressed, greatest width between opercles, body tapering to tail. Head profile convex over eyes, curving upward at tip of snout; inter-orbital space very narrow. Wide notch on opercular border conforming to pectoral fin base. Paired nostrils close behind tip of snout; anterior and posterior nasal openings separated by narrow membrane. Posterior border of maxillary reaching a vertical through posterior edge of orbit (maxillary slightly shorter in juveniles). Both jaws curving abruptly upward at snout, lower extending beyond upper jaw. Lateral line sloping from upper edge of gill opening to about midway between ventral base and dorsal margin and following a straight line to caudal base. Gillrakers absent. Pseudobranch present.

Proportions for the holotype and ranges for 12 paratypes are presented in Table 1. Counts for the holotype are followed by those for the paratypes in parentheses: D. 5 (5-6); A. 37 (35-37); P. 26 (25-27); V. 9 (9); C. 19 (19). Last dorsal, anal and ventral rays divided to base and counted as one. Dorsal fin rays weak, inconspicuous, originating behind origin of ventral fins. Anal fin base and rays very long; second or third ray longest (9 per cent of SL). Pectoral rays just reaching ventral origin; upper edge of base on a level with lower margin of orbit. Ventral fin rays strong, reaching three-fourths distance to anus; wide ventral base originating midway between lateral line and ventral margin. Posterior end of adipose base lying above terminal fourth or fifth anal ray; origin of adipose fin indistinct, continuous with a fatty ridge extending nearly to point above anus. A similar fatty ridge on ventral midline between anus and ventral fin bases. Caudal fin forked, principal rays preceded by 14-15 dorsal and ventral procurrent rays.

Tooth counts based on ten adult specimens: premaxillary 60-76; dentary, inner row 10-12, outer row 39-45; palatine, medial row 11-15, lateral row 2-4; lingual 13-16. Premaxillary teeth and outer row of dentary teeth small, close-set, slanting slightly toward rear of jaw. Inner row of dentary teeth, medial row of palatine teeth and lingual teeth long, dagger-like and sagittate. Smallest specimens have similar counts.

Body, nape and cheek covered with moderate-sized deciduous scales. Lateral line scales cycloid (only ones remaining on present specimens), enlarged, with one or two extending onto middle caudal rays. Each lateral line scale three dimensional, anterior border inferior and covered by raised posterior border of preceding scale; center of each scale pierced by a large lateral line pore to form a large lateral line canal, lined by anterior border of each scale and covered by posterior scale borders.

Eye lenses directed upward. White pearl-colored organ on black ventral half of eye. Horizontal length of organ one half (juveniles) to two-thirds (adults) of lens diameter. Vertical length of organ one third (juveniles) to one half (adults) of lens diameter. Upper margin of pearl-colored organ bordered by a band of superficial melanophores, varying from an intense band in small specimens to a diffuse band of fine dots in adults.

Precaudal vertebrae 13-14, caudal vertebrae 46-50, total vertebrae 60-63 (defined according to Hubbs and Lagler, 1958). If the first caudal vertebra is considered to be the one that corresponds to the interhaemal of the first anal ray, then the formula is 24-25 precaudal, 36-38 caudal vertebrae.

Esophagus short; posterior caecum of stomach very long, extending nearly to anal opening; pyloric region very short and constricted; two long pyloric caeca present; intestine a straight tube nearly the length of the body cavity. Stomach and intestine unpigmented, peritoneum black.

Specimens containing large (mature?) ovaries were collected throughout the year and may indicate a long or continual breeding period. Distinct ovaries were present in 27 individuals. Gonads were not detected on the three smallest specimens (90-94 mm. SL) and the Scripps specimen was not dissected. A histological examination of the gonads of two mature specimens revealed no trace of testicular tissue.

Small specimens (up to 110 mm. SL) are nearly colorless. The body wall is transparent and the black peritoneum gives a dark appearance to the ventral half of the trunk. The thin muscular layer over the body wall contrasts strikingly with the much denser dorsal musculature and the muscles associated with the ventral fins. Larger specimens are light brown, evenly covered with small melanophores. The caudal and anal fin membranes are lightly pigmented, but the other fins are colorless. Freshly preserved material has a silvery sheen over the entire body.

Distribution. The distributions of *B. macropinna* and the only other known Antarctic scopelarchid, *B. elongata* (Norman), are shown in Figure 2.

Benthalbella macropinna occurs in Antarctic waters between 48°13′ and 66°08′S. Its distribution is generally south of the Ant-

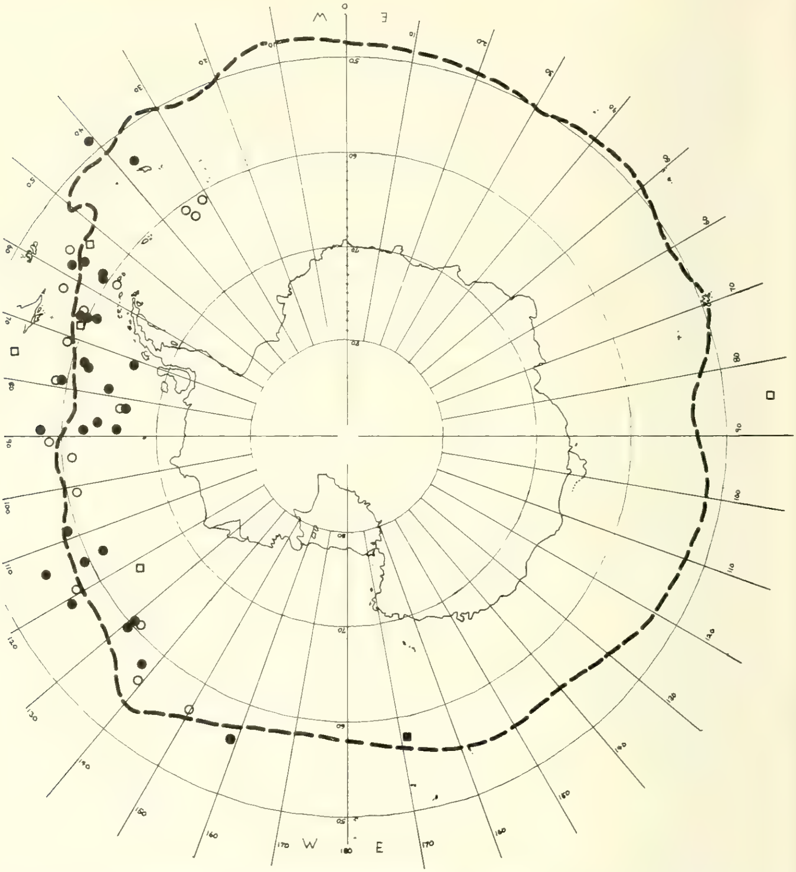

Figure 2. Distribution of *B. macropinna* (solid symbols) and *B. elongata* (open symbols). Circles represent *Eltanin* material; squares represent other records (Marshall, 1955; Andriashev, 1960). Antarctic Convergence shown as a dashed line.

arctic Convergence, but the species has been taken somewhat to the north of the Convergence as delimited by Deacon (1937). A circumpolar distribution is indicated because specimens have been taken between 37°43′W. and 168°53′E.

Benthalbella elongata has a distribution similar to the new species and was collected with it in the same haul on four occasions (Elt. Sta. 148, 802, 866 and 1163). *Eltanin* collections of *B. elongata* were made between 54°95′ and 61°31′S and between 31°04′ and

149°57′W. Other records, including one off South Africa, are summarized by Andriashev (1960).

Specimens of *B. macropinna* were collected in hauls reaching 610 to 2750 meters. *B. elongata* was taken between the surface and 2930 meters. No relationship between size of fish and depth of haul is apparent.

Discussion. Marshall (1955) considered the generic name *Benthalbella* Zugmayer (1911) unavailable because the generotype, *B. infans*, was a *species inquirenda* at the time of publication. He adopted *Neoscopelarchoides* Chapman (1939) (generotype *N. dentatus*) as the next available name. A *species inquirenda* is a doubtfully identified species. Zugmayer, in describing *B. infans*, indicated his belief that it was clearly a new genus and species regardless of the fact that it was a post-larva and that he was uncertain of its familial position. *Benthalbella* satisfies all the requirements for availability listed in chapter four of the International Code of Zoological Nomenclature (1964). In accord with the Law of Priority (Art. 23), *Benthalbella* (generotype *B. infans*), the oldest available name, must stand.

On the basis of superficial characters, *B. macropinna* resembles those species with high anal ray and vertebral counts: *B. elongata*, *B. linguidens* (Mead and Böhlke) and *B. diaphana* Rass. No close alliance between any of these forms and the new species is apparent however.

Of the known species of *Benthalbella*, *B. elongata* is the only species in which the adults retain a colorless peritoneum. All other members of this genus have unpigmented alimentary tracts, but black peritoneum in adults. McAllister (1959) advanced the hypothesis that the intense pigmentation of the digestive tract and/or the peritoneum favors predators by absorbing light emitted from engulfed luminous prey. His idea that this luminescent food would reveal the fish's position to a predator may be questioned because lanternfish (Myctophidae) were found in the stomachs of both unpigmented *B. elongata* and pigmented *B. macropinna.*

No male specimens of *B. macropinna* nor *B. elongata* were found, although 27 females of the former and 15 females of the latter species were examined. Cross-sections of the gonads from two specimens of each species reveal normal cystoarian ovaries with no associated testicular tissue. Therefore, the lack of male specimens probably should be attributed to other phenomena than hermaphroditism. It is possible that males are very rare or are not collected by the present collecting gear because of their small size, great velocity or somewhat different habitat.

TABLE 1

Body proportions for the holotype and ranges for 12 paratypes of *B. macropinna*, expressed as per cent of standard length.

	Paratypes		Holotype
	5 specimens	7 specimens	LACM 10118
Standard length (mm.)	67.7-140	163-221	209
Head length	20.2-22.6	17.7-21.6	19.0
Head depth	12.2-13.8	12.5-13.7	12.5
Snout length	5.1- 6.0	4.5- 5.5	4.9
Orbit diameter	7.9-10.7	5.9- 8.7	6.9
Interorbital distance	0.9- 1.3	0.9- 1.2	1.1
Postorbital distance	9.2-11.0	8.6-10.9	9.3
Upper jaw length	14.2-15.8	13.7-14.6	13.8
Mandible length	16.4-18.0	16.0-16.9	15.8
Body depth at ventral fin origin	10.9-16.3	14.1-16.7	15.2
Body depth at anal fin origin	12.9-14.7	14.6-19.0	16.8
Depth of caudal peduncle	3.5- 5.2	4.8- 5.6	4.8
Predorsal length	29.8-32.8	27.9-31.3	29.7
Preanal length	50.0-52.3	51.0-54.7	52.6
Prepectoral length	19.5-21.8	16.3-19.5	19.0
Preventral length	29.0-31.6	25.9-30.6	29.9
Distance from dorsal origin to caudal base	68.0-72.1	68.5-73.0	71.3
Distance from anal origin to caudal base	47.4-49.6	48.1-51.7	53.5
Pectoral fin length	9.6-13.0	7.7-10.0	7.7
Ventral fin length	16.7-20.2	16.7-18.1	17.8

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The literature on scorpion behavior is relatively sparse. Some of the reported observations apparently are results of a rather small sampling of individuals and species. The author has worked with living scorpions since 1935 and the Poisonous Animals Research Laboratory has processed a minimum of ten thousand living specimens annually since 1945. Most of these scorpions were and are from Arizona, with other areas of Southwestern United States being the next most common source. However, living material is also received almost weekly from remote parts of the world. A large number of the Arizona scorpions have been and are being used as a venom source for the manufacture of an anti-venin and in comparative venomology. Those from other areas were and are used as a source of venom but also in a study of the general biology of scorpions. Finally, the especially significant scorpion specimens were and are preserved as a part of a rather extensive collection for taxonomic and related studies. Unless otherwise indicated, the observations reported herewith are original and have never been published but are now presented with the hope of suggesting and encouraging much needed behavioral studies.

In many ways scorpions are highly desirable subjects for study. They are easily kept in captivity, feed readily, require only a small housing space, are relatively free of disease, can undergo relatively rough handling and are considered one of the oldest taxa of terrestrial animals.

The contemporary forms are divided into six families: the Buthidae, Chactidae, Diplocentridae, Vejovidae, Bothriuridae and Scorpionidae. Only the first four are represented in the scorpion fauna of the United States. Here the family Vejovidae has the largest number of species but the genus *Centruroides* of the family Buthidae has the largest populations.

Behavior as Related to Habitat: Scorpions can be roughly classified into two groups according to their usual habitat; *i.e.*, as either "bark" scorpions or "ground" scorpions. The Buthidae belong to the former group while the ground scorpions encompass the other families. As the designation indicates, bark scorpions are frequently, but not exclusively, found under the loose bark of trees (*e.g.*, in Arizona that of the cottonwood, pepper, eucalyptus) and in the crevices at the base of old petiole stubs of palm fronds. These are habitats of choice especially in the winter months when they may be found literally in piles of twenty to thirty animals. In laboratory containers, *Centruroides sculpturatus* Ewing, when not active during the daytime, will be found in stacks and, when the numbers are large enough (200 to 500 specimens), will form a living ramp over which active specimens escape over the edge of the container. When hiding under objects they generally display negative geotaxis. Frequently people are stung while picking up a board or rock because they press a scorpion which is clinging to the underside. In contrast to this, ground scorpions are rarely found clinging to the underside of the protecting object.

The position in which the cauda is held differs in ground and bark scorpions. When inactive, bark scorpions generally rest the curled cauda laterally on the substrate while that of the ground scorpions is curled over their dorsum. When moving leisurely at about 15°C bark scorpions of the genus *Centruroides* (Buthidae) make a definite "taildrag" in a fine dry sand substrate but ground scorpions carry the tail curled over their back.

Another contrasting behavior between these two groups relates to digging. Whereas ground scorpions are effective, vigorous and rapid diggers, bark scorpions seldom dig. A *Centuroides* scorpion placed under an inverted beaker on loose sand will dig out but over packed sand it seems helpless. The digging action of *Centruroides* is not vigorous and quite different from a vejovid scorpion. The latter will dig vigorously with its four front legs while resting on the posterior four. When the digging ceases, the hind four are used to kick the soil still farther back. The digging usually takes place shortly after the animal is placed under the inverted beaker. On the other hand, a *Centruroides* specimen may wait for hours before attempting to dig and the action is usually quite different. Generally the first three legs on one side are used to scrape out loose sand and then the three legs on the other side are used in the same type of action. Sometimes only the first and/or the second legs are used on one side and then the other. When a small space appears under the vessel, the pedipalps are pushed through and used in a pulling action while the last pair of legs are used for pushing. Then a pushing, pulling, wriggling action ensues. Even the telson may be used to help in the pushing action. The total activity is not very vigorous and the scorpion may rest frequently and for periods of 5 to 20 minutes. Once the pedipalps and anterior portion of the cephalothorax are under the edge of the vessel, no further definite digging action takes place. A wriggling, pushing action finally frees the animal from the inverted beaker. *Centruroides* scorpions will, likewise, not dig under objects to hide. Even their tendency to negative phototaxis and positive thigmotaxis does not stimulate them to burrow under a flat object pressed firmly against a sand substrate. On the other hand, if even a slight crevice is made available they manage by a sort of wriggling motion to force their way under the object. Ground scorpions are frequently found in sand taken from desert washes, but the above mentioned buthids have never been found under these conditions. Laboratory observations on buthids from other parts of the world and personal communications with biologists from these regions indicate that this seeming lack of burrowing behavior is a rather common family characteristic.

Some species of ground scorpions dig extensively. The larger species of the Diplocentridae have been observed to dig burrows up to eight or ten inches in length, using the entrance of the burrow as a site for capturing prey. Some vejovids [*e.g. Vejovis spinigerus* (Wood), *Hadrurus arizonensis* Ewing] in addition to digging under a rock, or other object, make burrows of considerable depth, some of which are often merely the enlargement of existing ground cracks. A ground scorpion under a rock in a desert wash will often follow the receding moisture line as the summer advances. *H. arizonensis* has been taken at a depth of eight feet below the surface of the sand. A well-fed scorpion is able to remain at such a depth until the temperature or moisture conditions moderate. The fact that the burrow caves in, burying the scorpion, seems to be of small consequence. Flooding such an area will cause the scorpion to surface.

Centruroides species invade human habitations more frequently than do the vejovids, chactids and diplocentrids. When members of the latter taxa do enter a house they are generally found under objects or in remote crevices. Centrurid specimens will, on the other hand, crawl on walls and ceilings; often eating prey while in such locations. Occasionally, they lose their "claw hold" and fall; the landing place may be an otherwise occupied human bed.

Behavior as Related to Survival: Satiation seems to play an important role in the reaction of scorpions to their environment and in their survival. Any behavioral study would have to take into account the state of their nourishment at the time of the observations. Satiated scorpions generally respond slowly or not at all to some stimuli while hungry scorpions are, in contrast, surprisingly alert. Hungry scorpions respond quickly to changes in light intensity while satiated individuals are very slow to react. A satiated scorpion may not respond to an insect crawling on it while a hungry scorpion reacts to its presence often without physical contact. Satiated scorpions are able to survive for long periods without food and water and with very little air. Satiated specimens of *H. arizonensis* have been kept in open containers for nine months without food or water. Well fed specimens of *C. sculpturatus* kept in glass vials closed with cork stoppers have survived 30 days without food or water.

C. sculpturatus is able to resist the harmful effects of fumigants. The products of burning formaldehyde or sulfur candles produce no apparent harmful effects to these scorpions. During exposures of up to one hour they were inactive but not incapacitated. Immediately upon removal from the test chamber, the exposed scorpions moved about in a normal manner. Exposure of approximately twenty minutes in a cyanide killing jar inactivates specimens of this same species but apparently full recovery occurs after removal from the jar.

The natural defenses of this ancient order apparently cannot cope with kerosene solutions of pyrethrum and the chlorinated hydrocarbons. A 0.15% concentration of pyrethrum will prove lethal to *C. sculpturatus* in approximately 20 minutes. A 10% DDT solution placed by means of a small, camelhair brush on only the pectines of this species will gradually produce a typical DDT syndrome and terminate lethally in about 3 to 5 days. Other small body areas, *e.g.* the ventral surface of the cauda or the two most posterior preabdominal sternites or the pedipalp chela, painted with this DDT solution will prove lethal in from 5 to 8 days. Three percent chlordane is not only lethal but fast acting. Apparently the pectinal movements against the substrate (subsequently discussed) and the taildrag of *C. sculpturatus* make it especially vulnerable to these residual, cuticle-penetrating insecticides.

At various times, specimens of *C. sculpturatus* and *H. arizonensis* have been recovered from the water in irrigation ditches in a completely limp condition with no visible sign of life. In one of our first experiences, the specimen was placed on paper toweling preparatory to mounting it in plastic on the following day. The next morning, however, the scorpion had disappeared. As other specimens were obtained from the same source, they were observed after being placed on paper toweling. Slight movements were observed after approximately three-fourths of an hour with apparent complete recovery in all cases within 2 hours. Mazzotti (1963) reports *Centruroides limpidus* (Karsch) surviving submersion for a period of 3 hours (10 specimens) with 100% survival, whereas after submersion of 6 hours, one out of ten did not succumb.

Scorpions appear to differ in their ability to survive freezing temperatures. Specimens of *C. sculpturatus*, *C. vittatus* (Buthidae), *V. spinigerus* (Vejovidae) and *Superstitionia donensis* Stahnke (Chactidae) were placed simultaneously and for the same length of time in the cube-freezing compartment of a refrigerator. All specimens were frozen stiff. The buthids did not recover but the other two species started to move slightly after thawing and finally seemed to regain normal activity. *S. donensis* and *V. spinigerus* are frequently, but not exclusively, found at elevations from 4000 to 7000 feet.

As has been intimated above, scorpions are hydropositive. The attraction is so great that a moist burlap sack can be used as a trapping device. The buthids of the United States drink water readily in captivity but the ground scorpions do so rarely; merely lying in a moist microhabitat seems to suffice. Laboratory tests have shown that buthids are positively rheotactic to a moisture-laden or cool current of air. Thus they are attracted into human dwellings and congregate around moist or cool areas, such as in bath tubs, sinks and the folds of moist clothing. Recently Abushama (1964), using *Leiurus quinquestriatus* (H & E), reported laboratory findings in support of these general observations.

Sensory Receptors and Behavior: Scorpions possess sensory organs that are more or less peculiar to the group. Notably so are the pectines. These are ventrally located comb-like structures articulating with the lateral areas of the basal plate. Each pecten consists, usually, of four areas: the marginal lamellae, the middle lamellae, smaller subcircular to subtriangular fulcra and the so-called "teeth" of the comb. These areas vary widely within the order. Some groups lack the middle lamellae while others have over twenty. Others again have no fulcra, but all species have pectinal teeth. These, however, vary widely in shape, size and number between the sexes and from species to species. They range in number from 3 to over 40, and in shape from short or long, narrow projections, to short or long, broad, paddle-like structures. On the ventro-lateral margin, the teeth usually bear large numbers of stubby bristles (Sinnesborste).

The pectines are recognized as representing the modified appendages of the 9th somite of the body (*i.e.*, the 3rd mesosomal segment), but their function has raised considerable dispute. The great diversity in their structure could indicate some diversity in function. Dumeril (1806) and Ubisch (1922) gave them roles in respiration; Meckel (1829) and Dufour (1856) considered them as external genitalia; Blanchard (1853) said they served to hold the two sexes during mating; Gaskell (1902) assigned to them functions of equilibration and audition; while Cloudsley-Thompson (1955) concluded that the main function of the pectines of scorpions lies in the perception of ground vibrations. Convincing evidence is lacking in support of any of these functions.

The tactile function of the pectines can be readily demonstrated by placing scorpions within a screen cube. As a specimen attempts to crawl at right angles over two adjoining edges in the cube, there will be a time when the gently waving pectines will not touch the wire surface. When this occurs, the scorpion stops at once, backs up and maneuvers away from the right angled approach until at least one pecten touches the surface before moving forward. This behavior can be duplicated by placing a scorpion on a table top so that it crawls at right angles to the sharp edge. The same type of trial and error takes place and the scorpion will move at an acute angle over the edge of the table to the underside. If this scorpion is again placed on the table top and stimulated to move rapidly, the pectines are held close to the body surface and the animal will bolt over the edge of the table.

The pectines also appear to function as chemoreceptors. A hungry scorpion will crawl over a dead insect until the pectines make contact. It is then that the scorpion moves backward and picks up the insect. Animals with pectines amputated will not react in this manner. Pocock (1893) reported a similar observation. Alexander and

Ewer (1957) presented similar evidence for the chemoreceptor function of the cheliceral platelets (trichocopae) found on the scorpion, *Opisthophthalmus glabrifrons* Pet. and *O. latimanus* C. L. Koch (Scorpionidae). The trichocopae consist of a row of three to seven platelets on the basal segment of each chelicera.

Tests with *C. sculpturatus* for auditory function of the pectines gave negative results. Both tuning forks and an audiogenerator were used, the latter through a range of 20 to 20,000 cycles per second. No response was elicited when air was the transmitting medium. Vibrations transmitted through a solid substance caused resting scorpions to move in both normal and pecten-amputated specimens.

Stinging Behavior: Scorpions sting both offensively and defensively. The cauda has five segments whose joints each permit enough freedom for rotatory movement so that the aculeus can be directed in all directions except toward the ventral surface.

In a defensive action, representatives of the genera *Hadrurus* and *Paruroctonus* raise both post- and pre-abdomens in a stiff, vertical position (Fig. 1). When strongly stimulated they strut in this threatening manner. The stinging action is a quick but well directed thrust. Other taxa of ground scorpions, as well as the buthids, deliver a series of flicking, chance thrusts of the aculeus followed by hurried attempts to escape.

The offensive sting of the scorpion is a more deliberate, thrusting action. This occurs when the prey is obstreperous and will not quietly submit to being devoured alive. Scorpions with powerful chela depend largely upon their pinching and crushing ability for both offensive and defensive action. The chela of some scorpions are often powerful enough to draw blood from a person holding the scorpion only by its cauda. The aculeus is also used to remove particles, especially irritating substances, from the trunk surface. Dried feces on the dorsum of the trunk are sometimes removed by a scraping action of the aculeus. This action may be elicited through irritation caused by excessive heat which may be induced by placing the scorpion within a ring of fire or by means of a lens concentrating a fine point of sunlight on its dorsum.

Food and Feeding Behavior: Scorpions eat small animals, both invertebrates and vertebrates, which they are able to subdue. Normally they eat insects, spiders, centipedes and the like. Sowbugs (Isopods, mostly *Porcellio laevis* Koch), for some reason, are re-

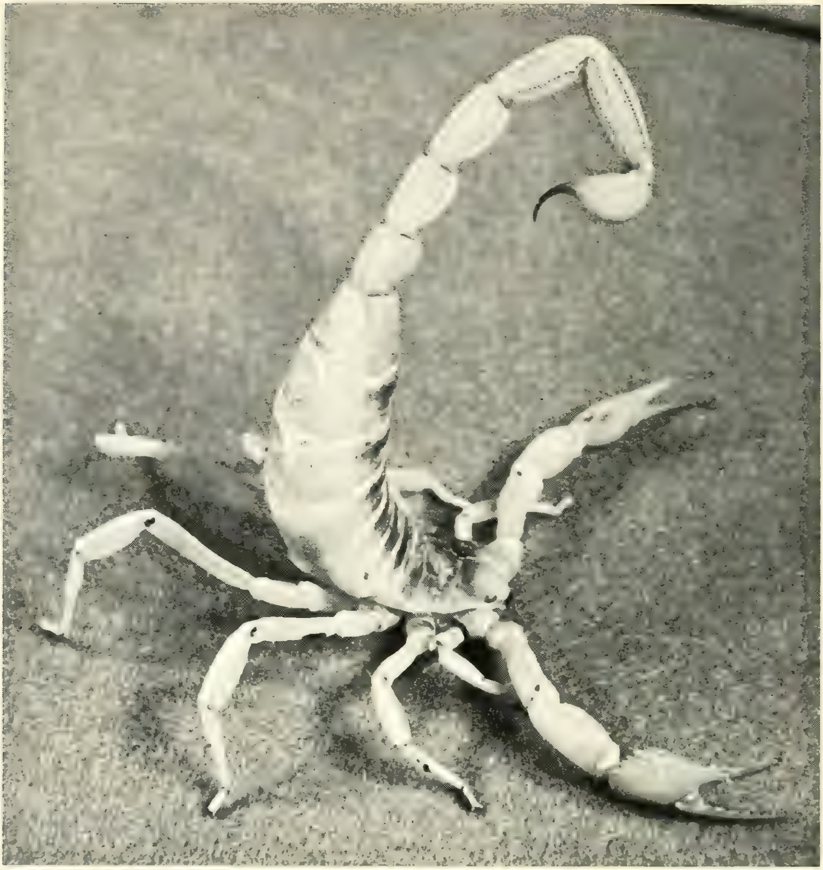

Figure 1. Defensive strutting-threatening behavior of *Hadrurus arizonensis.*

jected. A very hungry scorpion may grab one with its chela but drop it shortly thereafter. *H. arizonensis* has been observed, both in captivity and in its natural habitat, to eat a lizard *(Cnemidophorous)* (Fig. 2) with a total length of about 8 inches. Brunson (1951) published an excellent photograph of *H. spadix* Stahnke devouring a month-old water snake, *Natrix sipedon sipedon* (Linné).

The actual eating process has been variously reported. Brunson's (1951) remarks are representative of the common point of view. He states, "The most remarkable feature of the whole process was that

Figure 2. H. arizonensis eating a *Cnemidophorus* lizard.

nothing was left of the snake—not even a part of a bone or a tooth, nor could anything be identified in the resultant feces." This same statement seems apparently true when the prey is an insect except that this would be saying that the scorpion can digest the sclerotized portions of the integument.

Scorpions ingest only the body fluids of their prey and the concomitant tiny, solid particles held in suspension. The prey is torn into tiny bits which are packed together as small pellets and may be literally thrown away.

Numerous species have been carefully observed, both by the author and his students, eating insects of various kinds. The process is very similar in all cases. The scorpion uses its pedipalps to capture and hold the prey which, as indicated above, may or may not be stung before being devoured. The pedipalps move the prey to the chelicera which are small chelate appendages. Their shearing jaws are used to pierce, cut and tear the soft and hard parts of the prey into minute pieces (Fig. 3). As soon as the cheliceral activity begins,

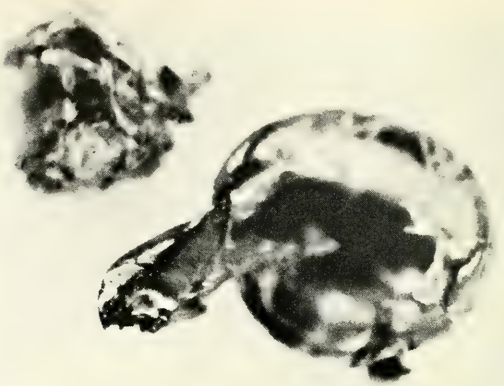

Figure 3. Centuroides gracilis formed this dry pellet (left) from the contents of a cricket head capsule (right). The scorpion sheared off the head and then dropped the pellet. (9X)

a copious, opalescent liquid exudes from the buccal region. After the tissue juices of the prey begin to flow it seems as though the buccal exudate lessens or possibly ceases to flow entirely. The tiny particles produced by the chelicera are packed between the coxa of the pedipalps. While the body fluids of the prey are abundant a sucking action takes place, as indicated by the back and forth movement of the first pair of legs. When the body fluids cease flowing, the cheliceral action starts again. Gradually the space between the coxa gets filled with particles. The cheliceral action ceases and the coxae squeeze out the juice contained in the pellet. After this juice is imbibed, the scorpion ejects the tiny, dry pellet in one of three ways. A slight spreading of the coxae of the pedilap may release it. Should this movement fail to release the pellet, the scorpion may extract it with the pedipalp fingers. If this action is not successful, the scorpion uses the claws of the first pair of legs as hooks and forcefully ejects the pellet. If the scorpion is in a small jar at the time, the tiny pellet may actually bounce from its side. Many of the pellets of the smaller species, *e.g. C. sculpturatus*, are barely visible to the naked eye. This entire process, consisting of sucking up free-flowing fluids, pressing out the fluid in the tiny pellets and casting out the resultant tiny, dried package is repeated until the prey is devoured. If the scorpion is very hungry, even the tarsi and the apparently dry elytra of beetles will be torn into tiny bits and transferred into these small pellets. Thus the uninitiated observer gets the impression that the scorpion has devoured all parts of the prey. His astonishment is increased when examination of the whitish, rather homogeneous feces fails to contain undigested sclerites or other hard parts of the prey's body.

The above feeding observations were made by placing the scorpions in a short, wide-mouthed jar with a plaster-of-paris bottom. Thus a non-slippery surface was provided for the scorpion, as well as a white background against which small particles, with the aid of a steromicroscope, could be observed readily.

Reproductive Behavior: *Courtship*. Scorpion reproductive activity is initiated by the male. If the female is receptive, he graps her pedipalps, first in the region of the femur or patella and later his pedipalp fingers are closed over hers. He now begins to walk backward and may or may not grasp her chelicerae with his. The typical "promenade á deux" now begins. This was first described by Maccary (1810) and the main portions confirmed subsequently by quite a number of other observers. One of the most recent and detailed descriptions is given by Alexander (1956).

Insemination. The courtship promenade culminates in the act of insemination which is accomplished by means of a relatively complex, white spermatophore. Alexander (1956) was the first to describe the process and accounts for her successful observations of the consummative act, where all others have failed, to providing a hard, rough substrate for the courting pair. She further notes that "if . . . the animals are provided with a hard surface the 'promenade á deux' lasts only for a few minutes. . . . After insemination the male usually drives the female away. . . . No evidence has appeared to suggest that the mating concludes with the female killing and eating the male as Fabre (1923 suggests."

Alexander (1956) concludes that "we now have information of the mating habits of scorpions of four of the six families: Scorpionidae, Chactidae, Bothriuridae and Buthidae, and it therefore seems likely that the same mechanism for insemination occurs throughout the whole order Scorpiones." Actually information has been obtained from a single species of each of four families and data from Diplocentridae and Vejovidae are lacking. Since the reproductive systems, both internal and external, of scorpions vary, even in families, the generalization of Alexander seems somewhat premature. We have observed remnants of spermatophores in the genital ducts of some members of the Vejovidae but in some species they have been noticeably absent. Then, too, the courtship described by Alexander has a number of elements absent in the mating routine of Southwestern United States scorpions. For example, the *C. sculpturatus* courtship is a simple pedipalp-holding promenade and the chelicera are not involved. However, only once have we observed a behavior suggesting the consummative act. In this case, the male, while holding on to only one chela of the female, used his free pedipalp to reach, first to his genital area and then to the genital area of the female. This was done several times and each time both animals raised their bodies to a higher position.

Bücherl (1956) and Matthiesen (1960) report observations in which the extruded genital papillae ("the two hemipenes," "paraxial organs" Pawlowsky, 1942) were extended and used as intromittent organs. The reports of these two investigators are not clear as to what they actually did see. The latter one (Matthiesen, 1960) makes no mention of Alexander's (1956) observations.

Bücherl (1956) states that, "The penis is projected and fixed on the soil directly under the open vulva of the female." Matthiesen (1960) makes such statements as, "The copulatory organ . . . detached itself from the body of the animal." . . . "A short time after copulation, the male ate the copulatory organ which remained." . . . "The following morning we found the copulatory organ on the bottom of the glass box." Those and other similar statements indicate a possibility that a spermatophore, reported by Alexander (1956), was being mistaken for a portion of the male reproductive system.

Much of the above reasoning seems to be based on the discussion of Pawlowsky (1924), Werner (1934) and Vachon (1952) referring to a brownish to black mass found often in the female genital orifice. Vachon refers to this as the *spermatocleutrum* and states "this mass, truly a hymen created by the male, is a puzzle as to its origin." . . . "It is possible that these substances . . . close the vagina and render further copulation impossible . . . it seems possible that with each copulation, the penis, all or less, breaks off and remains in the vagina. (trans)" Bücherl (1956) indicates that a female probably cannot have more than one mating during its life. Matthiesen (1960) reports that "the minimum time observed in which the female again receives the male was 34 days." Bücherl (1956) indicates that 6 to 8 weeks are required to regenerate the male copulatory organ.

From the above data one feels that the lost male copulatory organ" and the "spermatocleutrum" represent the spermatophore of Alexander. Her description fits in well with some of the observations of this writer. This is a case for suspended judgement and a need for more observation.

Reproductive Behavior: Life History. No clear-cut data are available as to the period of gestation. Female scorpions of *C. sculpturatus* isolated for over 6 months have produced young. Matthiesen (1960), after reporting on a supposed act of insemination, states "The female . . . seemed to be pregnant. She was separated directly after copulation, and, after 12 or 13 days gave birth to more than 20 offspring. A second birth occurred 115 days after the first." Reports for the gestation period vary and the observations seem to have been made on females that were not isolated for a period of 6 months or more before mating occurred and a previous insemination could have taken place.

Scorpions are ovoviparous. The young break out of the egg membrane and crawl upon the female's back (Fig. 4). The route is usually over the cheliceral area. If accidentally one of the young is caught in the chelicera the female may eat it and, subsequently, a large number of the litter. The size of the litter may vary from 12 to

Figure 4. C. sculpturatus with first instar young pickaback. Note the plumpness of the (yolk filled) pre-abdomens. Development is incomplete.

36 in *C. sculpturatus*. Sixty-six young have been produced in one litter by *Vejovis spinigerus*. Lucas (1890) reports a litter of 91 for *Centruroides gracilis* (Latreille).

The young of the first instar are incompletely developed and ride pickaback on the female until shortly after the first ecdysis. In *C. sculpturatus* this occurs 6 to 7 days after hatching (Fig. 5) and in *H. arizonensis* not until after the sixteenth day. The exuviae of the young are generally used on the mother's back as a sort of saddle cloth. During this period of parental care, the female refuses food and if not previously well nourished she may succumb. This condition, combined with the possible ragged appearance of the female produced by many protruding exuviae, seems to have given rise to the well known scorpion matricide fable.

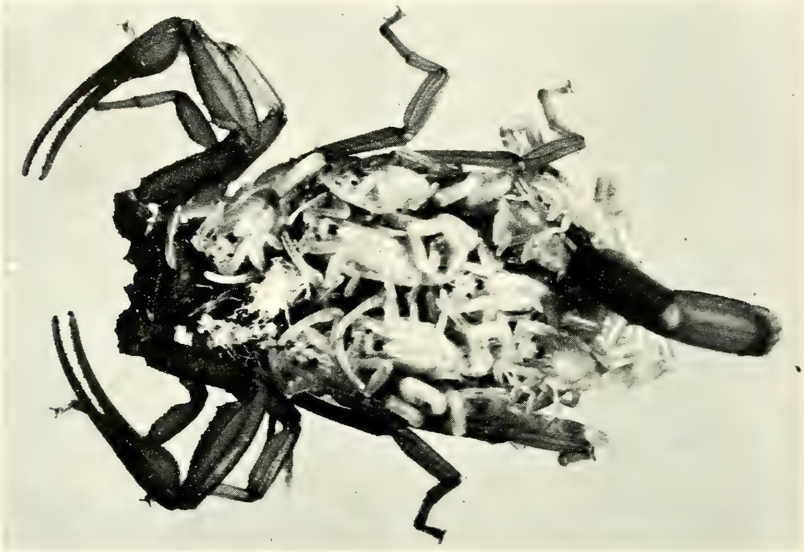

Figure 5. C. sculpturatus with second instar young pickaback. Development is complete and the young are ready to fend for themselves.

The young of the smaller species feed readily on fruit flies while the young of the larger species *(C. gracilis, H. arizonensis)* can handle small, immature cockroaches and small spiders. Subsequent ecdysis seems to be more associated with food intake than a definite time period. However, as development progresses the ecdyses become more widely spaced in time. One *C. sculpturatus* hatched in captivity was kept alive for 5 years (Fig. 6) without reaching maturity. Other scorpions of approximately this size kept alive in captivity for over one year did not undergo ecdysis. Even though a specimen of *Hadrurus hirsutus* (Wood), taken in Yuma, Arizona, measured 128 mm. (approximately 5 inches) from the anterior margin of the carapace to the trip of the aculeus, other specimens of this species under 80 mm. in length and kept in captivity for over two years did not molt.

Figure 6. C. sculpturatus in its seventh instar, immature and about two-thirds normal length. First instar exuviae not shown.

There are a great many unanswered questions associated with scorpion behavior. More controlled research is needed in all of its phases. The ancient origin of this order combined with the astonishing similarity between paleontological and modern forms, together with the high survival ability of the entire taxon, should make such research efforts very rewarding.

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FOSSIL ARTHROPODS OF CALIFORNIA. 29. SILICIFIED MIOCENE PUPAE OF CERATOPOGONID FLIES

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The work on the interesting silicified Miocene insects found imbedded in nodules, in lake bed strata, in California mountain areas, which must be recovered by acid extraction, is of necessity very slow and painstaking (see Pierce, various dates).

At present I have mounted 7,019 balsam slides of extracted material derived from 2,441 nodules, although a total of 32,898 nodules have been accessioned. Every nodule holds the potential of something new and interesting. The reporting on the findings must be by individual groupings of eggs, larvae, pupae, and adults—as time to work them up is available.

In a group like the blood sucking midges of the family Ceratopogonidae (formerly reported as Heleidae, recently ruled out by the International Commission on Nomenclature), the eggs offer a special problem, for only a few living species are recorded and described. I should state that prior to the early papers in this series, fossil insect eggs were unknown. A total of 38 *Dasyhelea* eggs have been isolated.

The larvae, having never been correlated with pupae and adults systematically, are a distinct problem. A total of 80 dipterous larvae are at hand, but not yet separated to family.

Our wealth lies in 818 dipterous pupae belonging to the Ceratopogonidae (Heleidae), and Chironomidae (Tendipedidae). On these I will begin to report in this article.

There are 60 fossil adults yet to be studied and separated to family, and there are some chances of correlation to the pupae. In nine cases, the adults within the pupa, with abdomen still extended, are being studied.

In no series of fossil insects have all stages of the insects been recovered in such perfect three-dimensional condition, crystal clear, and often manifesting internal organs: intestines, nervous system, brain, and tracheal system. This material may become a foundation stone in paleoembryology, using the term in its broad sense as defined by Hagan (1951:3) as covering all stages of immaturity in an animal.

Considering that only 7.41% of the collected nodules have been studied, it can be seen that we are only in the beginnings of this field. Insect-containing nodules are now known from the Calico Mountains, Mount Frazier, Mount Pinos, Mount Lane, and Death Valley; and unstudied nodules have been found in the Tehachapi and San Gabriel Mountains, and I expect them in at least half a dozen other ranges where boron has been mined. Our great need is for young people trained in systematic biology, geochemistry, and paleontology. This is a real challenge because it will require much patient research in a day when quick results are too often desired.

This report is on the ceratopogonid pupae, which are among the dominant creatures found, along with the dytiscid beetle larvae which presumably preyed upon them, and the anostracan fairy shrimps which no doubt scavenged the bottom. The ceratopogonid larvae perhaps fed upon the algae, or other plant life, and almost every nodule has yielded specimens of plant tissues. The ecological picture is slowly being revealed, nodule by nodule.

According to Wirth (1952), "The pupae are rather inactive, those of the aquatic forms coming to the water surface, working their way to the water's edge, and a short distance up on the shore, or on emergent vegetation, or driftwood just before emergence of the imago . . . The pupal period usually lasts from five to seven days."

It is postulated that volcanic catastrophes repeatedly killed the life in the ancient fresh water lake. The dead pupae lying on the bottom were covered by the calcium carbonate particles that slowly built up the lake bottom. Apparently the remarkable combination of volcanic chemicals instantly killed and preserved the tissues, catalyzing the silica in their bodies to replace the skeleton and organic walls, and converted the tissues into petroleum products.

Often in the same nodule will be the bodies of enemies, the dytiscid larvae. The pupae which we recover are in all stages of their week-long existence, as well as the empty cases of those which had emerged.

So far, slide mounts have been made of 818 dipterous pupae (Ceratopogonidae and Chironomidae) extracted from the nodules: 8 from Mount Frazier, 4 from Mount Pinos, and all others from the Calico Mountains. Of these, 390 pupae have been separated to family and species. Many of the undetermined fragments can be ultimately assigned on careful study of the spiny structure of the abdomen.

The pupae have been assigned to three distinct tribes in two subfamilies: Dasyheleinae; Ceratopogoninae, tribes Culicoidini and Stenoxenini. A difficulty lies in the fact that little is known of the life cycles of the modern insects. The principle American work has been done on the New York species by Thomsen (1937).

A number of the pupal types among these fossil pupae are not allied to any described pupa, but are undoubtedly ceratopogonid, hence it has been necessary to assign new generic names, realizing that when more is known of the pupae of existing genera, these fossils may ultimately be correlated. I feel that this step is justified, for we need to have names to associate our findings, and Palmer (1957) has already started the precedent. We are trying to bridge a gap of 20 million years.

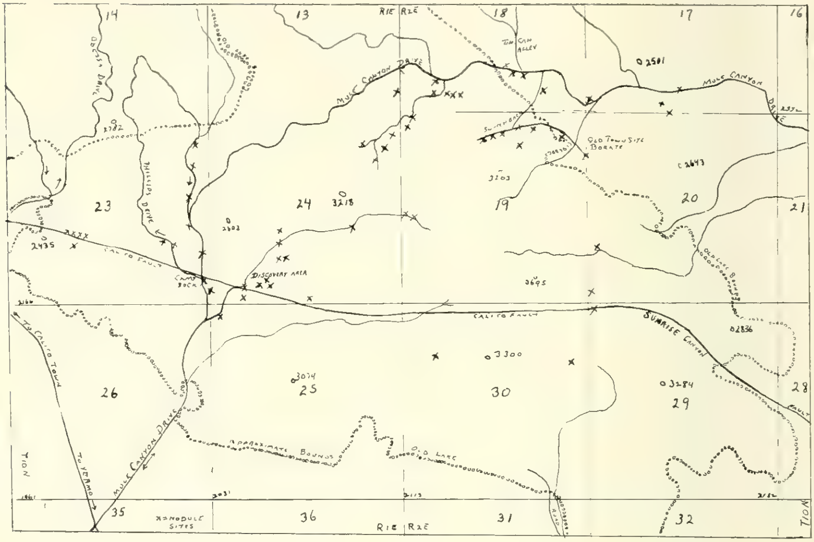
In the Ceratopogonidae the terminal segment of the pupa is so characteristic that I have, following Palmer's lead, given species names to each type, after first assigning species numbers for ready separation. Ten of these species are well distributed; eight others are more limited. Three pupal types are withheld because of doubts, and must be reported later.

Inasmuch as it seems that further exploration of all possible sites for these interesting nodules may result in giving stratigraphic or other valuable information, and that these pupae may be the keys for interpretation of relative age, etc., it is well to show how these ceratopogonid pupae line up in the quarter sections.

The Calico Mountains series were obtained from nodules collected in 8 sections, 14 quarter sections, extending the whole length and width of the ancient lake, lying along the Calico Fault and north of it (see Map). The total number of pupae isolated from each quarter section is followed in parenthesis by the number identified to species: In R.1.E., T.10.N., Section 23, SW ¼–8 (2); SE ¼–17 (7), NE ¼–10 (3); Section 24, SW ¼–149 (68), NE ¼–139 (67); Section 25, NW ¼–1. R.2.E., T.10.N., Section 17, SE ¼–1 (1), SW ¼–1 (1); Section 18, SW ¼–77 (36), SE ¼–36 (16); Section 19, NW ¼–53 (27), NE ¼–258 (112), undesignated ¼–54 (30); Section 20, SW ¼–1; Section 21, NW ¼–1; Section 29–0; Section 30–0.

The three identified Frazier Mountains specimens come from Mount Frazier, R.20.W., T.9.N., SW ¼ Section 36; and from Mount Pinos, R.21.W., T.8.N., NE ¼ Section 14 and SW ¼ Section 24.

The nodules from which this series of pupae were extracted were collected on many expeditions by the following persons: Charles and



Map. The Calico Mountains nodule sites.

Helen Artman, Mrs. A. G. Browne, John and Marie Carr, John Clark, Judith Clark, Kenneth Frey, Russell, Bernice and Cherry Gamage, John Gibron, Sr., Jeanne Hotchkiss, George Kanakoff, Mrs. Ruth Kirkby, Elza Kops, Sam Lager, Jere Lipps, Richard B. Loomis, Delmer Mangum, W. Dwight Pierce, Mary Robertson, Mrs. Laura Rouse, Rostick Ryshkoff, Dara Shilo, E. R. and Jim Vicklund, Jeff and Tom Wagner, Sheryl Weber, Donald, Ruth, Bruce and Carol Weissman in the Calico Mountains, and the late Mrs. Vergyle Ritchey in the Frazier Mountains.

The type material is deposited in the Invertebrate Paleontology Collections of the Los Angeles County Museum of Natural History (LACMIP).

Measurements were made to the nearest thousandth of a millimeter with the aid of an ocular micrometer.

DESCRIPTIONS OF PUPAE

Subfamily Dasyheleinae

The caudal plate is more complex than in the next subfamily, there being apicolateral and apicomedian lobes, and at least a spine or process to define each. The genital plates do not exceed the anal orifice. See Figures 1 to 8.

Genus *Dasyhelea* Kieffer

Wirth (1952) has illustrated the caudal plate of 5 living species, and Palmer (1957: 2, 4) 2 fossil species, and I am adding 5 fossil types (Figs. 1, 2, 5, 7, 8) which seem to belong in the series.

Dasyhelea australis antiqua Palmer 1957

Figure 4

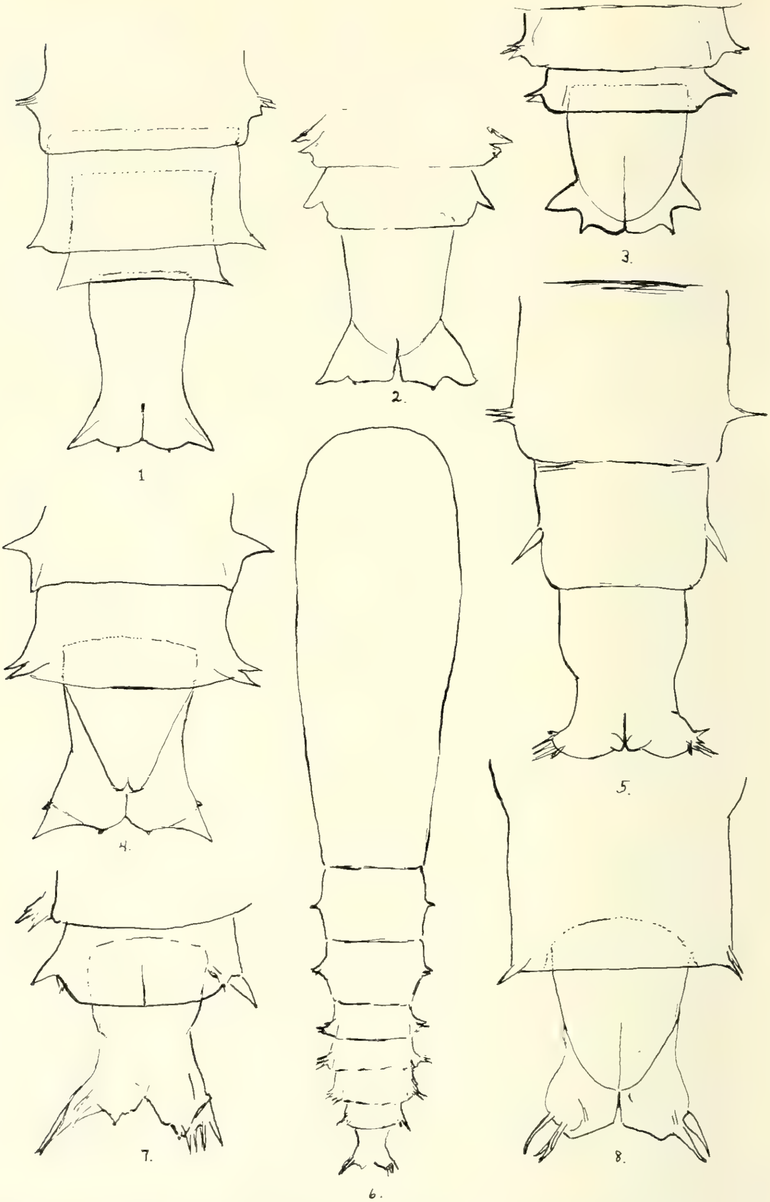
This pupal species is fully described and illustrated by Palmer (1957), and associated with adult female and male, and with a larval type. In view of the fact that we have found in the same quarter section (SW ¼ Section 24), 6 kinds of *Dasyhelea* pupae. and 5 kinds of other pupae in the same family, I cannot corroborate the association of other stages with any of the pupae until the adults included within their pupal shells have been thoroughly studied.

I have assigned to this species the pupal type No. 9, of which there are at present 105 specimens, found at elevations 2400 to 3000 feet in 10 quarter sections of the Calico Mountains, as follows: R.1.E., T.10.N., Section 23, SW ¼–2; SE ¼–3, NE ¼–1; Section 24, SW ¼ (type locality)–27, NE ¼–17; R.2.E., T.10.N., Section 17, SW ¼–1; Section 18, SW ¼–7, SE ¼–6, Section 19, NW ¼–5, NE ¼–27, unstated ¼–9; total 105.

The important features of this species are in the female caudal segment, which has the genital plates of triangular form, but with the apex a pair of rounded tips. The apicolateral processes are acute angled, directly only about 10° posteriorly, with tiny setigerous tubercles at center base; and each of the apicomedian lobes also has a tiny setigerous tubercle.

There has been some chance of confusing worn and partly eroded specimens of this species with *Dasyhelea judithae* (pupae No. 3) and the *Neopalpomyia* spp. (pupae No. 22 and 28).

There are 32 complete pupae, ranging in length from 2.18 to 3.94 mm., mean 3.27 mm. in normal specimens, and 4.59 to 4.71 mm. in two containing the extended adult.



Figures 1-8. Fossil pupae of Family Ceratopogonidae. Subfamily Dasyheleinae. extracted from Miocene nodules found in the Calico Mountains: *Figure 1: Dasyhelea judithae.* new species. LACMIP S 9124. last four segments of specimen 253.

The caudal segment of 96 specimens ranged in length from 0.269 to 0.426 mm., mean 0.321 mm., but most normally 0.3269 to 0.346 mm. In width of 94 specimens the range was 0.192 to 0.365 mm., mean 0.277 mm., most normally 0.269 to 0.307 mm.

Dasyhelea browneae, new species
Figure 5

Based on 6 pupae of pupal type No. 13, all from the Calico Mountains, from 4 adjoining quarter sections at altitudes 2400-2900 feet: R.1.E., T.10.N., Section 24, SW ¼–1, NE ¼–3; R.2.E., T.10.N., Section 19, NW ¼ (type locality)–1, NE ¼–1; total 6.

Holotype specimen 2450 registered as LACMIP Type S 9126, extracted from nodule 16966, collected by Mrs. A. C. Browne at Site 90, 2750 feet, in NW ¼ Section 19, R.2.E., T.10.N.

Four pupae are complete and measure 3.59 to 4.46 mm., mean 4.02 mm., type 3.99 mm. The longest pupa (No. 134) contains an adult with abdomen extended.

The terminal segment measures in length 0.307 to 0.403 mm., mean 0.336 mm., type 0.346 mm.; and in width 0.269 to 0.426 mm., mean 0.339 mm.; type 0.307 mm.

This segment is different from all others known, in that the apicolateral areas have clusters of 5 or more spines, directly laterally; and the apex is almost truncate, with four rounded lobes. In general shape it belongs near *D. kanakoffi*, but in armature resembles *D. dara*. The genital plates are broadly rounded at apex. The two preceding segments have strong median spines.

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from nodule 298, collected by W. Dwight Pierce at Site 10 (LACMIP 317), 2700 feet altitude, NE ¼ Section 19, R.2.E., T.10.N. *Figure 2*: *Dasyhelea kanakoffi*, new species, LACMIP S 9125, last three segments of specimen 159, from nodule 276A, collected by George Kanakoff at Site 3A (LACMIP 352), 2700 to 2750 feet, NE ¼ Section 24, R.1.E., T.10.N. *Figure 3*: *Dasyhelea stenoceras* Palmer, last three segments of specimen 2703, from nodule 175335, collected by Laura Rouse at Site 115, in NE ¼ Section 19, R.2.E., T.10.N. *Figure 4*: *Dasyhelea australis antiqua* Palmer, last three segments of specimen 2208, from nodule 3563, collected by Rostick Ryshkoff, at Site 15 (LACMIP 362), 2700 feet, SW ¼ Section 24, R.1.E., T.10.N. *Figure 5*: *Dasyhelea browneae*, new species, LACMIP S 9126, last three segments of specimen 2450 from nodule 16996, collected by Mrs. A. C. Browne at Site 90, 2750 feet, NW ¼ Section 19, R.2.E., T.10.N. *Figure 6*: *Dasyhelea dara* variant, entire pupa, specimen 2053, from nodule 142, collected by Jeanne Hotchkiss, at Site 4 (LACMIP 353) in NE ¼ Section 23, R.1.E., T.10.N. *Figure 7*: *Dasyhelea dara* variant, last three segments of specimen 2053. *Figure 8*: *Dasyhelea dara*, new species, LACMIP S 9127; last two segments of paratype specimen 3421 from nodule 1101. Collected by Dara Shilo at Site 10 (LACMIP 357), altitude 2700 feet, in NE¼ Section 19, R.2E., T.10.N.

Dasyhelea judithae, new species

Figure 1

Based on 20 pupal specimens of pupal type No. 3, 19 from Calico Mountains and one from Mount Pinos in the Frazier Mountains, collected as follows: Calico Mountains, R.1.E., T.10.N., Section 24, SW ¼–3, NE ¼–5; R.2.E., T.10.N., Section 18, SW ¼–2; Section 19, NW ¼–3, NE ¼ (type locality)–5; unstated ¼–1; Mount Pinos, R.21.W., T.8.N., Section 14, NE ¼–1; total 20. Named in honor of Judith Clark, one of the collectors.

Holotype pupa, specimen 253, registered as LACMIP Type S 9124, extracted from nodule 298, collected by W. Dwight Pierce at Site 10 (LACMIP 357), 2700 feet, in NE ¼ Section 19, R.2.E., T.10.N.

Total length of pupa depends on whether the abdomen is distended or contracted. Five complete pupae measure 2.88 (type), 2.88, 2.98 (containing adult), 3.11 and 3.36 mm., mean 3.04 mm.

The terminal segment measures 0.267 to 0.365 mm., type 0.307 mm., mean 0.3083 mm. in length; and 0.211 to 0.346 mm., type 0.240 mm., mean 0.2625 mm. in width at apex.

The apicolateral spines of the terminal segment are directed laterally and do not extend apically beyond the bounds of the apicomedian lobes.

The species is related to *Dasyhelea australis antiqua*, but the genital plates are apically broadly lobate, not triangular; the caudal segment is narrower, and the spiny armature of the abdomen is different. The seventh and eighth segments are armed with terminal spines; the sixth segment with a cluster of median lateral spines.

Specimen 86 is of special interest as it contains the adult with antennae not fully withdrawn from their sheaths, and the abdomen still extending the full length of the pupal abdomen.

Dasyhelea dara, new species

Figures 6, 7, and 8

Based on 34 pupal specimens of pupal type No. 14, from the Calico Mountains, and one from Mount Pinos in the Frazier Mountains, and named in honor of Dara Shilo, one of the collectors. These were extracted from nodules collected at altitudes 2510 to 2900 feet as follows: Calico Mountains, R.1.E., T.10.N., Section 23, NE ¼–1; Section 24, SW ¼–6, NE ¼–7; R.2.E., T.10.N., Section 18, SW ¼–3; Section 19, NW ¼–4, NE ¼ (type locality)–8, unstated ¼–1; Mount Pinos, R.21.W., T.8.N., Section 24, SW ¼–1; total 30.

The variants, Figures 6, 7, came from Section 23, NE ¼–1; Section 19, NE ¼–1, NW ¼–1; Section 18, SW ¼–1; total 4.

Holotype pupa, complete, specimen 1869, registered as LACMIP Type S 9136, extracted from nodule 244, collected by W. Dwight Pierce at Site 3A, altitude 2700 to 2750 feet, in NE ¼ Section 24, R.1.E., T.10.N.

Paratype pupa (Fig. 8) specimen 3421, registered as LACMIP Paratype S 9127, extracted from nodule 1101, collected by Dara Shilo at Site 10, (LACMIP 357), altitude 2700 feet, in NE ¼ Section 19, R.2.E., T.10.N.

Fifteen complete pupae measure 2.88 to 4.52 mm. in length, mean 3.339 mm. (holotype 3.65 mm.). The variants measure 3.07, 3.65 and 3.84 mm.

The caudal segment varies in length from 0.289 to 0.403 mm., mean 0.324 mm., holotype 0.307, illustrated paratype 0.403 mm.; in width 0.269 to 0.327 mm., mean 0.287 mm., holotype 0.269 mm., illustrated paratype (Fig. 8) 0.289 mm. In the variants (Figs. 6 and 7) this segment measures 0.307 to 0.384 mm. in length and 0.269 to 0.307 mm. in width.

In all but four variant specimens the caudal segment has the apicolateral corners extended diagonally with two long spines, but in the variants there is asymmetry, and one lateral corner has two spines, while the opposite has four or more spines. The other abdominal segments have many spines.

Dasyhelea kanakoffi, new species

Figure 2

Based on 70 pupal specimens (pupal type No. 5) all from the Calico Mountains, extracted from nodules collected as follows: R.1.E., T.10.N., Section 23, SE ¼–1; Section 24, SW ¼–6, NE ¼ (type locality)–20; R.2.E., T.10.N., Section 18, SW ¼–10, SE ¼–3; Section 19, NW ¼–3, NE ¼–18, unstated ¼–9; total 70. The nodules were collected at altitudes 2510 to 2900 feet.

Holotype pupa, specimen 159, registered as LACMIP Type S 9125, extracted from nodule 276A, collected by George Kanakoff at Site 3A LACMIP 352), 2700 to 2750 feet, in NE ¼ Section 24, R.1.E., T.10.N.

Nineteen pupae are complete and range in length from 2.40 to 4.61 mm., mean 3.3059 mm., type 3.264 mm.

The terminal segment ranges in length from 0.201 to 0.384 mm., mean 0.313 mm.. type and paratypes 0.346 mm.; and in width 0.154 to 0.289. mean 0.244. type and paratypes 0.269 mm.

The caudal segment has the appearance of being terminally truncate. in that the apices of the apicolateral and apicomedian lobes are almost on a line. The apicomedian lobes have a tiny spine. This species stands between *australis* and *stenoceras* in the positions of the terminal lobes.

Dasyhelea stenoceras Palmer 1957

Figure 3

This species (pupal type No. 7) was described by Palmer (1957) from pupae only. found at sites 19057 (type) and 19063b, c, in SW ¼. Section 24. R.1.E.. T.10.N.. and at site 19066 which Palmer does not locate. but is in either NE ¼ Section 24 or NE ¼ Section 19. R.2.E.. T.10.N.

From the Calico Mountains we have 28 pupae extracted from nodules found in R.1.E.. T.10.N.. Section 24. SW ¼ (type locality) –2. NE ¼–3; R.2.E.. T.10.N.. Section 18. SW ¼–1, SE ¼–1; Section 19. NW ¼–4. NE ¼–16, unstated ¼–1. One specimen. full of spherical crystals. from Mount Frazier. Kern County. SW ¼ Section 36. R.20.W., T.9.N.. at 5500 feet altitude. with broken anal segment, still seems to belong to this species.

Eleven pupae are complete. measuring in length 2.30 to 3.84 mm.. mean 2.77 mm.

The caudal segment is the distinguishing character with its apicolateral spines directed laterally and at right angles to the apicomedian spines which are terminal. This segment measures in length 0.21 to 0.307 mm.. mean 0.255 mm. and in width at lateral tubercles 0.21 to 0.307 mm.. mean 0.253 mm.

The respiratory trumpet was recovered on only one specimen.

Subfamily Ceratopogoninae

Tribe Culicoidini

Genus *Culicoides* Latreille

I am assigning 5 species of pupae to this genus. 22 species of which genus Wirth records as breeding in California waters. *C. variipennis* is found breeding in an alkaline pond at Borax Lake in Lake County. and at margin of Paso Creek carrying salt water from oil fields in Kern County.

Culicoides carri, new species
Figures 15 and 16

Based on a single complete pupa (pupa type No. 12), specimen 4279, extracted from nodule 2670, and registered as LACMIP Type S 9122, collected by John Carr at Site 2C in mine cave at 2700 feet, in SW ¼ Section 18, R.2.E., T.10.N.

Length of pupa 2.42 mm.

Caudal segment measures 0.211 mm. in length, and 0.192 mm. in width; provided with two long cerci-like appendages, extending almost straight, diverging about 12° beyond the anal tip. Genital sacs broad at base, extending beyond anal tip, but surpassed by the lateral appendages.

Culicoides fossilis, new species
Figure 11

Based on a partial specimen (pupa type No. 19), No. 805, designated as LACMIP Type S 9116, extracted from nodule 4729 collected by John Carr at Site 25 (LACMIP 373), altitude 2725 feet, in NE ¼ Section 19, R.2.E., T.10.N.

In this species the genital plates extend beyond the anus to the line connecting the apices of the apicolateral cerci-like appendages, which diverge from the longitudinal axis 40°.

The terminal segment is 0.192 mm. long, by 0.192 mm. wide at the top of the appendages.

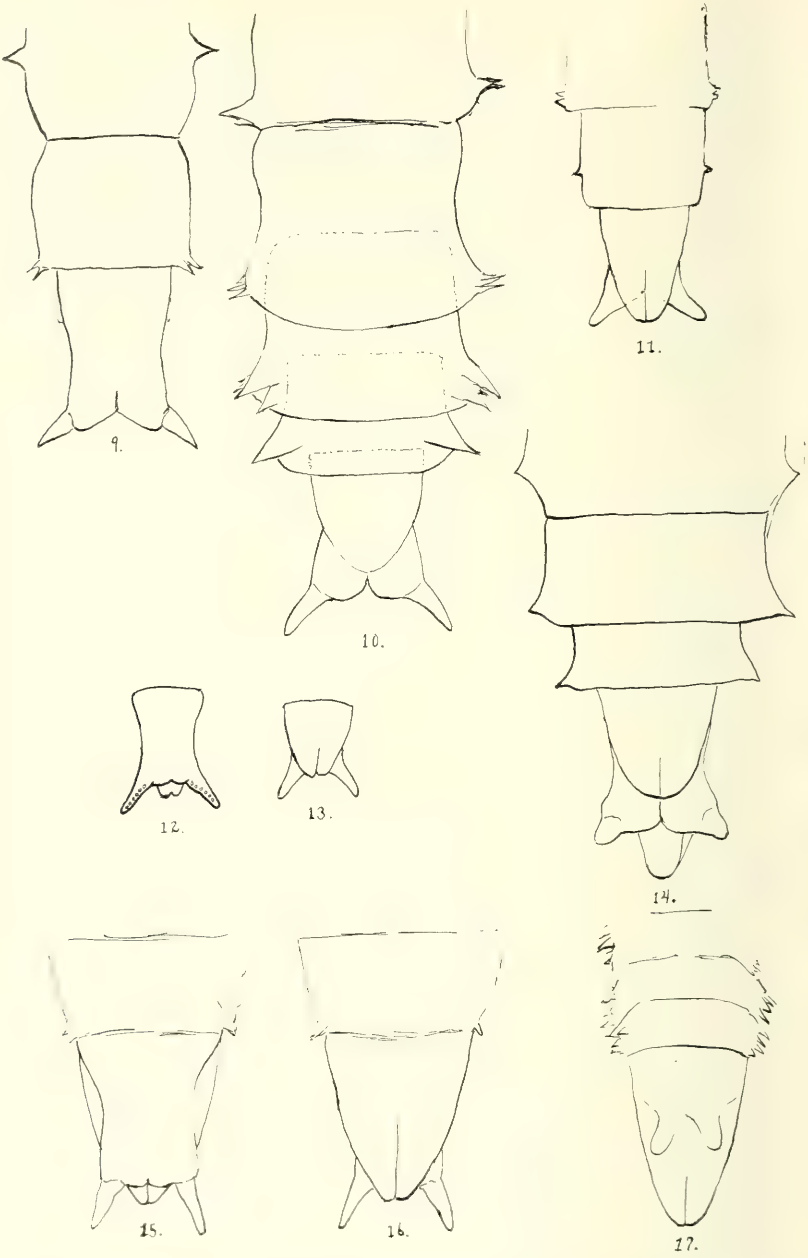
Culicoides laurae, new species
Figure 9

Based on a partial specimen (pupal type No. 29), No. 6831, recorded as LACMIP Type S 9114, extracted from nodule 20765, collected by Mrs. Laura Rouse in unspecified ¼ Section of Section 19, R.2.E., T.10.N.

The caudal segment is characterized by postero-lateral cerci-like appendages directed downward and outward at an angle of 12°. The segment measures 0.307 mm. in length and 0.269 mm. in width at apex of the appendages.

Culicoides megacanthus Palmer
Figures 12 and 13

Palmer (1957) records this species (my pupal type No. 8) from the SW ¼ Section 24 (LACMIP 372) at Sites 19057, 19063b and 19064b, at altitudes 2400 to 2700 feet, in R.1.E., T.10.N.



Figures 9-17. Fossil Pupae of Family Ceratopogonidae. Subfamily Ceratopogoninae. Tribe Culicoidini. extracted from Miocene nodules of Calico Mountains: *Figure 9*: *Culicoides laurae*, new species. LACMIP S 9114, last three segments of

I have one pupa from NE ¼ Section 19.

Palmer's illustration shows that the genital sacs extend beyond the anal orifice, but are surpassed by the long postero-lateral processes, which extend outward at an angle of 25°.

Culicoides miocenea, new species

Figure 10

Based on 10 Calico Mountains pupae (type No. 6) collected as follows: R.1.E., T.10.N. Section 24, SW ¼–1, NE ¼–1; R.2.E., T.10.N., Section 19, NE ¼ (type)–6, unstated ¼–1; Section 17, SE ¼–1; total 10. These were extracted from nodules collected at altitudes 2380 to 2900 feet.

The holotype specimen 2535, recorded as LACMIP Type S 9115, was extracted from nodule 16676, collected by George Kanakoff, at Site 17F (LACMIP 365) in NE ¼ Section 19, R.2.E., T.10.N.

Three pupae are entire and measure 3.26 (type), 3.44 and 3.75 mm., mean 3.48 mm.

The terminal segment is characterized by rounded genital sacs reaching the anal orifice, but greatly exceeded by the postero-lateral lobes, extending at an angle of 32°, with long cerci-like appendages. The preceding segments are provided with sharp spiny processes.

Neoculicoides, new genus

Pupal genital sacs far exceeding anal cercal lobes.

Type Species: Neoculicoides jeanneae, n. sp.

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specimen 6831 from nodule 20765, collected by Laura Rouse in unspecified ¼, Section 19, R.2.E., T.10N. *Figure 10*: *Culicoides miocenea*, new species, LACMIP S 9115, last five segments of specimen 2535 from nodule 16676, collected by George Kanakoff at Site 17F (LACMIP 365) in NE ¼, Section 19, R.2.E., T.10.N. *Figure 11*: *Culicoides fossilis*, new species, LACMIP S 9116, last three segments of specimen 805 from nodule 4729, collected by John Carr, at Site 25, altitude 2725, in NE ¼, Section 19, R.2.E., T.10.N. *Figure 12*: *Culicoides megacanthus* Palmer, drawn after Palmer (1957), dorsal view of last segment. Collected by Palmer, in SW ¼, Section 24, at Sites 19057, 19063b, 19064b, R.1.E., T.10.N. *Figure 13*: Same, ventral view of last segment. *Figure 14*: *Paraculicoides rouseae*, new species, LACMIP S 9121, last four segments of specimen 485 from nodule 28835, collected by Laura Rouse, at Site 17F (LACMIP 365), NE ¼ Section 19, R.2.E., T.10N. *Figure 15*: *Culicoides carri*, new species, LACMIP S 9122 dorsal view of last two segments of specimen 4279 from nodule 2670, collected by John Carr at Site 2C (LACMIP 351) in mine cave at 2700 feet, SW ¼ Section 18, R.2.E., T.10.N. *Figure 16*: Same, ventral view of last two segments. *Figure 17*: *Neoculicoides jeanneae*, new species, LACMIP S 9123, last four segments of specimen 4560 from nodule 532, collected by Jeanne Hotchkiss at Site 10 (LACMIP 357) at 2700 feet in NE ¼ Section 19, R.2.E., T.10.N.

Neoculicoides jeanneae, new species

Figure 17

Pupal type No. 20 is based on pupal specimen 4560, recorded as LACMIP Type S 9123, extracted from nodule 532, collected by Jeanne Hotchkiss at Site 10 (LACMIP 357), NE ¼ Section 19, R.2.E., T.10.N., altitude 2700 feet.

The total length of the pupa is 2.88 mm.

The apical segment is unusual in that the genital sacs are very long, narrowly rounded and far exceed the anal orifice and the two cercus-like lobes at middle. The postero-lateral processes are bluntly rounded and extend at 52° from anal base.

The sides of the preceding abdominal segments are armed with many sharp spines.

Paraculicoides, new genus

Pupal postero-lateral lobes blunt, directed outward, and exceeded by median dorsal lobe.

Type species: Paraculicoides rouseae, n. sp.

Paraculicoides rouseae, new species

Figure 14

Pupal type No. 11 is based on specimen 4845, recorded as LACMIC Type S 9121, extracted from nodule 28835, collected by Mrs. Laura Rouse at Site 17F (LACMIP 365) in NE ¼ Section 19, R.2.E., T.10.N.

The terminal segment measures 0.326 mm. in length and 0.192 mm. in width. The genital sacs are broadly rounded, barely over ½ as long as the segment, while the postero-lateral lobes are broad, blunt, directed outward at 12° from anal cleft, and greatly exceeded by the median dorsal lobe.

Subfamily Ceratopogoninae

Tribe Stenoxenini

Genus *Johannsenomyia* Malloch

Johannsenomyia hotchkissae, new species

Figure 18

Pupal species No. 1 is represented by 14 Calico Mountains pupae extracted from nodules collected as follows: R.1.E., T.10.N., Section 24, SW ¼–1, NE ¼–3; R.2.E., T.10.N., Section 18, SE ¼–1; Section 19, NW ¼–2, NE ¼ (type)–6, unstated ¼–1; total 14. Altitudes 2100 to 2800 feet, mostly 2700 feet.

Holotype specimen 467, registered as LACMIP Type S 9128, was extracted from nodule 437, collected by Jeanne Hotchkiss in NE ¼ Section 19 at Site 10, the Rouse anticline, at 2700 feet altitude.

Three pupae are complete and measure 2.63, 2.78, and 2.89 mm. (type), mean 2.76 mm. in length.

The caudal segment measures 0.192 to 0.365 mm. in length, mean 0.2970 mm., type 0.289 mm.; and 0.153 to 0.230 mm. in width, mean 0.197 mm., type 0.192 mm. This segment is quite simple in outline, with long apicolateral processes directed posteriorly, neither incurved, nor outwardly curved; without apicomedian lobes. It closely resembles *Johannsenomyia sybleae* as figured by Wirth (1952: 154).

Miopalpomyia, new genus

Pupal postero-lateral lobes elongate directed posteriorly.

Type species: Miopalpomyia shilo, n. sp.

Miopalpomyia shilo, new species

Figure 20

Based on pupal specimen 783 (pupal type No. 4), registered as LACMIP Type S 9130, extracted from nodule 2826 collected by Dara Shilo at Site 2D (LACMIP 351), about 2700 feet in SW ¼ Section 18, R.2.E., T.10.N.

Length of pupa 2.46 mm.

The terminal segment measures in length 0.269 mm., and in width at apices 0.230 mm. The postero-lateral processes are long, slender and diverging from the perpendicular 20°.

The preceding segments have very minute spines.

Neopalpomyia, new genus

Postero-lateral processes of pupal cauda directed sharply outward; apicomedian lobes evident.

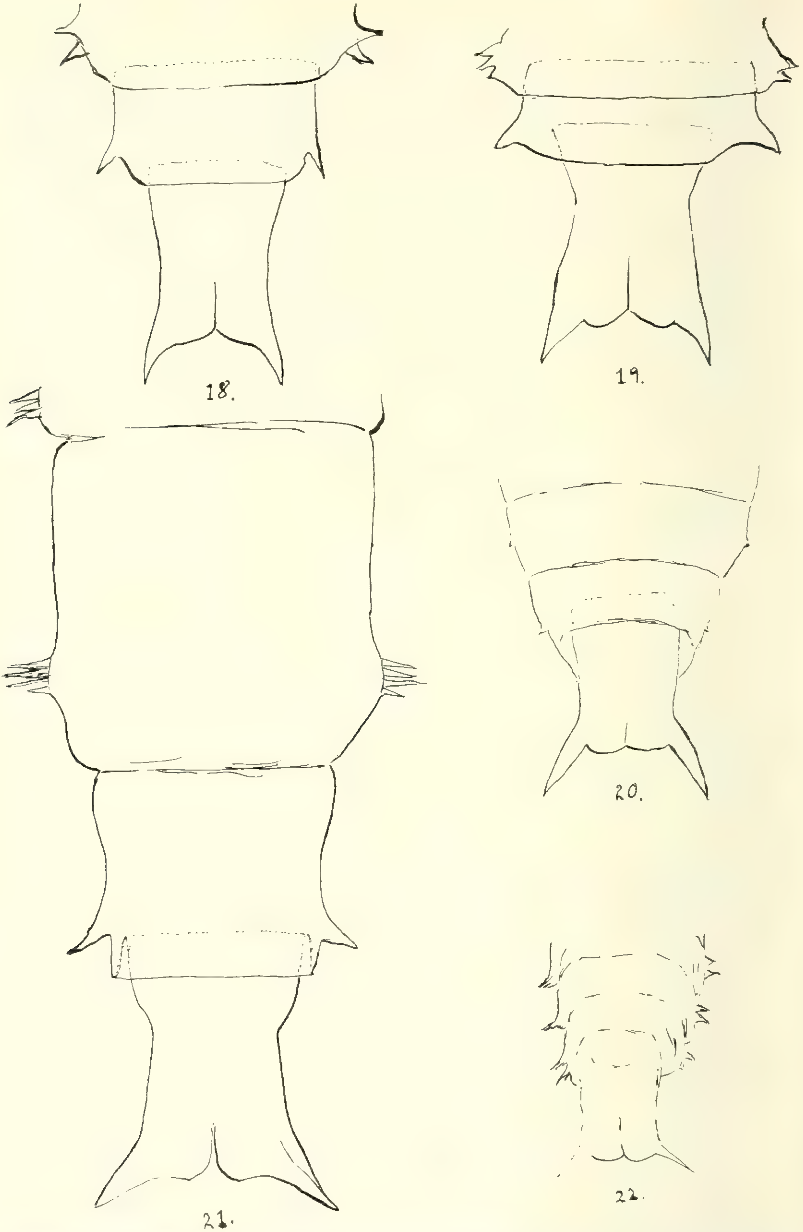
Type species: Neopalpomyia freyi, n. sp.

Neopalpomyia freyi, new species

Figure 21

Based on 20 specimens of pupal species No. 28, from R.1.E., T.10.N., Section 24, SW ¼–4; NE ¼–1; R.2.E., T.10.N., Section 19, NE ¼–9, undetermined ¼–2; Section 18, SW ¼–3; SE ¼–1.

Holotype specimen 4199, registered as LACMIP Type S 9131, ex-



Figures 18-22. Fossil pupae of family Ceratopogonidae. Subfamily Ceratopogoninae. Tribe Stenoxenini. extracted from Miocene nodules of the Calico Mountains: *Figure 18*: *Johannsenomyia hotchkissae*. new species. LACMIP S 9128. last three

tracted from nodule 10193 collected in SW ¼ Section 24, R.1.E., T.10.N., Calico Mountains, California. Named for Kenneth Frey.

Eight specimens are complete and measure 3.26 to 4.26 mm., mean 3.71 mm., type 4.03 mm. as pupa; 4.80 to 4.807 mm. as pupae containing adults with extended abdomens.

The caudal segment measures 2.50 to 3.84 mm., mean 0.334 mm., type 0.326 mm., in length; 0.230 to 0.403 mm., mean 0.341 mm., type 0.346 mm., in width at apex of processes.

This segment is sharply incised at median apex, and has postero-lateral processes acute and directed outward at an angle of 24° from the anal base.

The bristles on the preceding segments are many, long and sharp.

Neopalpomyia multispinosa, new species

Figure 22

Pupal species No. 26 is based on specimen 144, registered as LACMIP Type S 9132, extracted from nodule 277A, collected by George Kanakoff at Site 4 (LACMIP 353) in NE ¼ Section 24, R.1.E., T.10.N.

While the specimen is imperfect it differs from all others by the postero-lateral spines being about transverse, as they part from the anal terminus at 13°.

The preceding segments are armed with many sharp spines, the character upon which the new name is based.

Parapalpomyia, new genus

Pupal caudal segment with apicomedian lobes, and with long apicolateral pointed lobes.

Type species: Parapalpomyia ryshkoffi, n. sp.

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segments of specimen 467 from nodule 437, collected by Jeanne Hotchkiss at Site 10 (LACMIP 357), altitude 2700 feet, in NE ¼ Section 19, R.2.E., T.10.N. *Figure 19*: *Parapalpomyia ryshkoffi*, new species, LACMIP S 9129, last three segments of specimen 330 from nodule 107, collected by Rostick Ryshkoff at Site 2 (LACMIP 351), 2650 to 2800 feet, in SW ¼ Section 18, R.2.E., T.10.N. *Figure 20*: *Miopalpomyia shilo*, new species, LACMIP S 9130, last three segments of specimen 283 from nodule 2826, collected by Dara Shilo at Site 2D (LACMIP 351), about 2700 feet, in SW ¼ Section 18, R.2.E., T.10.N. *Figure 21*: *Neopalpomyia freyi*, new species, LACMIP S 9131, last three segments of specimen 4199 from nodule 10193, collected by George Kanakoff at Site 15 (LACMIP 362), about 2400 feet, SW ¼ Section 24, R.1.E., T.10.N. *Figure 22*: *Neopalpomyia multispinosa*, new species, LACMIP S 9132, last four segments of specimen 144 from nodule 277A, collected by George Kanakoff at Site 4 (LACMIP 353), NE ¼ Section 24, R.1.E., T.10.N.

Parapalpomyia ryshkoffi, new species

Figure 19

Pupal species No. 2 is based on 33 Calico Mountains specimens extracted from nodules collected in R.1.E., T.10.N., Section 24, NE ¼–5, SW ¼–8; R.2.E., T.10.N., Section 18, SW ¼–5, SE ¼–2; Section 19, NW ¼–3, NE ¼–9, undesignated ¼–1; total 33.

Holotype specimen 330, registered as LACMIP Type S 9129, was extracted from nodule 107, collected at Site 2 (LACMIP 351), 2650 to 2800 feet, in SW ¼ Section 18, by Rostick Ryshkoff.

Ten complete pupae measure in length 2.21 to 3.769 mm., type 3.173 mm., mean 3.1324 mm.

The caudal segment ranges in length 0.209 to 0.403 mm., mean 0.333 mm., type 0.307 mm.; and width 0.192 to 0.307 mm., mean 0.254 mm., type 0.250 mm. This segment is simple with apicolateral processes posteriorly produced, neither incurved, nor outwardly curved, with definite apicomedian lobes.

It is rather interesting that the type is from the same nodule as six specimens of pupal species No. 6, *Culicoides miocena*, described above, which is entirely different in character.

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NEW SPECIES OF *HAPLOPOGON* ENGEL WITH A KEY TO THE SPECIES (DIPTERA: ASILIDAE)

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The genus *Haplopogon* Engel, described from Turkestan, was found to occur in America by Pritchard (1941). Included were *Holopogon latus* Coquillett (1904) and *Holcocephala bullata* Bromley (1934) from Texas, and *Haplopogon erinus* Pritchard (1941) from Arizona. Martin (1955) described *triangulatus* from Texas. In the present paper, three species are described as new, and figures of the wings and male genitalia are given along with a revised key to the species.

These small flies, length 4 to 7 mm., are black and densely pollinose, with the basal portion of the wings brown and the apex hyaline or lighter in color. The costal and basal cells are brown in the wings of all species, so these cells are usually not mentioned specifically in the descriptions or key. The male genitalia are non-rotate and the female ovipositor is without a terminal circlet of spines. The surstyli or the ninth tergite, are broad basally and taper apically, and are the dorsal or superior forceps of Pritchard (1941), gonocoxites of Martin (1955), or superior forceps of Hull (1962).

The type series of *Haplopogon erinus* Pritchard was collected "in wheatfield" near Globe, Arizona. At Portal, Arizona, it was collected on the tips of the twigs or on the dead flowers of tar-bush, *Flourensia cernua* D.C., about two feet high, 2 miles northeast of town, 29 and 30, May 1962 (J. Wilcox) and 1 mile north west of town, 23 June, 1964 (Eric Fisher). *H. utahensis* new species was collected mostly on the tips of purple sage and a few on creosote-bush one to two feet high between 8 and 10 o'clock in the morning. *H. triangulatus* Martin was collected 15 miles south of Marathon, Brewster Co., Texas, 26 June, 1964 (Eric Fisher). These flies apparently occur only in the spring, from March to June.

Haplopogon Engel belongs in the subfamily Dasypogoninae and in the tribe Damalini (Hull, 1962). This tribe has the ovipositor apically with fine hairs, face on either side below with deep grooves and head from anterior view from one and one-half to two times as wide as high. The Nearctic genera can be separated by the following key:

1. Third antennal segment short and broad, wider than segments one and 2, style long, bristle-like 2
   Third antennal segment slender, narrower than antennal segment 2, style short globular or tapering, at most subequal in length to segment 3 3
2. Third antennal segment 1½x length of segments 1-2, style longer than segment 3; anal cell of wings long petiolate (*Damalis americana* Curran, Arizona, 7.5 mm.) . . . . *Orrhodops* Hull
   Third antennal segment ⅔ length of segments 1-2, style longer than segments 1-3; anal cell short petiolate (*flavidorsis* E. Hardy, Arizona, 18 mm.) . . . . *Bromleyeus* E. Hardy
3. Style of antennae short globular, one segmented and about ⅓ length of segment 3; head from anterior view about 2x as wide as high "goggle-like"; mystax confined to oral margin (Texas and east) . . . . *Holcocephala* Jaennicke
   Style of antennae tapering apically, two segmented, from half to subequal in length to segment 3; head from anterior view about 1½x as broad as high, not "goggle-like"; mystax extends at least half way to antennae (Texas and west) . . . . . . *Haplopogon* Engel

Orrhodops Hull and *Bromleyeus* E. Hardy are represented by single species in the Nearctic region and are indicated in the above key. *Holcocephala* Jaennicke is represented by three species in the middle western and eastern states, for a review of these and the Central American species see Pritchard 1938.

Key to the Species of *Haplopogon*

1. Axillary cell of the wings infuscated 2
   Axillary cell of the wings all or largely hyaline or milky 4
2. Mesonotum brown pollinose, hairs dense erect and as long as antennal segments 1-2; wings light brown, basally dark brown including anal and axillary cells, anterior crossvein at 21/41 length of discal cell; antennae measure 5-8-19-22; length 5-7 mm. (Texas) . . . . *bullatus* (Bromley)
   Margins of mesonotum light brown to grayish pollinose, hairs sparse recumbent and not longer than antennal segment 2 3

3. Central and intermediate areas of mesonotum confluent, deep brown, humeri and lateral anterior portion gray pollinose; brown of wings filling discal cell and base of posterior cells 1-3 and remaining basal portions of wings, anterior crossvein at 20/36 length of discal cell; antennae measure 8-10-18-20; length 6-7 mm. (Texas) .... *latus* (Coquillett)
   Central and intermediate areas of mesonotum brown to light brown, confluent or separated, lateral and posterior margins grayish white pollinose; apical ⅓ of discal and posterior cell 4 hyaline, anterior crossvein at 10/31 length of discal cell; antennae measure 5-7-17-13; length 4-6 mm. (Arizona) ..... *erinus* Pritchard

4. Discal and posterior cells 4-5 largely infuscated 5
   Discal and posterior cells 4-5 largely hyaline 6

5. Lower half of anal cell and axillary cell entirely hyaline, anterior crossvein at 17/32 length of discal cell; anterior half of mesonotum largely whitish pollinose; antennae measure 5-8-19-10; length 4-6 mm. (Utah) .... *utahensis* new species
   Anal cell wholly and narrow basal margin of axillary cell infuscated, anterior crossvein at 10/29 length of discal cell; central stripe of mesonotum light brown and extending to pronotum, intermediate spots indistinctly light brown, humeri and margins yellowish gray; antennae measure 4-7-16-10; length 4-5 mm. (Texas) .... *triangulatus* Martin

6. Central stripe and intermediate area of mesonotum confluent, light brown, broadly margined with gray pollen; anal and posterior cell 5 narrowly brown basally, anterior crossvein at 11/35 length of discal cell; antennae measure 6-8-21-16; length 5 mm. (Arizona) .... *parkeri* new species
   Mesonotum grayish white pollinose, the intermediate spots faintly light brown; anal and axillary cells white, posterior cells hyaline, anterior crossvein at 8/24 length of discal cell; antennae measure 5-6-12-10; length 4 mm. (Arizona) ...... *dicksoni* new species

Haplopogon dicksoni, new species

Figure 1

Male: Length 4 mm. Head black, densely white pollinose. Hairs and bristles white; mystax composed of long hairs extending about half way to antennae; face at antennae 12/17 width of one eye. Antennae black, golden pollinose; hairs white, 3 short ones dorsally

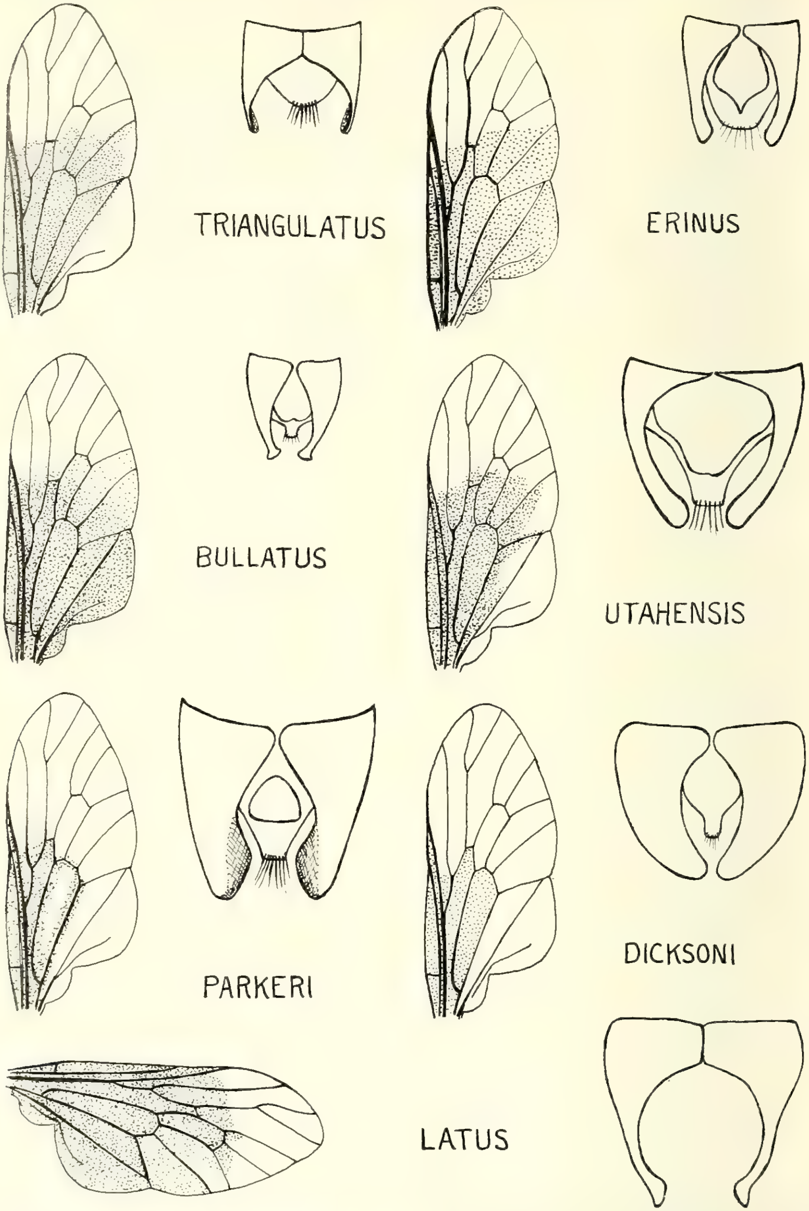

Figure 1. Wings of *Haplopogon* species (to left of species name) and dorsal view of surstyli of male genitalia (above species name except *latus* which is to the right). The surstyli of *latus* was drawn from Pritchard (1941) as no male specimens were available. The proctiger (anus or tergite 10) is shown between the surstyli except in *latus*.

on segment 3 and a long one apically; segments measure 5-6-12-10.

Mesonotum black, densely white pollinose, the intermediate area indistinctly light brown. Hairs white, sparse recumbent, longer erect in the dorsocentral rows posteriorly. Pleura and coxae densely white pollinose, hairs white. Scutellum black, densely white pollinose, about 12 short fine white discal hairs.

Abdomen black, densely white pollinose, dorsum subshining black. Hairs sparse white, long laterally and short dorsally. Venter white pollinose, hairs white. Genitalia shining black, hairs white, surstyli broad narrowing basally, much broader than other species.

Legs black; hairs and bristles white; claws black, yellowish basally; pulvilli white.

Halteres yellowish white, stem brown. Wings hyaline, anal and axillary cells milky white, costal and basal cells light brown; veins yellowish basally, brown apically, anterior crossvein at 8/24 length of discal cell.

Female: Length 5 mm. Face at antennae 17/25 width of one eye. Antennal segments measure 5-8-17-16. Mesonotum grayish white pollinose, posterior intermediate spots brownish; scutellum light brownish pollinose. Abdomen grayish pollinose, tergites 2-6 subshining black dorsally; sternite 8 and ovipositor black with white hairs. Knob of halteres light red, lower stem brown. Brown of wings extends narrowly into base of discal and posterior cells 4-5, and narrow dorsally in anal cell; anterior crossvein at 18/38 length of discal cell.

Holotype: Male, 10 mi. E. Aztec, Maricopa Co., Arizona, 8 April 1963 (R. C. Dickson), UCR. Swept from *Sphaeralcea*.

Named for R. C. Dickson who collected this specimen and who has turned up other rare species of Asilidae.

Allotype: Female, 18 mi. S. Gila Bend, Arizona, 18 April 1965 (Mont A. Cazier), Arizona State University.

Paratypes: 3 ♂♂, 2 ♀♀, same data as Allotype, 8, 12 and 18 May 1965 (M. A. Cazier, M. Mortenson, J. Wilcox); 10 ♀♀, 5 mi. E. Aztec, Arizona (Spot Rd.), 11, 20 May 1965 (J. Wilcox); 4 ♀♀, one mi. E. Mohawk, Arizona, 11 May 1965 (J. Wilcox).

Haplopogon parkeri, new species

Figure 1

Male: Length 5 mm. Head black, densely white pollinose. Hairs and bristles white, mystax extending three-fourths distance to antennae, hairs above shorter; face at antennae 16/25 width of one eye. Antennae black, golden pollinose; hairs white, 3 above on segment 3 the apical one the longest; segments measure 6-8-21-16.

Mesonotum black, humeri and broad margins gray pollinose, central and intermediate spots brown confluent. Hairs white, semirecumbent and about as long as second antennal segment, longer laterally and in posterior dorsocentral rows. Pleura and coxae grayish white pollinose, hairs white. Scutellum grayish white pollinose, about 30 white discal hairs.

Abdomen brownish black, densely gray pollinose laterally, thin dorsally subshining. Hairs long sparse white, only slightly shorter dorsally. Venter gray pollinose, hairs white. Genitalia black, tips of surstyli and lower forceps brown, hairs white.

Legs black; hairs and bristles white; claws black, reddish basally; pulvilli white.

Halteres yellowish white, stem brown. Wings hyaline; costal and basal cell, narrow margin of anal cell, narrow base of discal and posterior cell 4-5, brown, second basal cell with a central hyaline streak; veins brown, anterior crossvein at 11/35 length of discal cell.

Female: Length 5 mm. Antennal segments measure 6-8-20-13. Dorsum of abdominal segments 1-8 shining black, broad sides and venter gray pollinose. Ovipositor black, dorsum thinly grayish pollinose; hairs white and quite dense especially on venter. Basal third of the anal cell and basal fourth of the axillary cell, brown.

Holotype: Male, McMillan, Arizona, 28 June 1949 (J. Wilcox).

Named in honor of Frank H. Parker of Globe, Arizona, who has collected many species of Arizona Asilidae.

McMillan is a ghost town about 15 miles north of Globe on U.S. Highway 60 and is not shown on recent highway maps. *H. erinus* Pritchard was collected 10 to 15 miles north of Globe but I believe this was on State Highway 88 north west of Globe.

Allotype: Female, Globe, Arizona (Jct. Hwys. 60 and 70), 19 May 1965 (J. Wilcox).

Paratypes: 2 ♂♂, 4 ♀♀, same data as Allotype, 18, 19 May 1965. Collected mainly on dead twigs of *Acacia*, three to five feet high.

Haplopogon utahensis, new species

Figure 1

Male: Length 5 mm. Head black, densely white pollinose. Hairs and bristles white; mystax extending two-thirds distance to antennae, hairs shorter above; face at antennae 15/21 width of one eye. Antennae black, golden pollinose; hairs white, 4 long hairs above on segment 3; segments measure 5-8-19-10.

Mesonotum black, white pollinose anteriorly, central stripe behind suture and intermediate spots extending slightly anterior to suture brown pollinose, posterior lateral margins light brown. Hairs white, semirecumbent and about as long as antennal segment 2, longer erect in posterior dorsocentral rows. Pleura and coxae white pollinose, hairs white. Scutellum light brown pollinose, about 24 short white discal hairs.

Abdomen black, white pollinose, the dorsum thinly so and appearing shining black. Hairs short white, longer on the sides of the segments. Venter white pollinose, hairs white. Genitalia black, tips of surstyli brown, hairs white.

Legs black; hairs and bristles white; claws black, reddish basally; pulvilli white.

Halteres yellowish white, stem brown. Base of wings brown, extending from end of first vein to anterior crossvein, filling basal three-fourths of discal and posterior cell 4, a touch at base of posterior cell 3, basal half of posterior cell 5 and anal cell, and a touch at base of axillary cell; apex hyaline; veins brown, anterior crossvein at 17/32 length of discal cell.

Female: Length 5 mm. Mesonotum anteriorly yellowish gray pollinose and central brown stripe extending anterior to suture about half way to pronotum. Pleura and coxae gray pollinose. Ovipositor shining black, hairs white. A touch of brown at base of posterior cell 1 and about the basal three-fourths of the anal cell brown.

Holotype: Male, 7 mi. N. of St. George, Utah, Hwy. 91, 1 June 1963 (J. Wilcox).

Allotype: Female, same data.

Paratypes: 15 ♂♂, 43 ♀♀, same data, 1, 2 June 1963. Collected mainly on the tips of purple sage and a few on creosote-bush, 1 to 2 feet above the ground in the morning from 0800 to 1000 hours.

I am indebted to P. H. Timberlake, University of California, Riverside (UCR), and Eric Fisher, Los Angeles, for the loan of specimens. Types, except as indicated, have been retained in the authors collection.

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MOLLUSCAN SPECIES FROM EARLY SOUTHERN CALIFORNIA ARCHEOLOGICAL SITES

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INTRODUCTION

Archeology in southern California has had, in recent years, a very rapid growth. It has been spurred by: (1) research programs in the universities and colleges; (2) highway contracts emanating from the California Division of Beaches and Parks Interpretive Section; (3) extensive excavation financed by federal and state funds for water resources programs in the construction of dams; (4) long-range survey and excavation projects administered by the National Park Service; (5) grants given by the National Science Foundation and other non-profit organizaztions; (6) museum research programs; and (7) investigations by amateur archeological societies. The literature regrettably is scattered. Each large program usually has its own publication series, the reports of which find their way to most locally interested archeologists—the rest of the papers may have only limited distribution.

For the past six years I have been occupied in a program concerned with archeological field and laboratory sampling techniques. In salvage archeology (on highways, dams, building construction, etc.), time, funds, personnel, and materiel are critical and at a premium, and the hope of gathering adequate data from this sort of limited archeology calls for the use of every possible resource and technique. Thus we have used everything from heavy machinery (graders, bull-dozers, centrifugal pumps, etc.) to fine laboratory analysis on large quantities of finely screened midden down to its last component. In the course of the more detailed analyses of midden constituents—a technique now commonly called "Micro-analysis" or "Midden Analysis"—a singularly interesting corpus of data has emerged on the mollusks from southern California archeological sites.

Shellfish gathering was of tremendous importance to the southern California aborigines, with a large variety of species collected for food, ornaments, tools, and trade. In the course of identifying some of these mollusks I have often needed the services of specialists in the fields of invertebrate zoology. They, in turn, have expressed interest in the sum total of species recovered and their quantitative and qualitative distribution in the middens, especially from dated, early sites.

The following data do not purport to be definitive. From many sites certain categories of information are lacking: some papers list only species with no distribution or quantities; others consider the major food types and disregard the incidental or rare species; still others list only common or local names, and in some cases the species are doutbful. Several sites, well known from the horizons considered, are omitted because they did not have any shell remains.

However, in the reports used for this synthesis, I believe there are adequate data to give a good overall picture of the spatial and temporal pattern of collection and use of shellfish by the early inhabitants of the southern California coastal area.

Nomenclature adopted here follows the suggestions of James H. McLean, Curator of Invertebrate Zoology, Los Angeles County Museum. I have taken the liberty of changing (*i.e.*, correcting) the names of species listed by the separate authors so that each species may be referred to by a single name. The more familiar but now invalid names are bracketed after the now accepted nomenclature in the alphabetized lists at the end of this paper. Generic changes adopted are based upon the review of West American genera by Keen (1963). Further information about the distribution and habits of the edible bivalves listed here may be found in Fitch (1953), and information about abalones is given by Cox (1962). The latter paper includes a discussion on the occurrence of abalones in archeological sites.

Wallace's (1955) suggested chronology for southern California coastal archeology is used for broadly delimiting the area and the temporal divisions or horizons discussed. The area roughly encompasses the stretch of coast and the intersecting canyon valleys from Point Concepcion to San Diego. One southern Channel Island site, on Catalina Island, also is included. The two horizons considered are those with Early Man sites and the Milling Stone Assemblages.

EARLY MAN SITES

Early Man sites, those of presumed late Pleistocene or early Post-Glacial age, are rare in southern California. Such few sites as have been published seem to indicate a heavy shellfish gathering subsistence, supplemented by hunting and fishing, and an apparent absence of seed-grinding tools. Only Malaga Cove, Level 1 contains an adequate shell species coverage. The species were identified by the late Howard R. Hill, then Curator of Marine Zoology, Los Angeles County Museum of Natural History.

Malaga Cove, Level 1 (Walker, 1951)

Location: Malaga Cove, a part of Santa Monica Bay, is located in the city of Torrance, between Redondo Beach and Palos Verdes, Los Angeles County.

Age: Late Pleistocene or early Post-Glacial. No absolute date.

Species (arranged alphabetically):

Acanthina spirata
Acmaea limatula
Amiantis callosa
Balanus tintinnabulum
Cerithidea californica
Chione fluctifraga
Chione undatella
Conus californicus
Crepidula onyx
Donax gouldi
Haliotis corrugata
Haliotis cracherodii
Hinnites multirugosus
Laevicardium elatum
Lottia gigantia
Mytilus californianus
Nassarius tegulus
Ocenebra poulsoni
Olivella biplicata
Ostrea lurida
Polinices reclusianus
Protothaca staminea
Sanguinolaria nuttalli
Saxidomus nuttalli
Shaskyus festivus
Stenoplax conspicua
Tagelus californianus
Tegula gallina
Tresus nuttalli
Worm tube

General Remarks: Shell content high. No quantities given except these percentages of the following shells lumped together by common names: 50% cockles, 22% scallops, 20% cove oysters, 8% the rest. None of the shells were calcined; many were complete specimens. None of the species are extinct in the area.

Shell Ornaments and Tools:

Abalone dishes, asphaltum plugged
Abalone rim scoops
Abalone beads (?)
Abalone container with asphaltum
Clam inlays
Clam pendants
Cockle food-scrapers
Mussel spoons

Clam disk beads
Clam disks (gaming pieces?)
Spire-lopped *Olivella* beads
Univalve columella ornaments (?)

Milling Stone Horizon Sites

The Milling Stone Horizon (often called Oak Grove in the Santa Barbara area; Rogers, 1929) is an extensive period during which the predominant assemblages recovered consist of milling stones, manos, and rude lithic, unspecialized tools. Vegetal foods, especially seeds, are presumed to have been the mainstay of the diet with shellfish and game following in that order.

Little Sycamore Shellmound (Wallace, *et al.*, 1956)

Location: Southwestern Ventura County, 1.2 miles west of the Los Angeles County line at the mouth of Little Sycamore Canyon.

Age: Considered to be 4000-5000 years old at the time of the report, but is probably several thousand years older.

Species (arranged alphabetically):

Balanus sp.
Chione californiensis
Chione undatella
Chiton valves
Cypraea spadicea
Fissurella volcano
Haliotis cracherodii
Haliotis fulgens
Hinnites multirugosus
Kelletia kelletii
Laevicardium elatum
Lottia gigantea
Megathura crenulata
Mytilus californianus
Mytilus edulis
Norrisia norrisii
Olivella biplicata
Polinices reclusianus
Saxidomus nuttalli
Serpulorbis squamigerus
Shaskyus festivus
Spisula planulata
Tegula eiseni
Tresus nuttalli

General Remarks: Large quantity of shell remains. *Mytilus edulis* comprised the largest quantity with *Haliotis cracherodii* next. Following in numerical quantity were *Fissurella volcano*, *Lottia gigantea*, and *Shaskyus festivus*.

Shell Ornaments and Tools:

Spire-lopped *Olivella* beads
Cypraea spadicea pendants
Haliotis cracherodii pendant
Kelletia kelletii trumpets or bird-calls

Clamshell blunt-pointed object (flaking tool or punch?)
Saxidomus nuttalli smoothing or polishing, spatulate device
Spisula planulata object (scraper, fiber separator, shredder?)

Malaga Cove, Level 2 (Walker, 1951)

Location: Same as Malaga Cove, Level 1.

Age: 6510±100 B.P. on *Chione californiensis* (Ruby, 1961).

Species: Not given. Presumed to be much the same as in Level 1, but in far lesser quantity.

General Remarks: Food shell calcined.

Shell Ornaments and Tools:

Abalone bowls, asphaltum plugged
Abalone rim scoops
Clam disks (gaming pieces?)
Shell ornaments (types not given, probably spire-lopped and disk beads)

Zuma Creek (LAn-174) Peck, 1955)

Location: Near Point Dume on the western arm of Santa Monica Bay, 18 miles westerly along the coast from the city of Santa Monica, Los Angeles County.

Age: 4950±200 B.P. on *Haliotis cracherodii* (Ruby, 1961; Asher, 1959).

Species (roughly in order of numerical quantity):

Mytilus edulis
Mytilus californianus
Haliotis fulgens
Haliotis cracherodii
Hinnites multirugosus
Haliotis rufescens
Acmaea scutum
Tivela stultorum
Fissurella volcano
Chama pellucida
Olivella baetica
*Buccinum angulosum**
Trachycardium quadragenarium
Tegula funebralis
Olivella biplicata
Cypraea spadicea
Polinices lewisii

General Remarks: The largest percentage of food shells consisted of *Mytilus edulis* and *Mytilus californianus*. Many abalone shells were undamaged. All the shell species are presently found in the area except *Buccinum angulosum* (see note above).

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*Although listed by Peck, *Buccinum angulosum* is not known south of the Bering Strait, Alaska; a misidentification is likely (J. H. McLean).

Shell Ornaments and Tools:

Olivella beads, both *O. biplicata* and *O. baetica* (Spire-lopped)

Trachycardium quadragenarium as grave offerings

Tivela stultorum fragment (possible tool?)

Scripps Estates Site 1 (SDi-525) (Moriarity, Shumway, and Warren, 1959).

Location: Western San Diego County, 2.9 km. north of Alligator Point and about 0.9 km. north of Scripps Institution of Oceanography within the subdivision Scripps Estates Associates, Inc.

Age: 7370±100 B.P. (lowest level); 6700±150 B.P. (Burial 7); 5460±100 B.P. (surface)—all on *Mytilus californianus*.

Species (arranged alphabetically):

Aequipecten circularis aequisulcatum
Laevicardium elatum
Mytilus californianus
Olivella biplicata
Tivela stultorum
Abalone, limpets, chiton, sea urchins, and assorted small gastropods

General Remarks: Shellfish the primary source of food. *Mytilus californianus* and *Aequipecten circularis aequisulcatum* found in the greatest abundance. Calcareous remains of shell also found. *Laevicardium elatum* not presently found alive in the San Diego region, although known from Seal Beach, Orange County (Fitch, 1953).

Shell Ornaments:

Olivella biplicata necklace made up of about 90 spire-lopped beads with a central disk-shaped pendant of

Tivela stultorum directly associated with Burial 7

Laevicardium elatum complete shell (probably also part of the Burial 7 complex)

Parker Mesa (LAn-215) (King, 1962)

Location: Now called Sunset Mesa. Located on a terrace cut by Topanga Creek in Topanga Canyon, Los Angeles County.

Date: No absolute date. Considered coeval with Wallace's (1955) Milling Stone Horizon.

Species (in order of abundance):

Mytilus californianus
Protothaca staminea
Serpulorbis squamigerus
Septifer bifurcatus

Stenoplax conspicua
Tegula funebralis
Tegula gallina
Tetraclita squamosa rubescens
Balanus tintinnabulum
Fissurella volcano
Lottia gigantea
Chama pellucida

General Remarks: Shell concentration in the midden low. *Mytilus californianus* made up over 90% of the sample by weight; *Protothaca staminea* and *Stenoplax conspicua* somewhat less than 1%. The last four species (*Septifer bifurcatus* to *Chama pellucida*) constituted less than 0.1% of the sample each.

Shell Ornaments and Tools: None.

Glen Annie Canyon Site (SBa-142) (Owen, Curtis, and Miller, 1964)

Location: Ten miles west of the city of Santa Barbara overlooking Goleta Slough, Santa Barbara County.

Age: 6880±120 B.P. on shell, mainly *Saxidomus nuttalli*, from Burial 6, depth 12-18 inches below surface;
6980±120 B.P. on various shells, approximately 17 inches deep in association with a burial complex;
7270±120 B.P. on various shell, predominantly *Saxidomus nuttalli*, depth approximately 12 inches below surface;
6380±120 B.P. on various shells, at 24-30 inches, the lowest depth of control pit 18.

Species (roughly in order of their relative frequencies in a series of samples):

Chione undatella
Saxidomus nuttalli
Mytilus californianus
Tivela stultorum
Aequipecten circularis aequisulcatum
Chione californiensis
Protothaca staminea
Ostrea lurida
Mactra sp.
Macoma nasuta
Protothaca laciniata
Chione fluctifraga
Trachycardium quadragenarium
Olivella biplicata
Crepidula onyx
Tresus nuttalli
Haliotis sp.
Lottia gigantea
Cerithidea californica
Astraea undosa
Hinnites multirugosus
Acmaea incessa
Amphissa versicolor

Polinices reclusianus
Balanus sp.
Dentalium semipolitum
Conus californicus

General Remarks: The major part of the mollusks recovered were lagoon species. The first nine species listed (from *Chione undatella* through *Mactra* sp.) comprised over 80% of the shell remains. Shell ornaments were rare.

Shell Ornaments:

Spire-lopped *Olivella* beads
Rectangular *Olivella* beads
Clam disk beads
Dentalium semipolitum as grave offerings

An Early Channel Island Site

The data from the Little Harbor Site on Catalina Island are included in order to give a picture of shell resources and uses off the mainland. The site does not fall within the horizons above; it appears to be later, according to the one radiocarbon date available, and has as yet not been correlated with any mainland sites on the coast.

The Little Harbor Site, Catalina Island (Meighan, 1959)

Location: Catalina Island, 27 miles from Los Angeles Harbor on a headland 250 feet above the ocean.

Date: 3883±250 B.P. on charcoal from the basal levels in the midden at 24 inches below the surface.

Species (arranged alphabetically): The species listed in the column on the left are the common ones and were present in the column samples; the species listed in the column on the right are field samples and relatively rare, represented by one to several individuals only:

Acmaea sp.
Astraea undosa
Balanus sp.
Balanus glandula
Chiton sp.
Haliotis corrugata
Haliotis cracherodii
Haliotis fulgens
Mytilus californianus
Septifer sp.
Strongylocentrotus sp.
Tube worm

Aequipecten circularis aequisulcatum
Cerithidea californica
Conus californicus
Lottia gigantea
Maxwellia gemma
Megathura crenulata
Norrisia norrisii
Olivella biplicata
Polinices lewisii
Pseudochama exogyra
Tivela stultorum
Trivia solandri

General Remarks: Shellfish remains were taken from 11 column sample units of 2000 grams each and tabulated by weight. One midden sample contained one of the highest proportions of shell by weight (58%) that has been recorded in California. *Mytilus californianus* and *Haliotis* spp. predominate. Fish, shellfish and sea mammals were the dietary staples. Worked shell was rare.

Shell Ornaments and Tools:

Spire-lopped *Conus* beads
Spire-lopped *Olivella* beads
Barrel-shaped *Olivella* bead
Megathura crenulata ring
Haliotis sp. oblong pendant
Haliotis sp. fishhook fragments (considered intrusive)
Haliotis sp. perforated shells (scoops?)

Table 1.

List of molluscan species and their common names.

Pelecypods

Aequipecten circularis aequisulcatum (Carpenter)—Speckled Scallop
Amiantis callosa (Conrad)—White Cockle
Chama pellucida Sowerby—Agate Chama
Chione californiensis (Broderip)—Banded Cockle
Chione fluctifraga (Sowerby)—Smooth Cockle
Chione undatella (Sowerby)—Wavy Cockle
Donax gouldi Dall—Bean Clam
Hinnites multirugosus Gale—Rock Scallop
Laevicardium elatum (Sowerby)—Smooth Giant Cockle
Macoma nasuta (Conrad)—Bent Nosed Clam
Mactra sp.—Mactra
Mytilus californianus Conrad—California Mussel
Mytilus edulis Linnaeus—Bay Mussel
Ostrea lurida Carpenter—Native Oyster
Protothaca laciniata (Carpenter)—Rough-Sided Littleneck Clam
Protothaca staminea (Conrad)—Littleneck Clam
Pseudochama exogyra (Conrad)—Reversed Chama
Sanguinolaria nuttalli Conrad—Purple Clam
Saxidomus nuttalli Conrad—Washington Clam
Septifer bifurcatus (Conrad)—Branch-Ribbed Mussel
Spisula planulata Conrad—Flat Mactra
Tagelus californianus (Conrad)—Jack-Knife Clam
Tivela stultorum (Mawe)—Pismo Clam
Trachycardium quadragenarium (Conrad)—Forty-Ribbed Cockle
Tresus nuttalli (Conrad)—Gaper Clam [*Schizothaerus*]

Gastropods

Acanthina spirata (Blainville)—Unicorn Shell
Acmaea insessa (Hinds)—Seaweed Limpet

Acmaea limatula Carpenter—File Limpet
Acmaea scutum Eschscholtz—Plate Limpet
Amphissa versicolor Dall—Joseph's Coat Amphissa
Astraea undosa (Wood)—Wavy Turban Shell
Cerithidea californica (Haldeman)—California Horn Shell
Conus californicus Hinds—California Cone
Crepidula onyx Sowerby—Onyx Slipper Shell
Cypraea spadicea Swainson—Nut-Brown Cowry
Fissurella volcano Reeve—Volcano Keyhole Limpet
Haliotis corrugata Wood—Pink Abalone
Haliotis cracherodii Leach—Black Abalone
Haliotis fulgens Philippi—Green Abalone
Haliotis rufescens Swainson—Red Abalone
Kelletia kelletii (Forbes)—Kellet's Whelk
Lottia gigantea Sowerby—Owl Limpet
Maxwellia gemma (Sowerby)—Gem Murex
Megathura crenulata (Sowerby)—Giant Keyhole Limpet
Nassarius tegulus (Reeve)—Western Mud Nassa
Norrisia norrisii (Sowerby)—Red Top Shell
Ocenebra poulsoni (Carpenter)—Poulson's Rock Shell
Olivella baetica Carpenter—Beatic Olive
Olivella biplicata (Sowerby)—Purple Olive
Polinices lewisii (Gould)—Lewis' Moon Shell
Polinices reclusianus (Deshayes)—Southern Moon Shell
Serpulorbis squamigerus (Carpenter)—Scaly Worm Shell [*Aletes*]
Shaskyus festivus (Hinds)—Festive Rock Shell [*Murex*]
Tegula eiseni E. K. Jordan—Banded Top Shell [*T. ligulata*]
Tegula funebralis (A. Adams)—Black Top Shell
Tegula gallina (Forbes)—Speckled Top Shell
Trivia solandri (Sowerby)—Solander's Coffee-Bean Shell [*Pusula*]

SCAPHOPODA

Dentalium semipolitum Broderip & Sowerby—Polished Tusk Shell

AMPHINEURA

Stenoplax conspicua (Carpenter)—Showy Chiton [*Ischnochiton*]
Chiton (unidentified)

CIRRIPEDIA (*Barnacles*)

Balanus glandula Darwin—Acorn Barnacle
Balanus tintinnabulum Pilsbry—Pink Barnacle
Tetraclita squamosa rubescens Darwin—Scaly Barnacle

ECHINOIDEA

Strongylocentrotus sp.—Urchin

TABLE 2.

Occurrences by species of major food mollusks. (P) indicates present; (—) indicates absent.

MUSSELS	Malaga Cove 1	Little Sycamore	Zuma Creek	Scripps Estates	Parker Mesa	Glen Annie	Little Harbor
Mytilus californianus	P	P	P	P	P	P	P
Mytilus edulis	—	P	P	—	—	—	—
Septifer bifurcatus	—	—	—	—	P	—	P
ABALONES							
Haliotis corrugata	P	—	—	—	—	—	P
Haliotis cracherodii	P	P	P	—	—	—	P
Haliotis fulgens	—	P	P	—	—	—	P
Haliotis rufescens	—	—	P	—	—	—	—
Haliotis sp.	—	—	—	P	—	P	—
OYSTERS							
Ostrea lurida	P	—	—	—	—	P	—
COCKLES							
Chione californiensis	—	P	—	—	—	P	—
Chione fluctifraga	P	—	—	—	—	P	—
Chione undatella	P	P	—	—	—	P	—
Laevicardium elatum	—	P	—	P	—	—	—
Trachycardium quadragenarium	—	—	P	—	—	P	—
SCALLOPS							
Aequipecten circularis aequisulcatum	—	—	—	P	—	P	P
Hinnites multirugosus	P	P	—	—	—	P	—
CLAMS							
Chama pellucida	—	—	P	P	—	—	—
Protothaca staminea	P	—	—	—	P	P	—
Saxidomus nuttalli	P	P	—	—	—	P	—
Tivela stultorum	—	—	P	P	—	P	P
Tresus nuttalli	P	P	—	—	—	—	—

TABLE 3.

Comparative quantities of major food mollusk groups.

Site	*Mussels*	*Cockles*	*Clams*	*Abalone*	*Scallops*	*Oysters*
Malaga Cove, Level 1		50%			20%	8%
Little Sycamore	Majority			Important		
Malaga Cove, Level 2			NO RECORD			
Zuma Creek	Majority			Minor		
Scripps Estates 1	Majority				Minor	
Parker Mesa	90%					
Glen Annie	16%	40%	24%	Insignificant	2%	1%
Little Harbor	Major			Major		

TABLE 4.

Occurrences of molluscan species by site. (P) indicates present; (—) indicates absent.

	Malaga Cove 1	Little Sycamore	Zuma Creek	Scripps Estates	Parker Mesa	Glen Annie	Little Harbor	Total
ECHINOIDEA								
Strongylocentrotus sp.	—	—	—	P	—	—	P	2
PELECYPODS								
Aequipecten circularis aequisulcatum	—	—	—	P	—	P	P	3
Amiantis callosa	P	—	—	—	—	—	—	1
Chama pellucida	—	—	P	—	P	—	—	2
Chione californiensis	—	P	—	—	—	P	—	2
Chione fluctifraga	P	—	—	—	—	P	—	2
Chione undatella	P	P	—	—	—	P	—	3
Donax gouldi	P	—	—	—	—	—	—	1
Hinnites multirugosus	P	P	P	—	—	P	—	4
Laevicardium elatum	P	P	—	P	—	—	—	3
Macoma nasuta	—	—	—	—	—	P	—	1
Mactra sp.	—	—	—	—	—	P	—	1
Mytilus californianus	P	P	P	P	P	P	P	7
Mytilus edulis	—	P	P	—	—	—	—	2
Ostrea lurida	P	—	—	—	—	P	—	2
Protothaca laciniata	—	—	—	—	—	P	—	1
Protothaca staminea	P	—	—	—	P	P	—	3
Pseudochama exogyra	—	—	—	—	—	—	P	1
Sanguinolaria nuttalli	P	—	—	—	—	—	—	1
Saxidomus nuttalli	P	P	—	—	—	P	—	3
Septifer bifurcatus	—	—	—	—	P	—	P	2

Table 4. (continued)

Occurrences of molluscan species by site. (P) indicates present; (—) indicates absent.

	Malaga Cove 1	Little Sycamore	Zuma Creek	Scripps Estates	Parker Mesa	Glen Annie	Little Harbor	Total
Spisula planulata	—	P	—	—	—	—	—	1
Tagelus californianus	P	—	—	—	—	—	—	1
Tivela stultorum	—	—	P	P	—	P	P	4
Trachycardium quadragenarium	P	P	P	—	—	P	—	4
Tresus nuttalli	—	—	—	—	—	P	—	1
GASTROPODS								
Acanthina spirata	P	—	—	—	—	—	—	1
Acmaea insessa	—	—	—	—	—	P	—	1
Acmaea limatula	P	—	—	—	—	—	—	1
Acmaea scutum	—	—	P	—	—	—	—	1
Acmaea sp.	—	—	—	—	—	—	P	1
Amphissa versicolor	—	—	—	—	—	P	—	1
Astraea undosa	—	—	—	—	—	P	P	2
Cerithidea californica	P	—	—	—	—	P	P	3
Conus californicus	P	—	—	—	—	P	P	3
Crepidula onyx	P	—	—	—	—	P	—	2
Cypraea spadicea	—	P	P	—	—	—	—	2
Fissurella volcano	—	P	P	—	P	—	—	3
Haliotis corrugata	P	—	—	—	—	—	P	2
Haliotis cracherodii	P	P	P	—	—	—	P	4
Haliotis fulgens	—	P	P	—	—	—	P	3
Haliotis rufescens	—	—	P	—	—	—	—	1
Haliotis sp.	—	—	—	P	—	P	—	2

TABLE 4. (continued)

Occurrences of molluscan species by site. (P) indicates present; (—) indicates absent.

	Cove 1 Malaga	Little Sycamore	Zuma Creek	Scripps Estates	Parker Mesa	Glen Annie	Little Harbor	Total
Kelletia kelletii	—	P	—	—	—	—	—	1
Lottia gigantea	P	P	—	—	P	P	P	5
Maxwellia gemma	—	—	—	—	—	—	P	1
Megathura crenulata	—	P	—	—	—	—	P	2
Nassarius tegulus	P	—	—	—	—	—	—	1
Norrisia norrisii	—	P	—	—	—	—	P	2
Ocenebra poulsoni	P	—	—	—	—	—	—	1
Olivella baetica	—	—	P	—	—	—	—	1
Olivella biplicata	P	P	P	P	—	P	P	6
Polinices lewisii	—	—	P	—	—	—	P	2
Polinices reclusianus	P	P	—	—	—	P	—	3
Serpulorbis squamigerus	—	P	—	—	P	—	—	2
Shaskyus festivus	P	P	—	—	—	—	—	2
Tegula eiseni	—	P	—	—	—	—	—	1
Tegula funebralis	—	—	P	—	P	—	—	2
Tegula gallina	P	—	—	—	P	—	—	2
Trivia solandri	—	—	—	—	—	—	P	1
Limpets	—	—	—	P	—	—	—	1
Small gastropods	—	—	—	P	—	—	—	1
Tube worm	P	—	—	P	—	—	—	2
SCAPHOPODA								
Dentalium semipolitum	—	—	—	—	—	P	—	1

Table 4. (continued)

Occurrences of molluscan species by site. (P) indicates present; (—) indicates absent.

	Cove 1 Malaga	Little Sycamore	Zuma Creek	Scripps Estates	Parker Mesa	Glen Annie	Little Harbor	Total
AMPHINEURA								
Stenoplax conspicua	P	—	—	—	P	—	—	2
Chiton sp.	—	P	—	P	—	—	P	3
CIRRIPEDIA								
Balanus glandula	—	—	—	—	—	—	P	1
Balanus tintinnabulum	P	—	—	—	P	—	—	2
Balanus sp.	—	P	—	—	—	P	P	3
Tetraclita squamosa rubescens	—	—	—	—	P	—	—	1
Totals	30	24	16	10	12	27	24	143

TABLE 5

Occurrences of shell ornaments, tools, and grave offerings. (P) indicates present; (—) indicates absent.

	Malaga Cove 1	Little Sycamore	Malaga Cove 2	Zuma Creek	Scripps Estates	Parker Mesa	Glen Annie	Little Harbor	Total
Abalone									
Containers/asphaltum	P	—	—	—	—	—	—	—	1
Dishes, asphaltum plugged	P	—	P	—	—	—	—	—	2
Rim scoops	P	—	P	—	—	—	—	—	2
Perforated for scoops	—	—	—	—	—	—	—	P	1
Beads	P?	—	—	—	—	—	—	—	1?
Pendants	—	P	—	—	—	—	—	P	2
Fishhooks	—	—	—	—	—	—	—	P*	1
Clam									
Disk beads	P	—	—	—	—	—	P	—	2
Inlay	P	—	—	—	—	—	—	—	1
Pendants	P	—	—	—	P	—	—	—	2
Gaming pieces (?)	P	—	P	—	—	—	—	—	2
Spatulate tool	—	P	—	—	—	—	—	—	1
Scraper, shredder (?)	—	P	—	P	—	—	—	—	2
Flaking tool or punch	—	P	—	—	—	—	—	—	1
Whole shells in graves	—	—	—	P	P	—	—	—	2
Olivella									
Spire-lopped beads	P	P	P	P	P	—	P	P	7
Barrel-shaped bead	—	—	—	—	—	—	—	P	1
Rectangular beads	—	—	—	—	—	—	P	—	1

TABLE 5 (continued)

Occurrences of shell ornaments, tools, and grave offerings. (P) indicates present; (–) indicates absent.

	Malaga Cove 1	Little Sycamore	Malaga Cove 2	Zuma Creek	Scripps Estates	Parker Mesa	Glen Annie	Little Harbor	Total
Conus									
Spire-lopped beads	—	—	—	—	—	—	—	P	1
Miscellaneous									
Limpet rings	—	—	—	—	—	—	—	P	1
Whelk trumpets or bird calls	—	P	—	—	—	—	—	—	1
Cowry pendants	—	P	—	—	—	—	—	—	1
Cockle shell scoops	P	—	—	—	—	—	—	—	1
Mussel spoons	P	—	—	—	—	—	—	—	1
Univalve columella ornaments (?)	P	—	—	—	—	—	—	—	1
Dentalia grave offerings	—	—	—	—	—	—	P	—	1
Total types	12	7	4	3	3	0	4	7	40

*Considered intrusive

SUMMARY

From the above data it can be seen that a total of 25 species of pelecypods, 32 gastropods, one or more chiton, one scaphopod, three barnacles and one sea urchin are represented at the several southern California archeological sites reported here. Although nearly all of the species could be considered edible by aboriginal standards, it is quite possible that the smaller gastropods and barnacles came into the sites fortuitously—attached to the larger bivalves. Several species, *i.e., Dentalium semipolitum, Kelletia kelletii, Cypraea spadicea, Spisula planulata,* etc. occur only as grave offerings, tools, or ornaments.

Reference to a check list of the common bivalves of California (Fitch, 1953) shows that nearly all of the available common bivalves were known to the early populations along the coast. Missing are those species that do not grow in profusion or those found only in the deeper waters. Most of the edible species utilized by the early coastal inhabitants fall into four main groups on the basis of their habitat.

1. The first group consists of those bivalves found in large clusters attached to rocks at the low-tide zone. These are best exemplified by the mussels *(Mytilus californianus, Septifer bifurcatus)* and some small clams *(Chama pellucida, Pseudochama exogya)*. These species would require no special tools for their collection; they grow quickly and in great profusion, are nearly always visible, and are easily reached. *Mytilus californianus*, is, therefore, not surprisingly represented at every one of the early sites considered here; it continues to be one of the most common shell remains in middens along the California coast into proto-historic times.

2. The next group consists of those species living on the beaches of the open coast, found in the intertidal zone *(Tivela stultorum, Donax gouldi)*. *Tivela stultorum*, always highly esteemed as a food and whose thick, smooth shells made desirable ornaments is usually found just beneath the surface of the sand with the siphon extended to the surface. A probe, such as one made of the limb of a tree, would have served adequately for exposing the clams.

3. The largest group of common pelecypods are those found in sheltered bays, lagoons, and estuaries. Available at or near the surface in mud, or sand at low tide are: *Aequipecten circularis aequisulcatum, Trachycardium quadragenarium, Laevicardium elatum, Amiantis callosa, Protothaca staminea, Protothaca laciniata, Chione*

fluctifraga, *Chione undatella*, *Chione californiensis*, *Macoma nasuta*, and *Mactra californica*. Found clustered on the rocks in sheltered bays and lagoons as well are *Mytilus edulis* and the Native Oyster, *Ostrea lurida*. The presence of sites near the mouth of canyons, on bays and sloughs, and in other sheltered areas is reflected in the common occurrence in the middens of these easily collected molluscan species from the quiet water zones.

4. The last group consists of species found in the mud, sand, or small gravels of bays, lagoons and estuaries but buried from one to three feet, and requiring knowledge of the presence of the animals and a suitable probe with which to dislodge them: *Saxidomus nuttalli*, *Tagelus californianus*, *Sanguinolaria nuttalli*, and *Tresus nuttalli*. The two more-commonly-found clams, *Saxidomus nuttalli* and *Tresus nuttalli*, indicate their presence on firm, sandy mud, the first by narrow slit-like marks on the surface, the second by round openings an inch or two in diameter.

The abalones were the most frequently sought of the univalves; every site reported on here with the exception of Parker Mesa lists at least one species of abalone. Their habitats vary considerably (Cox, 1962: 28-34): *Haliotis cracherodii*, represented at 4 sites, is found in great numbers crowded together from near high tide to about 20 inches with most in the intertidal zone; *Haliotis fulgens*, reported from 3 sites, is a shallow water form which inhabits rocky areas from about low tide to 25 feet, but the majority are found in 10 to 20 foot depths; *Haliotis corrugata*, listed at 2 sites, is found in the more protected coastal and bay areas as well as along exposed coast in the active surf from the intertidal area to 180 feet or water with the majority found at from 20 to 80 foot depths; *Haliotis rufescens*, reported at only one site, is not found in sheltered bays but prefers rocky headlands and promontories where there is considerable wave action. Its maximum concentration lies between 20 to 50 feet in southern California.

While the abalone was deemed desirable by the aborigines for food, the beauty of its lustrous shell was not lost upon these early gatherers, shellfish collectors, and hunters. Ornaments, dishes and scoops were made at several of the sites, and it is likely that the shells were used for trading purposes as well. However, some sort of strong pry was needed to remove the animal from the rocks. *Haliotis* occurs most frequently on the under sides of rock ledges, where it clings, limpet-fashion, by its broad foot. Once the animal has taken hold, it requires the leverage of a bar or pry to dislodge it

(Ricketts and Calvin, 1962: 58). In later-horizon sites abalone pries of sea mammal bone are common; no similar tool was recovered from any of these earlier sites. Presumably suitable pries were made of more perishable material such as wood.

Several other gastropods appear to have been sought for food: *Lottia gigantea*, *Cerithidea californica*, *Polinices* spp., and *Tegula* spp. However, *Olivella biplicata*, *Conus californicus*, and *Megathura crenulata* were probably mainly collected for making ornaments —simple beads and rings.

With the growing body of information on early sites and a growing awareness of the importance of keeping adequate data on shellfish species and quantities, problems in diet preferences, species availability, depletion of species in some areas, distribution of shell artifacts, etc. may eventually be resolved. The assistance of specialists in invertebrate zoology will be required to help the archeologist interpret the ecological meaning of subtle shifts in molluscan populations in archaeological sites.

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I am deeply indebted to Dr. James H. McLean of the Los Angeles County Museum for his patient assistance and interest in this paper. Dr. Charles Rozaire, Curator of Archeology, Los Angeles County Museum, also read the early draft and offered valuable suggestions for its improvement.

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OBSERVATIONS ON THE ASTEROID ECHINODERM FAUNA OCCURRING IN THE SHALLOW WATER OF SOUTHERN CALIFORNIA (Intertidal to 60 Meters)

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INTRODUCTION

The Pacific Coast Asteroidea were monographed by Verrill (1914) and Fisher (1911, 1928, 1930). The purpose of this paper is to provide the field collector with a keyed guide to species that may be encountered from Pt. Conception to San Diego, based on species collected from various habitats encountered in the San Diego locale. In this manner, we hope that it will serve to complement Light's Manual (Smith, *et. al.*, 1961), which is particularly good for Central and Northern California.

The observations contained herein were obtained with the use of SCUBA. This tool has allowed us to work to depths of 60 meters in the La Jolla and Scripps submarine canyons, and to make observations and collections efficiently; often in underwater terrain so rugged that dredges and grabs could not be used.

RESULTS

We have located 18 species of the subclass Asteroidea in the San Diego area in the bathymetric range 0 to 60 meters. Of special interest is the fact that we are able to provide new zoogeographic or bathymetric range data for 12 species.

In the preparation of the following account, we have incorporated

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the ordinal classification of Fell (1963) into the classification system used by Fisher (1930:188-212). The arrangement of the text thus presents orders, families, etc. in the sequence in which they are encountered in the key provided. On occasion we have not followed locally-recognized generic or specific names when we felt that these names were not correct. We have not listed all of the systematic synomyms or previous notations with the exceptions of those where we depart from Fisher (1911, 1928, 1930).

Where possible we have provided food habits (or preferences) based on limited observations or as inferred from existing literature.

At the conclusion of the descriptive text, we have provided a glossary of the terms used, and a tabulated summary (Table 1) of the information provided by this paper.

Class ASTEROZOA
Subclass ASTEROIDEA
Order PLATYASTERIDA
Family LUIDIIDAE

Petalaster foliolata (Grube)

Luidia foliolata Grube, Fisher, W. K. 1911, Bull. U.S. Natl. Mus., 76:1, 106-113.

Petalaster foliolata (Grube), Fell, H. B., 1963, Phil. Trans. Roy. Soc. Lond., Ser. B., 246:433-434.

In his recent monograph on the phylogeny of sea-stars, Fell (1963) (1) removed the family Luidiidae from its long-standing place in the order Phanerozonia to place it in an earlier phylogentic order, the Platyasterida, and (2) divided the family into 9 genera (or perhaps subgenera) which places the species *foliolata* into the genus *Petalaster*.

This species was usually collected at depths of 20 meters or more in conjunction with a rather fine sand substrate such as the intercanyon shelf of La Jolla Bay. In the field the animal may be found either crawling on the surface or buried just below the surface but leaving its pentagonal outline. The animal autotomizes readily, and rarely was a whole non-regenerating specimen found.

Fisher (1911) reported *Dentalium* (Mollusca: Scaphopoda) and the remains of ophiuroids from their stomachs; Hulings and Hemlay (1963) studied the food habits of a congeneric species, *Petalaster* (=*Luidia*) *clathrata* from the Gulf of Mexico.

Order PHANEROZONIA

Family ASTROPECTINIDAE

Astropecten brasiliensis armatus Gray

Astropecten armatus Gray, Fisher, W. K., 1911, Bull. U.S. Natl. Mus., 76:1, 56-61.

Astropecten brasiliensis armatus Gray, Doderlein, L., 1917, Siboga Exped., 30:1, 84-85.

This species has long been known locally as *Astropecten armatus*. We feel that Doderlein (1917) has shown conclusively that it is a subspecies of a species with a rather extensive distributional range. Of the two species of *Astropecten* occurring in our locale, this species is the shallower living (3-15 meters), and can be separated from the following species (*A. verrilli*) by the presence of tubercles on the supramarginal plates. This characteristic is detectable even in quite small specimens.

In the field it has been observed to have a burrowing habit. Its food includes dead fish, the sea pansy (*Renilla kollikeri*), the sand dollar (*Dendraster excentricus*), and the Nassa mud snail (*Nassarius perpinguis*). Wells, *et al.* (1961) and Hulings and Hemlay (1963) studied the food habits of related species.

Astropecten verrilli de Loriol

Astropecten californicus Fisher, Fisher, W. K., 1911, Bull. U.S. Natl. Mus., 76:1, 61-67.

Astropecten verrilli de Loriol, Doderlein, L., 1917, Siboga Exped., 30:1, 85-88.

This species has also been known by another name, *Astropecten californicus* Fisher. We feel that, as in the previous case, Doderlein (1917) presented strong reasons for using the name we cite above. Fisher (1930) recognized Doderlein's revision in this case, but considered it a subspecies, *Astropecten verrilli californicus*.

This species is the most abundant asteroid on the sandy intercanyon shelf at depths of 15 to 80 meters. It does not seem to bury itself as frequently as is observed in the case of *Astropecten brasilien-*

sis armatus. Its food habits probably consist of polychaetes, molluscs, and ophiuroids.

Tethyaster sp.

Tethyaster canaliculatus (A. H. Clark), Clark, A.M. and A. H. Clark. 1954, Smith. Misc. Coll., 122, No. 11, 27 pp.

Tethyaster gigas Caso, Caso, M. E. 1960, An. Inst. Biologia, 31 (1&2): 449-61.

This specimen, the largest astropectinid in the San Diego area, was encountered several years ago by the late Conrad Limbaugh while using SCUBA at the Coronados Islands (9.3 km. south of Pt. Loma, San Diego). Recently we have confirmed this record by observing specimens at 30 meters on a mud-sand bottom along the east side of North Coronados Island (H. O. Chart 1149).

At the present time we have a single specimen (dried) with which to work (R=220). We are unwilling at the present time to assign this specimen to either of the above listed species. Caso (1960) made a strong bid to preserve the identity of her *T. gigas* which was synonymized with *T. canaliculatus* by Clark and Clark (1954). Both species are described from the Gulf of California, but in the case of *T. canaliculatus* the largest specimen examined was of R=95 mm. In the case of *T. gigas* the smallest specimen examined was of R=205 mm. In each case of the above species the ratio of R:r is 3.6 (Caso, 1960, reports 3.8 for *gigas* based on 245:68 which results in 3.6). In our specimen R=220 and r=70 to 80 (depending on what point is chosen as "the interradial margin between two rays." As a result, our ratio would be 2.9 to 3.2 indicating the disk is proportionally broader than either of the above species. A more complete series of our specimen is being sought, and it is hoped that the identity of our species will be established and throw some light on the relations of the other species described from this coast.

Under any circumstances, this record in conjunction with Limbaugh's unpublished observation is a significant extension of the range of either of the above species which were both described as limited to the Gulf of California.

In nature, the living animal is a bright orange-red, and as with *Mediaster*, the tube feet are red.

Limbaugh has been quoted as saying that his species was found feeding on the small white urchin, *Lytechinus*, which abounds in that particular habitat.

We wish to acknowledge the keen observational power of Mr. Art Wolfson, part-time Marine Collector, Department of Marine Biology of this Institution, for recognizing this specimen as being new to his faunal list, and for his kindness in bringing the specimen to us for identification.

Family ASTEROPIDAE
Dermasterias imbricata (Grube)

Dermasterias imbricata (Grube), Fisher, W. K., 1911, Bull. U.S. Natl. Mus., 76:1, 249-250.

Dermasterias, the "leatherbacked sea-star" has been encountered frequently in the kelp beds off La Jolla and Point Loma at depths of 8 to 25 meters. In the entrance channel to Mission Bay it has been found as shallow as 2 meters. Occurrence of this species in this area is a notable range extension; Fisher (1911) records its southern limit as Monterey Bay. *Dermasterias* is quite easily recognized by its smooth greyish-green leathery covering with orange to red imbrications on the aboral surface, the basis for its common name.

Observations from the field indicate that this species is a scavenger of bottom detritus, and may prey on moribund animals.

Family ODONTASTERIDAE
Peridontaster crassus (Fisher)

Odontaster crassus Fisher, Fisher, W. K., 1911, Bull. U.S. Natl. Mus., 76:1, 154-158.

Peridontaster crassus (Fisher). Koehler, R., 1920, Australasian Ant. Exped., 8:1, 185.

Fisher (1930) recognized the work of Koehler (1920) and has modified the name accordingly.

Peridontaster crassus is perhaps the most common asteroid inhabitant of the La Jolla Canyon wall (Stewart, *pers. comm.*, 1964[1]). We have found this species as shallow as 30 meters as opposed to Fisher's shallowest record of 85 meters. This species has not been seen in Scripps Canyon. The species is readily recognized by its distinctly pentagonal appearance, conspicuous marginal plates, and by its pale orange color. We have found no information on the food habits of this species.

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[1] Observation from the diving saucer "Denise" in the La Jolla Canyon.

Family LINCKIIDAE
Linckia columbiae Gray

Linckia columbiae Gray, Fisher, W. K., 1911, Bull. U.S. Natl. Mus., 76:1, 242-247.

In the past, *Linckia* was very abundant intertidally in rocky areas such as La Jolla Cove, Bird Rock and Pt. Loma of the San Diego area. It is still present, but it is not as abundant as in former days, probably because of the collecting pressure by the general public. It may be taken in the above habitats under rocks that are uncovered only by spring tides. Pequegnat (1964) recorded this species from a siltstone reef off Newport Harbor to the north where it is considered to be very near its northern limits.

This species may be recognized by its slender round arms with blunt tips, and its grey mottling on a reddish maroon background. Anderson (1962) found that *Linckia* is organized anatomically to be a feeder upon detrius.

Family GONIASTERIDAE
Mediaster aequalis Stimpson

Mediaster aequalis Stimpson, Fisher, W. K., 1911, Bull. U.S. Natl. Mus., 76:1, 198-202.

Mediaster is associated with rocky substrates at depths of 12 meters and deeper. In the field, this species appears superficially like *Patiria*, but the arm length (R) is distinctly greater than the distance to the inter-radial margins between the arms (r). In addition, there is the obvious appearance of the supra-marginal plates. The color is a uniform rose-red on the aboral surface, yellow below. Its food habits seem to be those of a scavenger living off bottom deposits of detritus or decaying animals.

Order SPINULOSA
Family ASTERINIDAE
Patiria miniata (Brandt)

Asterina miniata Brandt, Fisher, W. K., 1911, Bull. U.S. Natl. Mus., 76:1, 154-258.

Patiria miniata (Brandt), Verrill, A. E., 1914, Smith. Inst. Harr. Alaska Ser. 14. Caso (1961) and Ziesenhenne (1941) listed this species as *Asterina*. Fisher (1920) agreed with Verrill (1914) in placing the species in the genus *Patiria*. Recent discussion with Dr. Patricio Sanchez of Chile, who is quite familiar with other species of *Asterina* and *Patiria*, indicates that Verrill was correct in assigning this species to the genus Patiria. Unfortunately, neither Caso nor Ziesenhenne has presented any arguments for placing it in the genus *Asterina*.

Patiria is the most ubiquitous asteroid of our area; it has been encountered intertidally on rocky shores and to at least 30 meters on the walls of La Jolla Canyon. It may be found both on rocks and on sand or crushed shell. The animal has received its common name "bat star" because (R) is only slightly greater than (r). (For a concise definition of "R" and "r" please consult the glossary of terms used.) This colorful species occurs not only in solid colors, but also in mosaic assortments of color patterns.

Anderson (1959) studied the feeding mechanisms of this species and we have seen the voluminous folds of its stomach capture not only moribund creatures, but also living *Astropecten*. In an attack upon another asteroid, *Nidorellia armata*, the *Patiria* showed a remarkable ability to hydrolyze the chromoprotein of the former as evidenced by changing the olive green and black skin of the prey to an orange-red.

We can extend the range of *Patiria* as far south as San Hippolito, Baja California (Chart H.O. 624) where it was abundant in 12 meters of water; Caso (1962) reports finding a single juvenile in her collections from the Islas Revillagigedo (Chart H.O. 1688) lying southwest of the tip of Baja California.

Family ECHINASTERIDAE

Poraniopsis inflata (Fisher)

Poraniopsis inflata (Fisher), Fisher, W. K., 1911, Bull. U.S. Natl. Mus., 76:1, 261-266.

Poraniopsis, like *Peridontaster*, has been seen only in the La Jolla Canyon where it occurs at 40 meters. Like *Peridontaster* it is not frequently encountered, but in the field it can be easily distinguished by its conspicuous large white spines which are well set apart, by its broad stubby arms, and by its characteristically flabby appearance. This species is orange to pink aborally and white below.

We have not been able to obtain any observations on the food habits of this species.

Henricia leviuscula (Stimpson)

Henricia leviuscula (Stimpson), Fisher, W. K., 1911, Bull. U.S. Natl. Mus., 76:1, 280-293.

From the standpoint of species form and variety this genus apparently posed more problems for Fisher than any other asteroid group in this monograph. With regard to the genus he says, "Although well acquainted with the variability of starfishes, I have never before met with such an extreme example as the species of this genus present. . . . So great and numerous are the variations in most of the species recorded below, that each is to be regarded as a center of variation, deviations from the type proceeding in many directions until they meet and often merge with aberrant members of nearly related forms." Our local modal representative appears to be nearest his subspecies *dyscrita*.

In the field, *Henricia* may be confused with *Linckia* due to the superficial morphological similarity, but they can be separated by noting that *Linckia* is always a red-maroon and grey mottled color, whereas *Henricia* is almost always a solid color (yellow, orange, brown, purple). Furthermore, the surface of *Linckia* is covered with multitudes of semi-spherical granules, whereas the paxillae of *Henricia* appear in undulating series or furrows.

In our area, *Henricia* is usually not encountered in water shallower than 10 meters and ranges to much greater depths on the canyon walls. It is found most frequently in areas where there is rock encrusted with sponges, bryozoans and the like. Anderson (1960), based on anatomical studies, has proposed that this species is probably a particulate detritophage. Our observations in the laboratory and field have confirmed this.

We have seen this species as far south as Turtle Bay, Baja California (Chart H.O. 1310).

Order FORCIPULATA
Family ASTERIIDAE
Subfamily PYCNOPODIINAE
Pycnopodia helianthoides (Brandt)

Pycnopodia helianthoides (Brandt), Fisher, W. K., 1928, Bull. U.S. Natl. Mus., 76:2, 154-160.

Pycnopodia is the most spectacular asteroid in our waters with its multibrachiate form reaching as much as a half-meter in diameter.

This species is abundant in the Pt. Loma kelp beds and in the area of New Hope Rock (Chart H.O. 1149). It has also been found on the walls of La Jolla and Scripps Canyons to a depth of 40 meters. Although several color varieties are known to occur to the north, we have found only the pale lavender to purple form in our area.

Fisher (1928) observed that *Pycnopodia* is an avid predator and that it will attack a variety of organisms including *Stichopus californicus*, a holothuroid. Locally, we have observed *Pycnopodia* eating the sea urchin *Strongylocentrotus*, and the snail, *Tegula*.

Subfamily COSCINASTERIINAE

Astrometis sertulifera Xantus

Astrometis sertulifera Xantus, Fisher, W. K., 1928, Bull. U.S. Natl. Mus., 76:2, 119-126.

Along with *Patiria*, *Astrometis* is a common inhabitant of the tidepools, hiding under rocks and showing a remarkable negative response to light when exposed. Although Fisher (1928) lists its bathymetric distribution as "to shallow depths," we have seen the species as deep as 35 meters in the Scripps Canyon where it was found on the tops of rocks in opposition to its habit in tidepools. In the field, the animal is easily recognized by its orange and blue spines and bright orange oral side. This species is a voracious predator and has been seen feeding on *Tegula* and other gastropods, pelecypods and barnacles.

From the literature, and our own observations, this species appears to have a disjunct distribution. Cape San Lucas, Baja California is the type locality, and Fisher has several records for the Gulf of California. We have also found this species in the Gulf of California, near Cape San Lucas, but we did not find it at stations from Arrecife Sacramento extending to the south end of Santa Margarita Island, Magdalena Bay while collecting intertidally downward to 20 meters. Neither did Ziesenhenne (1937) encounter this species during the collecting by the Templeton-Crocker Expedition from Magdalena Bay south around to La Paz, Baja California.

Sclerasterias heteropaes Fisher

Sclerasterias heteropaes Fisher, Fisher, W. K., 1928, Bull. U.S. Natl. Mus., 76:2, 112-118.

In those places in which *Sclerasterias* and *Astrometis* occur they may be confused, but the former can be readily separated in the field by the lack of coloration in the spines, the pale oral surface, and the arrangement of spines into fairly discrete rows. This species is usually found in the deeper kelp beds among the holdfasts and on rocks at about 20-25 meters depth. They do not seem to reach the size of *Orthasterias*; however, they may be as large as *Astrometis* where they co-occur (20 cm. tip to tip).

Like *Astrometis*, this species has a disjunct distribution. Fisher (1928) lists the southern limit as south of San Diego (undefined). Ziesenhenne (1937) and Caso (1962) give records for the Islas Revillagigedos south of Baja California. However, as with *Astrometis,* we did not encounter this species in the collections made down to the area of Magdalena Bay. Neither was this form seen during the limited collections we made at Cape San Lucas.

Orthasterias koehleri (de Loriol)

Orthasterias koehleri (de Loriol), Fisher, W. K., 1928, Bull. U.S. Natl. Mus., 76:2, 139-148.

Orthasterias is perhaps the prettiest of the three coscinasterid species occupying our territory, and its rosy pink ground color with grey mottling is a sufficient field character to help in separating it from its two near relatives, *Astrometis* and *Scleresterias.* Although Fisher (1928) reports their southern limit as Santa Cruz, we have found this species to be relatively abundant in this area as shallow as 20 meters where they may be found in association with encrusted rocks.

The food habits of this species parallel those of *Astrometis, Sclerasterias*, and *Pisaster giganteus.*

Subfamily ASTERIINAE

Pisaster giganteus (Stimpson)

Pisaster giganteus (Stimpson), Fisher, W. K., 1930, Bull. U.S. Natl. Mus., 76:3, 172-180.

Pisaster giganteus is the largest of our three species of *Pisaster* and may frequently by seen in rocky areas of 3-4 meters depth. In some rocky intertidal areas exposed by tides of —0.5 or more, this species may be taken along with *Astrometis*, *Linckia*, *Patiria*, and

Pisaster ochraceous. In the case of *P. ochraceous*, it is strictly subtidal, whereas our deepest record for *P. giganteus* is 45 meters in the Scripps Canyon.

In the field, this species can be separated from the other two members of the genus by its sky-blue coloring and large, white, blunt spines.

Fisher lists its range as northern Baja California (undefined); we can reliably extend its range to San Pablo Bay, 84 km. southeast of Pta. Eugenia Light (Chart H.O. 624).

Pisaster brevispinus (Stimpson)

Pisaster brevispinus (Stimpson). Fisher, W.K., 1930, Bull. U.S. Natl. Mus., 76:3, 180-187.

Of the three species of *Pisaster*, this species has the most unusual coloration and ecological niche. The pink coloration is consistent; we have never seen variations such as are seen in *P. ochraceous*. In size, it very nearly approaches *P. giganteus*; in general morphology it more resembles *P. ochraceous*, due to the reduced spines. The species is aberrant in that it occupies a mud substrate rather than rock as with the other two species. Hence, we have a case of very discrete species niche zonation:

Pisaster ochraceous—rocky intertidal
Pisaster giganteus—rocky subtidal
Pisaster brevispinus—subtidal mud

Fisher lists the southern limit of this species as Santa Barbara, but it is found locally in the Mission Bay entrance channel at 10 meters, and at the head of La Jolla Canyon at 20 meters depth.

Pisaster ochraceous (Brandt)

Pisaster ochraceous (Brandt), Fisher, W. K., 1930, Bull. U.S. Natl. Mus., 76:3, 164-172.

In areas where the mussel, *Mytilus*, abounds there lies *P. ochraceous*. Feder (1960) studied its biology and we can add nothing to his accounts. The species is strictly intertidal with the exception that it may occur deeper on pier pilings. Fisher lists the southern limit as Tijuana, Baja California, but we have observed a small specimen on the southeast side of Cedros Island (Chart H.O. 1193).

This species is rather variable in color and arrangement of the small white spines. Three color groups should be distinguishable: orange, brown and purple.

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TABLE 1

A "Species List" Summary of the Information Provided by this Publication.

A. Species related to their habitat in the San Diego, California area.

INTERTIDAL ROCK
- *Astrometis sertulifera*
- *Linckia columbiae*
- *Patiria miniata*
- *Pisaster giganteus*
- *Pisaster ochraceous*

SUBTIDAL ROCK
- *Astrometis sertulifera*
- *Dermasterias imbricata*
- *Henricia leviuscula*
- *Mediaster aequalis*
- *Orthasterias koehleri*
- *Patiria minata*
- *Pisaster giganteus*
- *Pycnopodia helianthoides*
- *Sclerasterias heteropaes*

SUBTIDAL MUD-SAND
- *Astropecten brasiliensis armatus*
- *Astropecten verrilli*
- *Petalaster foliolata*
- *Patiria miniata*
- *Pisaster brevispinus*
- *Tethyaster* sp.

CANYON WALLS
- *Henricia leviuscula*
- *Orthasterias koehleri*
- *Patiria miniata*
- *Peridontaster crassus*
- *Poraniopsis inflata*
- *Pycnopodia helianthoides*

B. Species not found intertidally at southern limit of range, though found intertidally to the north.

- *Dermasterias imbricata*
- *Henricia leviuscula*
- *Orthasterias koehleri*
- *Patiria miniata*
- *Pisaster brevispinus*
- *Pycnopodia helianthoides*

C. Species whose range has been extended southward by this publication.

- *Dermasterias imbricata*
- *Henricia leviuscula*
- *Orthasterias koehleri*
- *Patiria miniata*
- *Pisaster brevispinus*
- *Pisaster giganteus*
- *Pisaster ochraceous*

D. Species whose range has been extended northward by this publication.

Tethyaster sp.

A KEY TO THE SUBCLASS ASTEROIDEA OF SOUTHERN CALIFORNIA (INTERTIDAL TO 60 METERS)

1\. Abactinal skeleton in the form of paxilliform plates; paxillae of rays extend to lower edge of ray; supramarginal plates absent; tube feet pointed (without sucker disk) . . . .
Order PLATYASTERIDA . . . . *Petalaster foliolata*
1a. Abactinal skeleton not always of paxilliform plates; when paxillae are present they always join supramarginal plates on each ray 2

2\. Marginal plates usually large and conspicuous; abactinal skeleton in the form of paxilliform plates, or flat tesselate plates which may be smooth or armed with semi-spherical granules (*Linckia*); tube feet may lack sucker disks (*Astropecten*) . . . .
Order PHANEROZONIA 3
2a. Marginal plates usually not large and conspicuous; abactinal skeleton not composed of true paxilliform plates, nor in the form of a tesselated pavement, more usually reticulated or imbricated; tube feet always with sucker disks 9

3\. Tube feet without sucking disks 4
3a. Tube feet with well developed sucking disks 6

4\. Supramarginal plates with spines or tubercles . . . .
. . . . *Astropecten brasiliensis armatus*
4a. Supramarginal plates devoid of spines or tubercles 5

5\. Inframarginal spines needle-like, pointed . . . .
. . . . *Astropecten verrilli*
5a. Inframarginal spines spatulate, chisel-like . . . .
. . . . *Tethyaster canaliculatus*

6\. Aboral surface of disk and arms including supramarginal plates covered with a smooth leathery membrane . . . .
. . . . *Dermasterias imbricata*
6a. Aboral surface of disks and arms with distinct paxillae or with semi-spherical granules hiding the paxilliform plates 7

7\. Rays short or stubby, neither slender nor pointed, giving the animal a pentagonal appearance . . . . *Peridontaster crassus*
7a. Rays slender or pointed, not stubby 8

8\. Rays round in x-section, covered with semi-spherical granules; disk small . . . . *Linckia columbiae*
8a. Rays not round, distinct paxillae and supramarginal plates, upper surface not granulate; disk large . . . . *Mediaster aequalis*

9\. Upper surface of body without scissor-like pedicellariae . . . . . . Order Spinulosa 10
9a. Upper surface of body with scissor-like pedicellariae . . . . Order Forcipulata 12

10\. Rays giving a distinct pentagonal appearance, webbed . . . . *Patiria miniata*
10a. Rays distinct, not webbed 11

11\. Large conspicuous white spines present; rays blunt . . . . *Poraniopsis inflata*
11a. No large conspicuous spines, rays attenuate . . . . *Henricia leviuscula*

12\. With many rays (15-24) . . . . *Pycnopodia helianthoides*
12a. With few rays (5-6) 13

13\. Spines of rays styliform; arms round, slender, elongate 14
13a. Spines of rays short, blunt to capitate; arms thick and bulky 16

14\. Spines of living animal bright blue with orange tips; only the outer of the two inframarginal spines carry a cluster of crossed pedicellariae . . . . *Astrometis sertulifera*
14a. Spines not colored as above; the inner as well as the outer inframarginal spines carry a cluster of crossed pedicellariae 15

15\. Slender spines in about 5 longitudinal rows; general body color of living animal is mottled brown . . . . *Sclerasterias heteropaes*
15a. Slender spines are numerous, not in a longitudinal series; general body color of the living animal is deep rose mottled with pink and cream coloration . . . . *Orthasterias koehleri*

16\. Spines of the aboral surface rather evenly scattered, not in distinct concentric groups, robustly conspicuous; general body color of the living animal is light and dark blue; tips of spines tinged with purple . . . . *Pisaster giganteus*
16a. Spines of the aboral surface in concentric groups or forming a network, not conspicuous 17

17\. Body color of living animal is pale pink . . . *Pisaster brevispinus*
17a. Body color of the living animal is orange, reddish-brown or purple . . . . *Pisaster ochraceous*

GLOSSARY

Abactinal plates: the plates making up the calcareous network of the dorsal side of the starfish. The corresponding ventral plates are the actinal plates.

Capitate: blunt or globose.

Inframarginal spine: spines located on the marginal plates on each side of the arms. There are two marginal plates on each side, the inframarginal and supramarginal plates.

Paxillae: modified projections on the upper surface of the dorsal arm plate (abactinal plates); consisting of a stalk bearing a flat expanse covered with minute spinelets.

Pedicellariae: small pincer-like organs found all over the body surface of the Order FORCIPULATA.

R: the abbreviation used to express the distance from the center of the disk in a sea-star to the tip of the arm.

r: the abbreviation used to express the distance from the center of the disk in a sea-star to the interradial margin between two rays.

Reticulated: forming a network.

Styliform: slender and pointed.

Supramarginal plates: upper series of marginal plates on the sides of the arms of sea-stars.

Tesselate: forming little squares.

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STUDIES ON THE SALINITY AND HUMIDITY TOLERANCES OF FIVE SPECIES OF ISOPODS IN A TRANSITION FROM MARINE TO TERRESTRIAL LIFE

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Introduction

Organisms which are undergoing a transition from sea to land are faced with a great number of physiological and physical stresses. Estuaries are the commonest route from the sea (Pearse, 1927) and subject organisms to rather gradual changes in the factors of stress. A route through the intertidal area directly to land is usually considered a more drastic transition in terms of rapid changes in stress factors. Here the organisms encounter such problems as rapid temperature and osmotic fluctuations and an immediate change from aquatic to aerial respiration. The actual osmotic problem, however, is similar in the sea and on land, and is reversed in fresh water. That is, both marine and terrestrial organisms are faced with a problem of water loss while fresh water forms are faced with a problem of gaining water. In this respect an intertidal transition requires less physiological adjustment than a transition through an estuary.

The isopod crustaceans include excellent examples of animals undergoing the transition to land life. Five species of isopods, representing different degrees of adaptation to land life, were subjected to tolerance tests in various salinities and humidities. The species used for these tests were *Cirolana harfordi*, a completely marine form; *Idothea* (*Pentidotea*) *wosnesenskii*, *Ligia occidentalis*, and *Alloniscus perconvexus*, each representing a successively higher level on the shore; and *Porcellio* (*Porcellio*) *scaber*, a terrestrial species.

This study was conducted in 1960 and 1961 at the Pacific Marine Station of the University of the Pacific, Dillon Beach, Marin County, California.

Materials and Methods

Specimens were maintained in a water table at a temperature of 14°C. The summer salinity tests were conducted in July, 1960, and the winter tests in February, 1961. The following salinities were used in all experiments involving various concentrations of sea water:

Medium	Salinity o/oo
100% sea water	32.25
75% sea water	25.75
50% sea water	17.00
25% sea water	8.32
10% sea water	3.60
fresh water	0.25

The test samples were placed in dishes containing 200 ml. of the test solution and observed for a 48-hour period. Fifty per cent death times were recorded as well as the activity of the survivors at the end of the test. In cases where a 50% death was not noted during the 48 hour period the result was recorded as (48+).

The humidity tolerance tests were also conducted in the water table at 14°C during April, 1961. Desired humidities were maintained through the use of various concentrations of sulfuric acid as described by Miller (1938). Flasks containing the acid solutions were placed in gallon jars and individuals of each species were placed in beakers and set in the jars. The containers were sealed and a small pin hole placed in the lids. This hole was sealed and only opened to stimulate the animals with a thin wire to determine death times. Records were kept as in the salinity tests.

All test animals were considered dead when they no longer responded to mechanical stimulation of the body or appendages. Control groups were placed in the water table during each test.

Habitat, Behavior and Adaptive Morphology

Most of the test animals were collected in the Second Sled Road area near Dillon Beach. This region of the California coast is of the sort usually described as a semi-protected rocky coast, and is ideal for studying the transition to land. This area is characterized by high humidities and heavy fog. The annual average rainfall of the area has been reported as 31.65 inches and the mean air temperature as 54.2°F (Johnson, 1961). The tidal range is from six to eight feet. These moderating conditions are favorable to the survival of animals undergoing a transition to land.

Presented here are some of the more important anatomical and behavioral adaptations of each species to its level in the transition area and some of the charcteristics of their particular habitats.

Cirolana harfordi: completely aquatic; found under rocks, mid-tide and deeper; environmental temperature fluctuations gradual; peraeopods weak; pleopods thin for aquatic respiration.

Idothea wosnesenskii: commonly found on *Porphyra perforata* in areas exposed by most low tides; subjected to rapid changes of from 3 to 4°C and osmotic stress during periods of exposure; peraeopods equipped with terminal, prehensile hooks used in attaching to algal curtains; lateral extensions of the uropods are modified as thick flaps which cover the pleopods retaining a drop of water during periods of exposure.

Ligia occidentalis: typically found high in the spray zone in rocky areas; remain in moist cracks and crevices during warm periods (temperatures here are from 2 to 4°C higher than the ambient air temperatures and higher humidities are maintained); peraeopods are ambulatory and the body is flattened allowing entrance into crevices; pleopodal exopodites are thickened and protect the thinner endopodites from dying; uropodal spines are used to dip into water and draw moisture onto the respiratory surfaces.

Alloniscus perconvexus: found buried 3 to 6 inches in sandy beaches above the berm; the moisture content of the inhabited sand ranged from 2.9 to 5.5%; sand temperatures were very stable; strong, robust peraeopods facilitate burrowing; pleopodal exopodites thickened as in *Ligia*; depth of burrowing varied with moisture content of sand.

Porcellio scaber: completely divorced from the sea; found under boards and stones in moist areas; attitude of concealment moderates the rate and intensity of temperature and humidity changes; peraeopods are ambulatory; pseudotrachea located on the first and second pairs of pleopods, the remaining three pairs are probably non-functional.

The dependance of *Porcellio scaber* on the pseudotrachea was demonstrated by removing various pairs of pleopods and noting the survival times in a relatively low humidity (25 to 30% R.H.). The results of this test are shown in Table 1.

TABLE 1

Fifty per cent death times of *Porcellio scaber* after removal of various sets of pleopods.

Pleopod Pairs Removed	*50% Death Time*
1, 2	1 hour
2, 3, 4, 5	2.25 hours
3, 4, 5	10 hours
none	12 hours

These results illustrate the importance of the first two pairs of pleopods; those possessing the respiratory structures. Similar information was presented by Miller, 1938.

DISCUSSION OF PHYSIOLOGICAL DATA

Tables 2, 3, and 4 are the recorded 50% death times in the various experimental salinities and humidities. Due to a lack of available specimens, *Alloniscus perconvexus* was not subjected to the winter salinity tests and only three species were used in the humidity experiments.

In both the summer and winter tests *Cirolana harfordi* and *Idothea wosnesenskii* were clearly defined as marine, aquatic species. *I. wosnesenskii* did show a somewhat greater tolerance to lowered salinities than did *C. harfordi* possibly relating to the exposure of *Idothea* to rain and fog during periods of low tides. *Ligia occidentalis* showed a somewhat intermediate tolerance to various salinities. Individuals of this species were, at times, observed in the field to be completely submerged in tidal pools. Accordingly they show a high tolerance to 100% sea water. In salinities much lower than 100% sea water the survival times for *L. occidentalis* decreased rapidly supporting the suggestion that their evolutionary history does not include a transition through esturine conditions.

The optimum salinities for *Alloniscus perconvexus* were shown to be the 50% and the 75% sea water solutions. Heavy fog and fresh water runoff prevail in the area in which this species was collected and the interstitial water was certainly of a lowered salinity. Although 50% death was not noted for *A. perconvexus* in 100% sea water some of the specimens had died by the end of the test period. Even in the suggested optimum salinities the animals were inactive after 48 hours illustrating the fact that this species is not adapted to complete submergence in any water. Lowered survival times in salinities of less than 50% sea water suggest, again, the non-esturine transition. The low survival times of *Porcellio scaber* in all aquatic situations illustrate the adaptation to terrestrial life of this species.

Cirolana harfordi showed an expected range of humidity tolerances displaying very low survival times in the less humid situations and an increase in survival times with higher humidities.

Abbott (1940) suggested that the intermediate species in a transition from sea to land show a controlling influence over humidity. *Ligia occidentalis* displayed a rather stable tolerance to all of the humidity tests. As would be expected, *Porcellio scaber* showed the highest tolerances to low humidities.

Since isopods are not capable of extracting moisture from air which is not near saturation (Edney, 1957), the increased survival times of these organisms in higher humidities, other than 100%, were probably due to an increase in their ability to retain body water rather than an absorption of moisture from the air.

TABLE 2

Salinity tolerance tests for winter populations of four species of isopods from Dillon Beach, California.

Species	*No. individuals*	*Medium*	*50% death time*
Cirolani harfordi	6	FW	1 hr.
	6	10% SW	3 hrs.
	6	25% SW	34 hrs.
	6	50% SW	(48+)
	6	75% SW	(48+)
	6	100% SW	(48+)
Idothea wosnesenskii	6	FW	1.5 hrs.
	6	10% SW	12 hrs.
	6	25% SW	47.5 hrs.
	6	50% SW	(48+)
	6	75% SW	(48+)
	6	100% SW	(48+)
Ligia occidentalis	6	FW	10.5 hrs.
	6	10% SW	9 hrs.
	6	25% SW	11.5 hrs.
	6	50% SW	21.5 hrs.
	6	75% SW	34 hrs.
	6	100% SW	(48+)
Porcellio scaber	6	FW	2 hrs.
	6	10% SW	5 hrs.
	6	25% SW	3 hrs.
	6	50% SW	3.5 hrs.
	12	75% SW	5.5 hrs.
	12	100% SW	4 hrs.

TABLE 3

Salinity tolerance tests for summer populations of five species of isopods from Dillon Beach, California.

Species	*No. individuals*	*Medium*	*50% death time*
Cirolana harfordi	6	FW	1 hr.
	6	10% SW	7 hrs.
	6	25% SW	46 hrs.
	6	50% SW	(48+)
	6	75% SW	(48+)
	6	100% SW	(48+)
Idothea wosnesenskii	6	FW	4 hrs.
	6	10% SW	29 hrs.
	6	25% SW	(48+)
	6	50% SW	(48+)
	6	75% SW	(48+)
	6	100% SW	(48+)
Ligia occidentalis	6	FW	7 hrs.
	6	10% SW	8 hrs.
	6	25% SW	9 hrs.
	6	50% SW	19 hrs.
	6	75% SW	(48+) 2 dead
	6	100% SW	(48+)
Alloniscus perconvexus	6	FW	37 hrs.
	6	10% SW	15 hrs.
	6	25% SW	24 hrs.
	6	50% SW	(48+)
	6	75% SW	(48+)
	6	100% SW	(48+) 2 dead
Porcellio scaber	6	FW	14 hrs.
	6	10%	13 hrs.
	6	25% SW	16 hrs.
	6	50% SW	24 hrs.
	6	75% SW	23 hrs.
	6	100% SW	17 hrs.

TABLE 4

Humidity tolerance tests for spring populations of three species of isopods from Dillon Beach, California

Species	*No. individuals*	*Rel. hum.*	*50% death time*
Cirolana harfordi	6	00%	2 hrs.
	6	25%	2 hrs.
	6	50%	6.5 hrs.
	6	75%	20 hrs.
	6	100%	45 hrs.
Ligia occidentalis	6	00%	34 hrs.
	6	25%	46 hrs.
	6	50%	32 hrs.
	6	75%	32 hrs.
	6	100%	(48+)
Porcellio scaber	6	00%	20 hrs.
	6	25%	(48+)
	6	50%	(48+)
	6	75%	(48+)
	48	100%	(48+)

In the first set of experiments (summer salinity tests) a record was made of the size and sex of each animal. No juvenile forms were used and size did not appear to have an effect on death time. Sex influenced the survival times only in the cases of gravid females which were less tolerant of adverse conditions than the other individuals.

An attempt was made to train *Cirolana harfordi* to lowered salinities to illustrate the ability of isopods, as a marine group, to adjust to variations in the environment. Table 5 is a record of the times the various test groups were subjected to each solution before being transferred to a lower salinity.

TABLE 5

Acclimation times in lowered salinities for *C. harfordi.*

Group A (five specimens)

Solution	*Acclimation Time*
100% SW	24 hrs.
90% SW	25 hrs.
80% SW	23 hrs.
70% SW	65 hrs.
60% SW	28 hrs.
50% SW	84 hrs.
40% SW	175 hrs.
30% SW	final solution

Group B (five specimens)

Solution	*Acclimation Time*
100% SW	24 hrs.
75% SW	25 hrs.
50% SW	23 hrs.
25% SW	final solution

Group C (six specimens)

Solution	*Acclimation Time*
100% SW	24 hrs.
30% SW	final solution

The results of the above experiments were as follows:

Group A: In 40% sea water one gravid female died after 72 hours. After 93 hours in 30% sea water, another gravid female died. The remaining three individuals were returned to 100% sea water after 93 hours and all died within one hour.

Group B: All of the individuals in this test died after 17 hours in 25% sea water.

Group C: These individuals were placed directly from 100% sea water in 30% sea water. A 50% death was recorded after 50 hours. The remaining specimens were replaced in 100% sea water. Two of these individuals survived for 10 hours and the third recovered completely.

All of the specimens used in the above tests were collected at the same time and in the same area. No deaths were observed in a control group in 100% sea water throughout the entire experiment.

It can be seen from the above data that a much longer survival time was attained by slowly lowering the salinity than when animals were placed directly in the 30% sea water solution, and that training to a lowered salinity reduces the ability to survive in 100% sea water.

SUMMARY

Certain species of isopods occur in a vertical series of shore habitats suggestive of a transition from marine to terrestrial life. The five species involved in this study exhibit structural, behavioral and physiological adaptations to the various levels which they occupy in the transition.

In general the more terrestrial isopods are heavily chitinized and the exopodites of the pleopods form a thick, protective covering for the endopodites. The thoracic appendages and general body form of the various species facilitate survival in the different environments by adhering to a basic theme of desiccation prevention.

Physiologically, the tolerances of the different species to variations in humidity and salinity corellate with the particular habitat involved and illustrate adaptations to the situations in which each species is found.

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THE EARLY STAGES OF *GRAPTOLITHA (LITHOPHANE) DILATOCULA* SMITH. *(LEPIDOPTERA: PHALAENAE)*

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This rare phalaeniid moth, *Graptolitha dilatocula*, was first described by Smith (1900) in the Genus *Xylina*. At present, lepidopterists place it either in *Graptolitha* or *Lithophane*. Jones (1951) gave it the common name "Two-spotted Pinion." Its range is apparently limited to the Pacific coast, from California to British Columbia. In the far north the flight of the moth has been recorded for February, March, April, May and October. Hampson (1906: pl. CII, fig. 18) gave a colored figure of a male from California.

Eggs were secured from a confined female taken at Big Rock Creek, San Gabriel Mountains, Los Angeles County, on February 20, 1965, elevation 4200 feet, in an area where alder (*Alnus rhombifolia* Nutt.) predominated. The eggs were laid February 25 to March 1, on alder leaf buds and bark placed in the rearing cage.

Egg: (Fig. 1 a-b) Width, approximately 0.7 mm. Height, 0.5 mm. Color, white, heavily overlaid with black mottlings which are not uniformly placed, but most of which are concentrated on the body surface of the egg rather than on the ridges. The base is flat, and the side walls rise to a conical top, with no micropylar depression. The micropyle is minute and flat. There are approximately 42 vertical ribs or ridges running from the base to the micropylar area, but many of these become obsolete in the upper third of the egg. Along the crest of each rib there is a line of pearly-white nodules. Near the micropyle some of the nodules are partly obscured by black spotting. The eggs hatched from March 18 to 21, 1965, and were immediately placed on *Alnus rhombifolia*, which they accepted readily.

First Instar Larva: (Fig. 1 c) Length, 2.2 mm. Head width approximately 0.32 mm. Color; uniform glistening yellow. The three central ocelli are tipped with black.

Body; narrower than the head; uniform translucent gray-green. Legs and venter tinged with yellow. Numerous relatively short white setae arise from small tubercles. Some are shaded with gray.

The young larvae feed mainly on the upper surface of the leaf. At the end of the first instar their bodies become plump, and wider than the head. They later transfer to young leaves on the under sur-

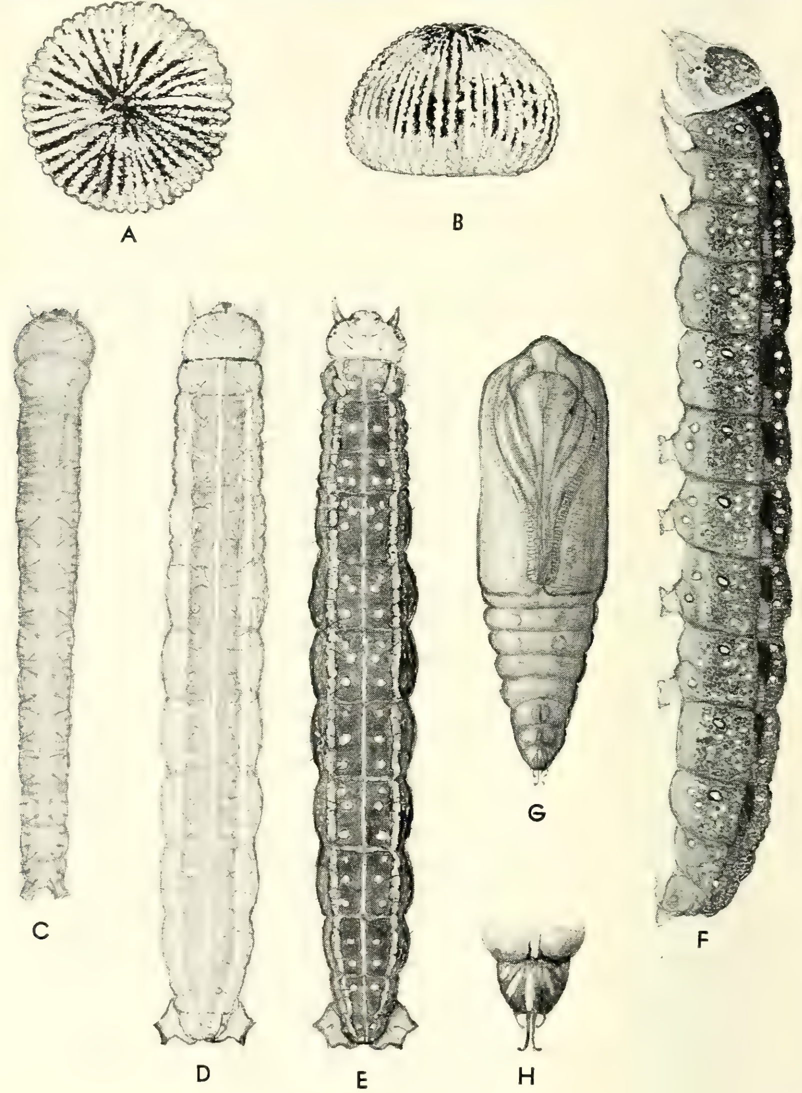

Figure 1. Early Stages of *Graptolitha dilatocula.* (A) Egg, viewed from top. (B) Egg, lateral aspect. (C) First instar larva. (D) Fifth instar larva, green phase. (E) Fifth instar larva, brown phase. (F) Mature larva, lateral aspect. (G) Pupa, ventral aspect. (H) Cremaster. All figures enlarged. For natural size measurements, refer to text. Reproduced from water color drawing by J. A. Comstock.

face. Still later they skeletonize the leaves and rest, when not feeding, in the depressions between the veins. Molting occurred from March 27 onward.

Second Instar: Length, 4 mm. Head width, 0.62 mm. Head, glistening ivory-white. Ocelli, black. Mandibles tinged at tips with light orange. Setae, colorless.

Body; first segment approximately the same width as head, gradually tapering toward the cauda. Color, cream on the first three segments, gradually becoming lighter caudally. There is a barely discernible middorsal narrow white line, and paralleling it dorsolaterally a similar but wider white line of the same character. Numerous raised papillae run longitudinally over the body. The setae are translucent. Legs and prolegs concolorous with the body.

At the termination of this instar the narrow middorsal white line is clearly defined, as is also the wider dorsolateral line paralleling it. In addition, a third longitudinal line occurs laterally. Between these lines there is a row of white spots.

Some of the larvae began at this phase to feed on scrub oak, (*Quercus dumosa* Nutt.), so, possibly, other host plants besides alder might be chosen for ovipositing,

Third Instar: (Recorded April 6, 1965, the third day following moult). Length, 8 mm. Head width, 1 mm. Head, ivory, with a slight tinge of green; spiracles, white: ocelli, tipped with black; edges of mandibles light brown.

Body; ground color two shades of green, the dorsal area darker. Lateral and ventral areas, light green. There is a middorsal longitudinal narrow white line of dots and dashes; lateral to this a wider line of the same character. The dark green area between these two lines bears a row of raised white spots. Those on the 1st to 3rd segments tend to run transversely. From the 4th to 11th they are arranged in pairs each side of the center line. Lateral to the wide white line there are two narrow longitudinal lines of small dots. Inferior to these the ground color is light green. Numerous white raised papillae are scattered along the area, but these do not extend onto the venter. Legs, very light green; prolegs concolorous with body; crochets, red-brown. At the end of this instar the larva attained a length of 10 mm.

Fourth Instar: April 13, 1965. Length, 12.5 mm. Head width, 1.5 mm. Color of head, light green, the ocelli tipped with black. Mandibles edged with brown. Antennae and all setae, white.

The body is colored and marked as in the prior instar with varying shades of green, and spotted white lines. The venter is free of white papillae.

Fifth Instar: (Fig. 1 d and e). Length, 17 mm. Width through center of body, 3 mm. Width of head, 2.3 mm. Head, uniform light green; mandibles nearly white, with brown edges; antennae, white; ocelli tipped with black; setae, white.

In this instar, and also in the fourth, there begins to occur two color forms of the larva, a predominantly green form, and a mottled brown form. Of 23 larvae noted on April 21, 1965, 19 were of the green form, and 4 of the brown. In both, the head is unchanged in color. These two phases are illustrated in Figs. 1d and e. In the green form the body has the same two middorsal and dorsolateral cream bands. The area between these bands is rich green with a slight tinge of yellow. The dots within this area are white. The region lateral to this and extending down to the spiracular line is green, of a darker shade than the dorsum, and this same shade covers the venter. The spots are white. The legs are translucent light green with brown tips. The prolegs are greenish-white with pinkish crochets. The ventral surface has a few white spots on the 4th, 5th, 9th and 11th segments.

In the brown form the lines and spots are exactly the same, but all of the green areas are replaced with a rich brown.

A percentage of our larvae was utilized for the purpose of illustrating. As a precautionary measure the remainder were retained at an elevation nearer that of the species natural habitat. There was a high mortality rate among those reared in the coastal environment, as they became infected with a fungoid wilt disease or virus, possibly due to the increased humidity. One example survived to the sixth instar.

Sixth Instar: (Fig. 1 f). April 25, 1965. Length of larva, 25 mm. Width of body through center, 4.5 mm. Width of head, 3.6 mm. Head, ground color, ivory, the cheeks heavily mottled and spotted with dark gray. Front, slightly shaded with light gray; ocelli, black; mandibles, gray-brown on edges; antennae, translucent ivory.

Body; heavily spotted and mottled with various shades of brown. The longitudinal middorsal stripe nearly obsolescent, a few fragments only of it near the posterior margins of segments. Dorsolateral longitudinal band also nearly obsolescent except for portions of it on the posterior margins of each segment. Where this band is absent there are large patches of black. The white nodules bearing setae are present as in the preceding instar, but seem more conspicuous in contrast to the mottled dark ground color. Legs and prolegs translucent ivory; crochets, inconspicuous light brown; venter, light brown.

From examples reared at the higher elevation it was evident that the brown form only persisted in the mature phase.

A pupa was available from this lot for illustration.

Pupa: (Fig. 1 g). Length, 19 mm. Width transversely at wing margins, 6 mm. Antennae and maxillae reach nearly to the wing margins. Texture of head, thorax and wing margins, minutely striated. Abdominal segments smooth and glistening. Body color, uniform deep brown. The cremaster terminates in a pair of recurved spurs, the tips curving laterally, their color, dark brown. There is a second pair of smaller recurved spurs inclining mediodorsally, which are translucent light brown, as shown in Figure 1 h.

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LITTORAL BIOTA OF LAGUNA GUERRERO NEGRO, BAJA CALIFORNIA DEL SUR, MEXICO

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Lagoons on the lower western coast of the peninsula of Baja California del Sur, Mexico, between 24° and 30° N. are allied both geologically and biologically to those found further north in the States of Baja California, Mexico, and California, United States of America. The largest lagoon complex is the Bahia Magdalena series centered on 25° N. Another large series is that one at 28° latitude encompassing Laguna Ojo de Liebre (Scammon Lagoon), which is on the depressed edge of an extremely flat alluvial plan. Pear-shaped Laguna Guerrero Negro lies near the center of this 200-odd square mile complex. The north-south length is 8 miles and the east-west width is approximately 5 miles. Wide-shelved and precipitously-walled meanders drain the lagoon. Typically, the deepest channels are immediately at the head of the entrance channel behind the lagoon barrier, which is a large sand island covered by wind-scalloped barchans. There at the entrance depths are from 35 to 40 feet, whereas the 150-foot wide drainage laterals are 25 to 30 feet deep.

The combination of these natural features with an extremely dry climate is such that the lagoon is an excellent site for large-scale solar salt processing operations. Puerto Venustiano Carranza lies within Laguna Guerrero Negro at 28° 02. 1′N, 114° 08. 0′W, and was established in 1957 as a company-operated port by Exportadora de Sal, S.A., to handle its salt trade (P. J. Cutting, *pers. comm.*, 1963). Because of an extensive dredging program, deep-draft freighters are accommodated at this port. Biota observed or collected within a 5-mile radius of this port's position are the subject of this report.

Tides flood the lagoon complex with remarkable celerity. The tide rises across the tidal flats almost faster than a man can walk; consequently, vast areas become inundated within a few minutes. By reverse token, ebbs quickly expose the flats. Shallow pools appear in profusion across the flats after low water, but these are never more than a few yards in diameter and only a fraction of a foot deep. After a short time these pools disappear, probably by vertical drainage, and the bare tidal flats seem completely free of any life.

Notwithstanding the formidable appearance of the tidal race, currents are not greater than 2.3 knots. Afternoon ebbs carry away water that is perceptibly warmer than floods of an earlier hour. This follows, no doubt, from insolation of the sheets of water lying across the broad shelves of the flats. Horizontal underwater visibility varies during tidal stand from 8 to 11 feet during hour of bright sunshine (observations by William Evans and Wheeler North, *pers. comm.*, 1963). When tides are flowing, however, suspended debris turns the water murky.

Phleger and Ewing (1962) noted that waters of Laguna Guerrero Negro are isohaline. Mid-summer salinites are 35.5 to 37.5 ppt., while those of the winter are 34.7 to 35.6 ppt. Presumably, this indicates the influences of increased evaporation and insolation during the summer months. Flood tide salinites, naturally, are more dilute than those of ebbs.

Bottom sediments of the lagoon basin consist predominantly of minute gray sand particles intermixed with organic silt. There are occasional outcrops of fine-grained fossiliferous sandstone strata. A coquina specimen taken from the southern part of the lagoon proved to be cemented detrital limestone. The cement was calcium carbonate, and detrital components were shell fragments plus pulverized foramens (A. Inderbitzen, *pers. comm.*, 1963).

Vegetation of the dryland fringes of the lagoon is dominated by salt bush (*Suaeda californica*) and pickleweed (*Salicornia virginica*). Marsh grass (*Spartina foliosa*) is the principal species of the exposed tidal flats. Eel grass (*Zostera marina*) grows as far as the tide reaches and down under the water to a depth of twenty feet in the channels. Principal plant species are listed in Table 1 (see note). Pickleweed (*Salicornia*) blends into heavy stands of marsh grass (*Batis maritima*) but toward dry land it phases into *Suaeda*. Samples of foraminifera taken from the beach sands contained abundant concentrations of *Elphidium gunteri* and *Quinqueloculina laevigata*. All of these samples contained small amounts of *Rotorbinella versi*, *Q. Lamarckiana*, *Q. limbata*, and *Q. costata*.

The most abundant copepod in the winter appears to be *Acartina tonsa*. Also present with incidental frequency are *A. lilljeborgii*, *Paracalanus*, and *Pseudodiaptomus* spp. The indicator species of the marshes are the fiddler crab (*Uca crenulata*) and the horn snail (*Cerithidea californica*). On the flats one will often find bubble shells (*Bulla gouldiana*), starfish, and if, one digs, an abundance of clams and sweet potatoes (*Molpadia arenicola*). Common fishes of the channels are guitarfish (*Rhinobatos productus*). mullet (*Mugil cephalus*). and species of bass (*Paralabrax* spp). Ducks and shorebirds —especially whimbrels (*Numenius phaeopus*) and curlews (*N. americanus*)—are present in the winter by the tens of thousands. Bottle-nose dolphins (*Tursiops gilli*) and calving gray whales (*Eschrichtius gibbosus*) occasionally enter the lagoon. These conspicuous fauna are likewise listed in Table 1.

Among the latent resources of the lagoon complex are those that are based on the harvest or observation of wildlife. One can see and hunt multitudes of sea ducks and other edible waterfowl, since these lagoons lie within the Pacific flyway. Fishing, certainly a likely source of recreation, may also serve as a base for a limited commercial fishery. Green turtles (*Chelonia mydas*) were seen infrequently; these are used elsewhere on that coast for food, and fishermen from Isla Cedros enter the lagoon to take them for market. At present, however, salt processing is the sole industry.

TABLE 1. Typical plant and animal species of shores and baywater at Laguna Guerrero Negro, Baja California del Sur, Mexico during the winters of 1962, 1963 and 1964.

Strand Assemblage	
Salt bush	*Suaeda californica*
Ice plant	*Mesembryanthemum crystallinum*
Pickleweed	*Salicornia virginica*
Marsh grass	*Batis maritima*
Marsh grass	*Spartina foliosa*
Tidal Flat Assemblage	
Eel grass	*Zostera marina*
Foraminifera	*Elphidium gunteri*
Yellow sponge	*Tetilla mutabilis*
Sea pansy	*Renilla amethystina*
Sweet potato	*Molpadia arenicola*
Sand dollar	*Dendaster excentricus*
Sea hare	*Navanax inermis*
Bubble shell	*Bulla gouldiana*
Basket shell	*Nassarius fossatus*
Horn Shell	*Cerithidea californica*
Moon snail	*Polinices reclusianus*
Hardshell cockle	*Chione undatella*
Jack knife clam	*Tegula ligulata*
Bay scallop	*Plagiotonium circularis*
Skeleton shrimp	*Caprella scaura*
Shore crab	*Hemigrapsus oregonensis*
Pistol shrimp	*Crangon californiensis*
Fiddler crab	*Uca crenulata*
Burrowing crab	*Speocarcinus californiensis*
Black brant	*Branta nigricans*

Whimbril	*Numenius phaeopus*
Long-billed curlew	*Numenius americanus*
Godwit	*Limosa fedoa*
Channel Assemblage	
Alga	*Dasya pedicellata*
Alga	*Griffithsia multiramosa*
Copepod	*Acartina tonsa*
Black tunicate	*Metandrocarpa dura*
Guitarfish	*Rhinobatus productus*
Striped mullet	*Mugil cephalus*
Sand basses	*Paralabrax* spp.
Green turtle	*Chelonia mydas*
Surf scoter	*Melanitta perspicillata*
Bottlenose porpoise	*Tursiops gilli*
Gray whale	*Eschrichtius gibbosus*

[1] Verification or tentative identifications were made as follows:

Spermatophytes: Dr. Charles Lindsay, California Academy of Science; Algae: Dr. E. Yale Dawson, United States National Museum; Foramenifera: Mr. Martin Reiter, Los Angeles Harbor College; Copepods: Dr. A. Fleminger, Scripps Institution of Oceanography; Molluscs: Mr. John E. Fitch, California Department of Fish and Game; Tunicates: Dr. Donald A. Abbott, Hopkins Marine Station; Other determinations were made by the present writer.

As it stands today, Laguna Guerrero Negro has become the site of the largest salt producing facility along the eastern Pacific coast. Since processors at San Francisco and San Diego have responded to this challenge by increasing their production, it appears that the configurations of the present port and lagoon will be changed to allow further industrial development. Insofar as the biota of the lagoon is concerned, it is expected that successive changes in species composition will ultimately take place.

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STUDIES ON NORTH AMERICAN BEES OF THE GENUS *HYLAEUS*.
3. THE NEARCTIC SUBGENERA
(Hymenoptera: Colletidae)

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The remarkably uniform appearance, structural similarities and diverse ecological tolerances of the nondescript representatives of this genus have rendered *Hylaeus* one of the most difficult of all bee genera. These difficulties are far out of proportion to the number of species currently recognized in the Nearctic Region.

Part of the inherent difficulty of this genus lies in the inadequacy of earlier descriptions. Of the many descriptions published of North American *Hylaeus* over the foregoing hundred years, few are sufficiently detailed to enable one to recognize the entity described. The technique of illustrating the male terminalia has only been in use for the past fifty years; even this, however, has been inadequate sometimes due to a lack of appreciation for the more subtle characters.

Another important factor is the range of structural variability which a single species may exhibit. In his revision of the Nearctic *Hylaeus*, Metz (1911) noted and commented upon this variability. Indeed, he became so convinced of the extent of variation that he was unable to separate certain species; Metz apparently did not make use of certain more subtle, and less variable, features that were available. He relied too heavily upon color and punctation in separating the females, and placed great faith in the male terminalia. Unfortunately, much of his work was conjectural, based upon limited series from a few areas.

As has so often happened in this genus, the females presented Metz with his greatest difficulties. In fact, it was not at all unusual to find as many as five species, representing two or three subgenera, mixed together as the females of a single species. Michener (1944) did not attempt a key to the subgenera based on females. During the course of my studies on this genus, I eventually found that I was able to sort females to subgenus on the basis of general habitus. This, unfortunately, is not the sort of method which is usable as a key, and a critical examination of females of all the available Nearctic species

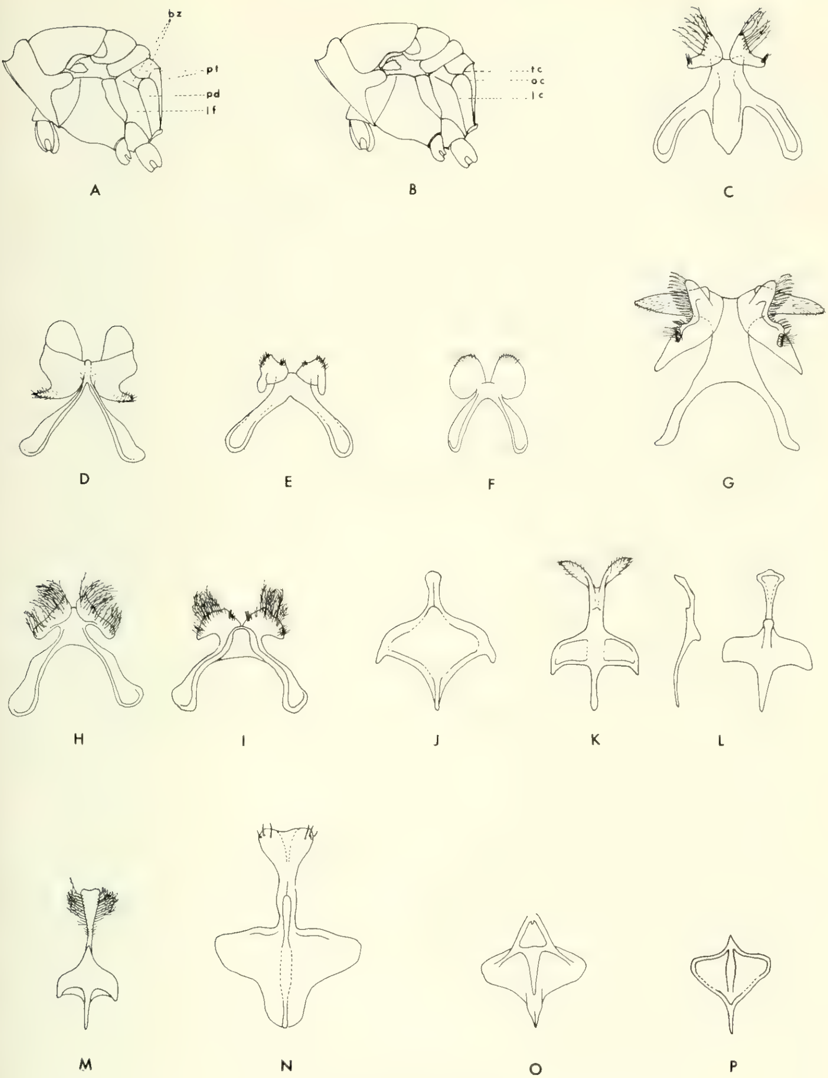

Figure 1. Hypothetical thorax of *Hylaeus,* lateral aspect. A., illustrating propodeal zones: bz = basal zone; pt = propodeal triangle; pd = propodeal disc; lf = lateral face. B., illustrating propodeal carinae; tc = transverse carina; oc = oblique carina; lc = lateral carina, C-I, eighth sternites of males: C., *H.* (*Prosopis*) *rugulosus* (Cockerell); D., *H.* (*Paraprosopis*) *wootoni* (Cockerell); E., *H.* (*Prosopella*) *hurdi* Snelling; F., *H.* (*Hylaeana*) *azteca* (Cresson); G., *H.* (*Hylaeus*) *ellipticus* (Kirby); H., *H.* (*Metziella*) *sparsus* (Cresson); I., *H.* (*Cephalylaeus*) *basalis* (F. Smith). J-P., ninth sternites of males: J., *H.* (*Prosopis*) *rugulosus*; K., *H.* (*Paraprosopis*) *wootoni*; L., *H.* (*Prosopella*) *hurdi*, lateral and dorsal aspects; M., *H.* (*Hylaena*) *aztecus*; N., *H.* (*Hylaeus*) *ellipticus*; O., *H.* (*Metziella*) *sparsus*; P., *H.* (*Cephalyleus*) *basalis.*

was made. The results are given in the key to subgenera which is presented below. The fact that each of the three major subgenera (*Hylaeus*, s. str., *Prosopis* and *Paraprosopis*) contains at least one species with an atypical female has rendered the key unavoidably cumbersome.

Certain of the terms employed in the following key should be explained beforehand. These same terms shall be used, as they are here, in all future publications on this genus. That portion of the face between the inner margins of the eyes, bounded anteriorly by the anterior clypeal margin and posteriorly by the middle (or anterior) ocellus, is termed the *facial quadrangle.* The propodeum offers many useful characters in the carinae and the various areas which they demark. The horizontal, basal portion of the propodeum (usually distinct), is termed the *basal zone.* The central area of the basal zone contains two carinae which converge medio-posteriorly on the *propodeal disc;* these demark the *propodeal triangle*, which is divided into two areas: the horizontal *basal area* and the more or less vertical *declivity of the propodeal triangle;* in certain groups, the two faces of the propodeal triangle are separated by a *transverse carina* at their juncture. The propodeal disc, in some groups, is separated from the sides of the propodeum by the *lateral carinae* where these faces meet. The lateral carinae are sometimes connected with the transverse carina obliquely across the basal zone by the *oblique carinae* (Fig. 1a, b.)

KEY TO NEARCTIC SUBGENERA OF *Hylaeus*

1. Antennae thirteen-segmented; abdomen with seven visible segments; clypeus largely or entirely yellow; males 2
Antennae twelve-segmented; abdomen with six visible segments; clypeus largely or entirely dark; females 8

2. Antennal scape not greatly expanded, longer than broad; anterior tentorial pits near middle of lateral clypeal margin 3
Antennal scape greatly expanded, at least as broad as long; anterior tentorial pits above middle of lateral clypeal margin . . . . *Cephalylaeus* Michener

3. Apical process of sternite IX usually bare, not or scarcely bifid; lobes of sternite VIII rather small, neither pectinate nor deeply emarginate 4
Apical process of sternite IX usually hairy, bifid; lobes of sternite

VIII large, outer margin pectinate or with deep emargination 7

4. Apical process of sternite IX bent upward at an angle of 45° near apex; integument of head and thorax very coarsely punctate . . . . *Prosopella* Snelling
Apical process of sternite IX only slightly bent; integument of head and thorax with punctures not unusually coarse 5

5. Apical process of sternite IX with numerous branched hairs along lateral margins; apical lobes of sternite VIII rounded apically . . . . *Hylaeana* Michener
Apical process of sternite IX bare, or with three or four branched hairs on apical margin; apical lobes of sternite VIII acute or narrowly rounded apically 6

6. Apical process of sternite IX acute, considerably shorter than disc of sternite; anterior coxae with outer margin sharply angulate to spinose . . . . *Metziella* Michener
Apical process of sternite IX truncate or slightly emarginate, distinctly longer than disc of sternite; anterior coxae with outer margin evenly rounded . . . . *Prosopis* Fabricius

7. Apical lobes of sternite VIII pectinate; simple or branched hairs present on anterior and posterior parts of lobes . . . . *Hylaeus* Fabricius
Apical lobes of sternite VIII not pectinate, outer margins with deep emarginations, hairs usually confined to lateral processes of lobes . . . . *Paraprosopis* Popov

8. Punctures of head and thorax coarse; rugulae of basal triangle of propodeum transverse, not longitudinal, basal triangle without defined posterior declivity; facial foveae above ending much nearer eyes than ocelli; clypeus with conspicuous macula . . . . *Prosopella* Snelling
Punctures of head and thorax not notably coarse; if coarse, *then* rugulae of propodeal triangle longitudinal, triangle usually with well-defined posterior declivity; facial foveae and clypeus variable 9

9. Entirely devoid of maculae on head and thorax; genae broader than eyes; facial quadrangle broader than long; basal triangle with longitudinal rugulae obsolescent or absent; foveae ending midway between eyes and ocelli . . . . . . *Cephalylaeus* Michener
Usually with maculae at least on sides of face; if face immacu-

late, propodeal triangle with well developed longitudinal rugulae; facial quadrangle longer than broad; foveae variable 10

10. Anterior coxae with well-developed lateral spine or tooth; propodeal triangle with rugulae obsolescent, without well-defined posterior declivity; genae slightly wider than eyes; thoracic punctures sparse and fine . . . . *Metziella* Michener
Anterior coxae without lateral spine or tooth; if toothed, propodeal triangle with well-defined rugulae and posterior declivity; genae usually no wider than eyes; thoracic punctures variable 11

11. Basal depression of tergite I longer than broad; dorsal surface of tergite I impunctate, strongly tessellate and dull; punctures of thorax rather coarse, obscured by very dense tessellation or roughening of the integument; carina bordering posterior margin of horizontal zone of propodeum strongly sinuate; sides of propodeum distinctly and deeply punctate . . . . *Hylaeana* Michener
Basal depression of tergite I triangular, wider basally than long; horizontal surface of tergite I either strongly shining or distinctly, deeply punctate, or both; thoracic punctures usually fine, integument as a rule not strongly tessellate or roughened between punctures; posterior carina of basal zone of propodeum, when present, transverse or evenly curved, not at all sinuate; punctures of sides of propodeum as a rule not distinct 12

12. Punctures of horizontal area of tergite I, and usually of tergite II, as a rule, dense and distinct; facial foveae usually ending midway between eyes and ocelli, or nearer ocelli; posterior declivity of basal triangle of propodeum separated from horizontal face by distinct transverse carina . . . . *Paraprosopis* Popov
Punctures of tergites I and II fine, usually separated by two or more times a puncture diameter; if denser, *then* apical margin of tergite II reflexed upward; facial foveae usually ending nearer eyes than ocelli, rarely attaining midpoint; posterior declivity of basal triangle of propodeum separated from horiozontal face by a carina, or not 13

13. Integument of tergites I and II rather strongly shining, with fine punctures separated by three or more times a puncture diameter; apical margin of tergite II never reflexed upward; lateral and

oblique carinae of propodeum usually present and distinct; if absent, declivity of basal triangle not marked anteriorly by transverse carina, rugulae of horizontal area obsolescent and mesopleurae densely tessellate, with fine, obscure, scattered punctures on upper half . . . . *Hylaeus* Fabricius

Integument of tergites I and II somewhat shining, with distinct punctures, frequently coarse, separated by less than three times a puncture diameter; apical margin of tergite II usually slightly reflexed upward; lateral and oblique propodeal carinae usually absent; when present, mesopleurae rugoso-punctate . . . . *Prosopis* Fabricius

Subgenus *Prosopis* Fabricus

Prosopis Fabricius, 1804. Systema Piezatorum, 293.

Type of subgenus: Sphex signata Panzer *Mellinus bipunctatus* Fabricius, 1804. Desig. by Morice and Durant, 1914.

This Holarctic subgenus apparently is the most widely distributed in North America, extending from above the Arctic Circle at least as far south as Mexico City, Mexico; various species are found throughout the United States. Most of the females are readily recognizable as members of this subgenus, but there exists a small group of species in the southeastern United States which is atypical. These species differ from typical *Prosopis* in having the head and thorax very coarsely punctate, with well developed lateral and oblique propodeal carinae; several are marked with reddish on the basal tergites.

In addition to the characters given in the key, the males of this subgenus may be recognized by the unmodified antennal scape and short supraclypeal mark (one-half, of less, as long as the clypeus). Superficially, both sexes resemble members of the subgenus *Paraprosopis*, but are generally larger and with the abdomen more finely and sparsely punctate.

There are currently sixteen species of *Prosopsis* recognized in North America. The names here considered valid are:

H. affinis (F. Smith, 1853)
  Synonyms: *H. ziziae* (Robertson), *H. ziziae dunningi* Cockerell
    H. albertensis Cockerell
H. confluens (F. Smith, 1853)
  Synonym: *H. triangularis* (Cockerell)
H. flammipes (Robertson, 1893)

H. illinoisensis (Robertson, 1896)
 Synonym: *H. certus* Mitchell
H. insolitus Snelling, 1966
H. modestus modestus Say, 1837
 Synonyms: *H. pennsylvanica* (Cockerell), *H. nucleolus* (Viereck), *H. sayi* (Robertson), *H. minyra* (Lovell), *H. binghami* (Lovell), *H. supracurta* (Swenk and Cockerell)
H. nelumbonis (Robertson, 1890)
H. ornatus Mitchell
H. rugulosus coquilletti (Cockerell, 1896)
H. rugulosus episcopalis (Cockerell, 1896)
H. rugulosus giffardiellus Cockerell, 1925
H. rugulosus metzi Snelling, 1966
H. rugulosus rugulosus (Cockerell, 1896)
 Synonyms: *H. r. fallax* (Cockerell), *H. universitatis* (Cockerell)
H. schwarzii (Cockerell, 1896)
 Synonym: *H. fossata* (Metz)
H. transvittatus (Cockerell, 1917)
H. volusiensis Mitchell, 1951

Subgenus *Paraprosopis* Popov

Prosopis subg. *Paraprosopis* Popov, 1939. Comptes rendus (Doklady) de l'Academie des Sciences de l'U.R.S.S. (n.s.) 25: 169.

Type of subgenus: Prosopis pictipes Nylander. Monob. and orig. desig.

This subgenus, as the preceding, is of Holarctic distribution, but does not seem to be as widely distributed in the Western hemisphere; species extend from southwestern Canada to northcentral Mexico. In North America the group reaches its greatest development in the Rocky Mountain area.

In the females of most species the facial foveae end at or beyond the midpoint between the eyes and lateral ocelli, the thoracic punctures are rather dense, the lateral and oblique propodeal carinae are present, and the first tergite is usually densely, sharply punctate. The males are characterized by small size, unmodified antennal scapes, short first flagellar segment, densely punctate abdomen, and the bifid, hairy process of the ninth sternite.

The following North American species are recognized, in addition to several undescribed species from the southwestern states:

H. asininus (Cockerell and Casad, 1895)
  Synonyms: *H. bipes* (Cockerell and Casad), *H. a. bigeloviae* (Cockerell)
H. calvus (Metz, 1911)
H. coloradensis (Cockerell, 1898)
H. cookii (Metz, 1911)
H. georgicus (Cockerell, 1898)
  Synonym: *H. g. leana* (Cockerell)
H. floridanus (Robertson, 1893)
  Synonym: *H. eulophi* (Robertson)
H. megalotis (Swenk and Cockerell, 1910)
H. nevadensis (Cockerell, 1898)
  Synonyms: *H. hesperiphila* (Cockerell), *H. oregonensis* Bridwell
H. packardi Mitchell, 1951
H. perparvus Cockerell and Sumner, 1931
H. personatellus (Cockerell, 1915)
H. polifolii (Cockerell, 1901)
  Synonym: *H. p. catalinensis* Cockerell
H. seclusus Cockerell and Sumner, 1931
H. tuertonis (Cockerell, 1906)
H. wootoni (Cockerell, 1896)
  Synonyms: *H. divergens* (Cockerell), *H. clandestinus* (Viereck), *H. excavata* (Swenk and Cockerell).

Subgenus *Prosopella* Snelling

Hylaeus subg. *Prosopella* Snelling, 1966. Proc. Biol. Soc. Wash., 79:139-144.

Type of subgenus: Hylaeus (*Prosopella*) *hurdi* Snelling. Monob. and orig. desig.

This subgenus is known only from Arizona and Mexico. Although only one species has been described, there are several apparently undescribed Mexican species which are referable to this subgenus. The coarse punctures, transversely rugulose propodeal triangle and small size are diagnostic of the female. The male, which superficially resembles species of *Paraprosopis*, is best recognized by the shape of the ninth sternite.

Subgenus *Hylaeana* Michener

Hylaeus subg. *Hylaeana* Michener, 1954. Bull. Amer. Mus. Nat. Hist., 104:28.

Type of subgenus: Hylaeus panamensis Michener. Monob. and orig. desig.

In the Nearctic region this subgenus is represented only by *H. aztecus* (Cresson). The small size of the female, its coarse thoracic punctation and impunctate, tessellate, dull abdomen are characteristic. The characters outlined in the key are most diagnostic of the male.

Currently, only two North American species are assigned to this subgenus, although there are several undescribed species in tropical Mexico and Central America.

H. aztecus (Cresson, 1869)
  Synonym: *H. dubiosa* (Cresson)
H. panamensis Michener, 1954

Subgenus *Hylaeus* Fabricius

Hylaeus Fabricius, 1793. Ent. System., 2:302.

Type of subgenus: (*Prosopis annulata* Fabricius)=*Apis annulata* Linne. Desig. by Latreille, 1810.

This rather large, and diverse, Holarctic subgenus contains several of our most common representatives of the genus. The species are primarily northern and montane, although a few have become xerophilous. While a few of the species [e.g., *H. conspicuus* (Metz), *H. ellipticus* (Kirby), *H. verticalis* (Cresson)] are of moderate size, most are small, slender species. In the females, the punctation is generally fine [except in *H. stevensi* (Crawford)], and the lateral and oblique propodeal carinae are usually distinct; in certain members of the *H. cressoni* complex (distinguished by their small size, slender appearance, tessellate and sparsely punctate mesopleurae) these carinae may be obsolescent or absent, and the rugulae of the propodeal triangle may be greatly reduced. The facial foveae in all the described Nearctic species end much closer to the eyes than the lateral ocelli.

In addition to the characters given in the key, the males may be recognized by the elongate, slender supraclypeal area (more than one-half as long as the clypeus) and in many species the antennal scapes are distinctly broadened and somewhat concave beneath.

One unnamed species occurs in California and Arizona. Those species currently considered valid are:

H. conspicuous (Metz, 1911)
H. cressoni cressoni (Cockerell, 1907)

Synonyms: *H. pygmaea* (Cresson), *H. pasadenae* (Cockerell)

H. cressoni mesillae (Cockerell, 1895)

Synonym: *H. magniclavis* (Swenk and Cockerell)

H. ellipticus (Kirby, 1827)

Synonyms: *H. antennata* (Cresson), *H. varifrons* (Cresson)

H. gaigei (Cockerell, 1916)

H. grossicornis (Swenk and Cockerell, 1910)

H. labiatifrons Cockerell, 1896

H. laciniatus Cockerell and Sumner, 1931

H. maritimus Bridwell, 1910

H. repolitus Cockerell and Sumner, 1931

H. rudbeckiae (Cockerell and Casad, 1895)

Synonyms: *H. bakeri* (Cockerell), *H. digitatus* (Cockerell), *H. rudb. subdigitata* (Cockerell), *H. rudb. ruidosensis* (Cockerell), *H. digitata fedorica* (Cockerell), *H. rudb. granulatus* (Metz)

H. saniculae (Robertson, 1896)

H. stevensi (Crawford, 1913)

H. teleporus (Lovell, 1911)

H. verticalis (Cresson, 1869)

Synonyms: *H. tridentulus* (Cockerell), *H. tridens* (Cockerell), *H. subtristis* (Swenk and Cockerell), *H. melitina* (Lovell)

Subgenus *Cephalylaeus* Michener

Hylaeus subg. Cephalylaeus Michener, 1942. J. N.Y. Ent. Soc., 50:273.

Type of subgenus: Prosopis basalis F. Smith, 1853. Orig. desig.

This subgenus apparently is restricted to North America; only two species are known. Of the two species, one (*H. nunenmacheri* Bridwell) is apparently restricted to California, while the other [*H. basalis* (F. Smith)] occurs transcontinentally across Canada and the northern United States with southern extensions along the major mountain ranges. The females of both species may be recognized by the entirely black integument, broad faces, fine punctation. Furthermore, these two species seem to show a decided preference for flowers of the family Rosaceae; no other members of the genus in North America exhibit any apparent tendencies to restrict their floral visitations. The males may be readily recognized by their greatly expanded antennal scapes.

The two species assigned to this subgenus are:

H. basalis (F. Smith, 1853)
H. nunenmacheri Bridwell, 1919

Subgenus *Metziella* Michener

Hylaeus subg. *Metziella* Michener, 1942. J. N. Y. Ent. Soc., 50:273.

Type of subgenus: (*Prosopis potens* Metz)=*Prosopis sparsus* Cresson, 1869. Monob. and orig. desig.

This is a strictly Nearctic subgenus, known from two rare, poorly known species found in the eastern half of the continent. Mitchell (1960:78) indicated that *H. potens* (Metz) might be a synonym of *H. sparsus* (Cresson), but hesitated to take action since he had not seen Metz' type and the original description failed to mention certain critical characters. The type of *H. potens*, which is now in the Los Angeles County Museum, has been examined, and there is no doubt that *H. potens* (Metz)=*H. sparsus* (Cresson) (new synonym).

The two species of this subgenus are:

H. hydrangeae Mitchell, 1954
H. sparsus (Cresson, 1869)
  Synonyms: *H. thaspii* (Robertson), *H. potens* (Metz).

UNASSIGNED SPECIES

The following species have not yet been assigned to any of the above listed subgenera:

H. aenigmus (Viereck, 1903)

This apparently is a *Prosopis*, judging from the description, and most probably is a synonym of *H.* (*P.*) *rugulosus* (Cockerell), a common and widely distributed species in New Mexico.

H. graenicheri Mitchell, 1954

This species was based on females only, from southern Florida. Professor Mitchell has sent specimens to me, and an examination indicates that this species is not closely related to any Nearctic species. Certain characters indicate a possible relationship with species of the Neotropical subgenus *Hylaeana*. Definite assignment must await the discovery of the male.

H. suffusus (Cockerell, 1896)

This was described from a male collected in "Nevada," and remains unknown. The longitudinally channeled apical antennal segment, if natural, is unique in the genus. The description is not sufficiently detailed to make possible a definite subgeneric assignment, although the small size and dense abdominal punctation suggest that it might belong in *Paraprosopis*.

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ON *BOCCARDIA HAMATA* (WEBSTER), NEW COMBINATION (POLYCHAETA, SPIONIDAE)

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Introduction

During the summer of 1964 studies were conducted on spionid polychaete larvae taken from plankton hauls at Morro Bay, California. Conspicuous larvae of a certain polydorid metamorphosed in the laboratory. They were first identified as *Polydora hamata* Webster which is known from the Atlantic and Gulf coasts of the United States but not the Pacific coast. These young worms (up to 34 segments) possessed branchiae on segments 7 to 12 (characteristic of the genus *Polydora*), posterior notopodial hooks, and small terminal protuberances on the pygidium (similar to pl. IX, fig. 118 of Webster, 1879a). With continued growth of the organism small branchiae became evident on segments 2, 3, and 6 which indicated the worms belonged to the genus *Boccardia* and had the characteristics of *B. uncata* Berkeley, a well-known Pacific species. Information gained from a subsequent examination of preserved adults of *P. hamata* and *B. uncata* from the Atlantic, Gulf, and Pacific coasts of the United States and *P. uncatiformis* Monro from Uruguay has necessitated the following taxonomic revision.

Polydora hamata Webster is herein transferred to the closely related genus *Boccardia*. *Boccardia uncata* Berkeley and *Polydora uncatiformis* Monro are herein placed in synonymy with *Boccardia hamata* (Webster), new combination. Further support for this revision follows a discussion of the adult morphology and ecology of *B. hamata*. The larval development will be presented in a later paper.

Acknowledgments

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ence Foundation, under the supervision of Dr. Keith H. Woodwick. The author is indebted to Dr. Woodwick for supplying laboratory facilities, library materials, and technical assistance and for critically reading this paper. A special debt of gratitude is extended to my wife, Crystal, who assisted in collecting and sorting of specimens.

Boccardia hamata (Webster), new combination

Figures 1-11.

Polydora hamata Webster, 1879a, pp. 251-252, pl. 8, figs. 111-116, pl. 9, figs. 117-118; 1879b, p. 119; Hartman, 1944a, pp. 336, 340; 1951, pp. 82-83; 1959, p. 384; Hopkins, 1958, pp. 273-275; Rioja, 1960, pp. 304-306.

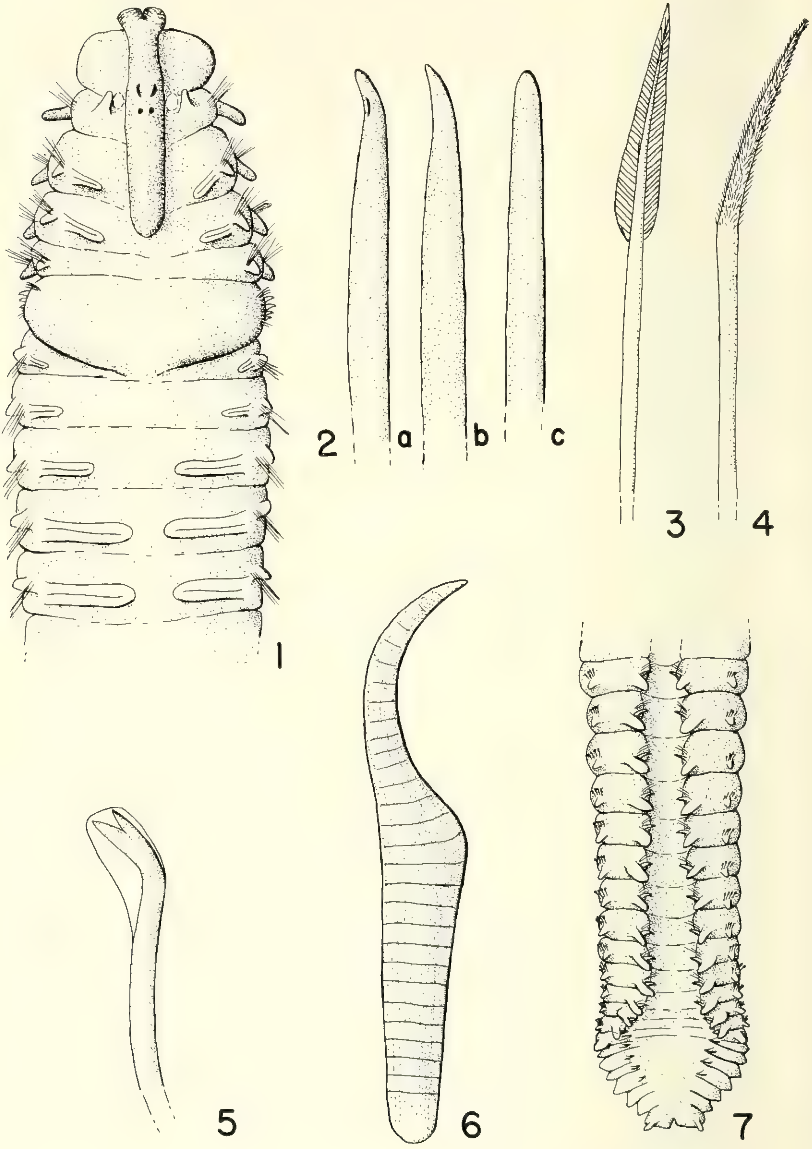
Boccardia uncata Berkeley, 1927, p. 418, figs. 9-13; Okuda, 1937 (as *Polydora (Boccardia) uncata*), pp. 238-240, figs. 16-17; Hartman, 1941, p. 304, pl. 48, figs. 46; 1944b, p. 260; 1954, p. 9; 1959, p. 375; 1961, p. 168, pl. 15; Berkeley and Berkeley, 1952 (as *Polydora (Boccardia) uncata)*, pp. 14-15, figs. 18-21; Filice, 1958, p. 290; Reish, 1961, p. 86; 1963a, p. 25; 1963b, p. 427; Imajima and Hartman, 1964, p. 281.

Polydora uncatiformis Monro, 1938, pp. 311-313, figs. 1-3; Hartman, 1959, p. 385.

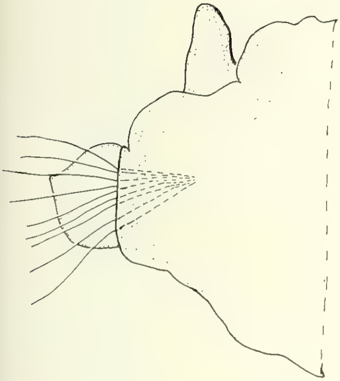
Adult Morphology

The largest specimens from Morro Bay, California were 37.0 mm. long and 0.8 mm. wide and had more than 270 segments. Specimens examined from Atlantic, Gulf of Mexico, and other Pacific localities were shorter and had fewer segments. Branchiae are present on segments 2, 3, 6 and posteriorly throughout most of the body length. The posterior abranchiate segments bear heavy curved notopodial hooks. Preserved specimens from mud flats are often a muddy brown color possibly because they feed on detrital silt. Preserved specimens from other habitats are flesh colored. Living specimens are light tan and have red blood pulsing through the palps, branchiae, and the dorsal and ventral vessels.

The prostomium is distinctly bifid anteriorly, almost flaring in young specimens (Fig. 1). It expands broadly in the region of the eyes and as a caruncle extends to the posterior border of the third segment. There is no nuchal tentacle. The four eyes consist of a large, irregularly shaped anterior pair and a small, round posterior



Boccardia hamata (Webster). *Figure 1*. Anterior end in dorsal view, x 53. *Figure 2*. Modified setae from segment five, seen at different angles, x 280. *Figure 3*. Companion seta from segment five, x 633. *Figure 4*. Superior dorsal seta from segment five, x 633. *Figure 5*. Ventral hooded hook from a posterior segment, x 700. *Figure 6*. Notopodial hook from a posterior segment, x 573. *Figure 7*. Posterior end in dorsal view, x 40.



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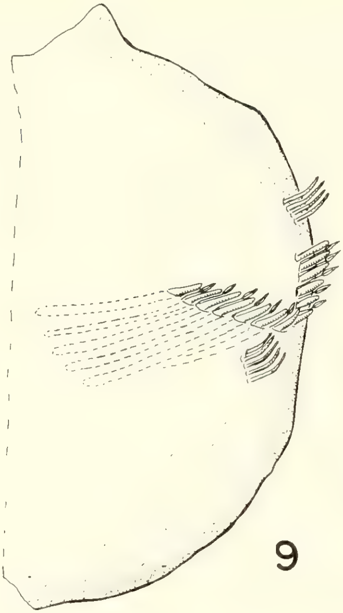

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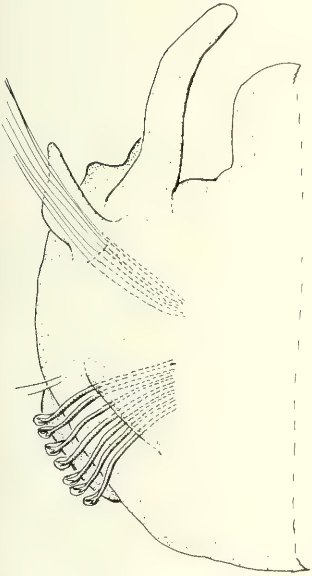

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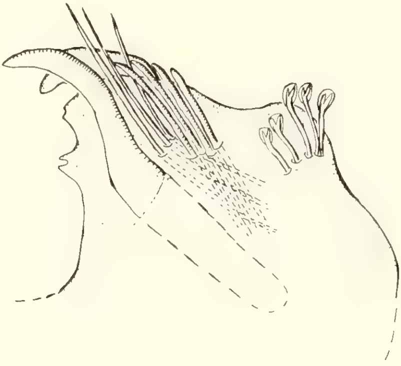

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Boccardia hamata (Webster). *Figure 8.* A first parapodium in anterior view, x 100. *Figure 9.* A fifth parapodium in posterior view, x 60. *Figure 10.* A median parapodium in anterior view, x 100. *Figure 11.* A posterior parapodium in posterior view, x 100.

pair. The peristomium is variable in shape, depending upon age and contraction during preservation. In younger specimens the peristomium is narrower than the first segment, but in older specimens and those greatly contracted during preservation it is more truncate and as wide as the first segment. Palpi arise from the peristomium between the first notopodium and the prostomium; they extend back over the dorsum to about segment ten.

The first segment is half as wide as the second. The conical-shaped notopodial lobes are shifted dorsally and come to lie alongside the prostomium (Fig. 8). In some specimens they may stand erect, in others they may fold over. There are no notopodial setae. The neuropodial lobe is laterally located and is flattened on its anterior and posterior sides. When seen dorsally it appears finger-like. A small fan-shaped fascicle of slender capillary setae is present in the neuropodium.

The second and third segments differ from segment one in having well developed notopodial lobes with capillary setae, long finger-like neuropodial lobes, and ventral fascicles with more capillary setae. The branchiae which begin on segment two are only slightly longer than the notopodial lobes, while the branchiae of segment three are at least twice as long as the notopodial lobes.

Segment four lacks branchiae but is similar in other respects to segments two and three. It is somewhat compressed posteriorly by the large fifth segment.

The modified fifth segment is large and well developed, overlapping segment six with a heavy dorsal musculature. Parapodial lobes are absent. The dorsal setae are modified to include a small bundle of superior dorsal geniculate setae (Fig. 4) just above a semi-circle of alternate heavy, modified spines and pennoned companion setae (Fig. 9). The heavy spines have a simple falcate appearance with no accessory structures (Fig. 2). The companion setae have the main shaft extending to the end of the pennon and they are closely interspaced among the heavy spines (Fig. 3). The neuropodium includes only a small tuft of geniculate setae located ventral to the modified dorsal setae.

Segment six is narrower than segment seven. The notopodial lobe and its capillary setae are more ventrally located than on segment seven. The neuropodium is present as an elongated dorso-ventral raised ridge, possessing a fascicle of capillary setae on its anterior side. Branchiae resume on the sixth segment as a small pair, slightly longer than the notopodial lobe.

The bidentate neuropodial hooded hooks are first present on segment seven, continuing throughout the rest of the body. Segments in the middle of the body have hooded hooks with the main fang directed dorsally (Fig. 10), while those at the posterior end are reversed with the main fang directed ventrally (Fig. 11). Anteriorly a small tuft of slender capillary setae accompanies the hooded hooks. The setae diminish in number towards the middle of the body, but increase again in those posterior segments possessing specialized notopodial hooks.

The notopodia from segment eight through the last two-thirds of the worm possess slender capillary setae. In the last 30 segments a dorsal median channel between the notopodia is produced by the dorsal elevation of the parapodia (Fig. 7). Three types of setae are found in each segment of this region; a small bundle of long slender capillary setae, four or five shorter thick capillary setae, and a single large hook curving in towards the midline. This hook is present on the last 20-30 segments of a mature adult. When specimens were placed in a clearing media and mounted on slides numerous cross striations and fine longitudinal lines appeared on the hooks (Fig. 6). These cross striations gave the appearance of overlapping plates. The hooks develop early in the adult life for they are present at about the 21-segmented stage.

The pygidium is composed of two blade-like lappets, each possessing a terminal process (Fig. 7). The processes are variable in size and may be very short, or long and finger-like.

DISTRIBUTION AND ECOLOGY

Boccardia hamata is known on the Pacific Coast (as *B. uncata)* from British Columbia to Baja California (Berkeley and Berkeley, 1952; Hartman, 1961; Reish, 1963b). It has been reported from oyster beds, estuarine mud, *Dodecaceria* sp. masses, and other littoral conditions. The species is known from Japan, inhabiting mud flats (Okuda, 1937). On the east and gulf coasts of North America it is known to penetrate oyster shells or other gastropod shells (Webster, 1879a-b; Hartman, 1951). It was reported from Uruguay (as *Polydora uncatiformis)*, inhabiting brackish water (Monro, 1938).

In central California *B. hamata* inhabits algal holdfasts, hermit crab shells, and estuarine mud. In the holdfasts it constructs tubes in accumulated sand and was the only spionid found in algal holdfasts of *Egregia* sp. collected at Cayucos and *Macrocystis pyrifera* Bory collected at Monterey. *Boccardia hamata* is found at Cayucos in shells of *Tegula brunnea* (Philippi) inhabited by the hermit crab, *Pagurus granosimanus* (Stimpson). It was associated in those shells with other polydorids including *Boccardia tricuspa* (Hartman), *B. columbiana* Berkeley, *Polydora limicola* Annenkova, and *P. ciliata* (Johnston). In the mud from brackish streams entering Morro Bay it is associated most commonly with the polychaetes *Capitella capitata* (Fabricius), *Hemipodus californiensis* Hartman, *Armandia bioculata* Hartman, *Polydora nuchalis* Woodwick, *Pseudopolydora kempi* (Southern), *Streblospio benedicti* Webster, and an amphipod, *Corophium* sp. Larvae of *B. hamata* were abundant in the plankton at Morro Bay from June to August, 1964.

Discussion

Polydora hamata was described by Webster (1879a) from Virginia and New Jersey (1879b). The co-type collection is from Great Egg Harbor, New Jersey (USNM 377). Webster found *P. hamata* inhabiting bivalve shells. Recently it has been reported by Hartman (1951) and Hopkins (1958) from the Gulf of Mexico where it inhabited oyster shells. Rioja (1960) reported it from the Lagoon of Mandina (eastern Mexico) from bivalve shells.

The genus *Polydora* is characterized as possessing branchiae posterior to the modified fifth segment and usually having hooded hooks from segment seven posteriorly. *Polydora hamata* was described as having these characteristics. The type lot of Webster (USNM 377) was kindly sent by Dr. Meredith L. Jones of the United States National Museum. The type material consisted of five slides and two small posteriorly incomplete specimens. One slide was labeled "head" and contained the prostomium and first four segments. Branchiae were present on segments two and three. One of the incomplete specimens possessed branchiae on segments 2, 3, and a small pair on 6. The second specimen was damaged, the anterior end being partially broken through. No branchiae were visible on segments two and three, but small branchiae were present on segment six. Specimens of *Polydora hamata* reported by Hartman (1951) from Louisiana were examined and found to have branchiae on segments 2, 3, 6 and on successive segments.

A comparison of Atlantic and Gulf of Mexico specimens of *P. hamata* with *P. uncatiformis* from Uruguay (paralectotype from the British Museum of Natural History) and *B. uncata* from California and British Columbia yielded no significant morphological differences.

Polydora hoplura Claparède has been compared to *P. hamata* Webster as being its most closely related species (Hartman, 1951; Hopkins, 1958). Since *P. hamata* has been found to be a *Boccardia*, it is apparent now that the two are not so closely related. Hopkins (1958) suggested that *P. hamata* larvae, like the larvae of *P. hoplura* would probably remain in the egg sacs until attaining a stage of 17 or more segments. The development of *B. hamata* has been found not to be of that type and will be reported on in a later paper.

Boccardia redeki Horst and *B. truncata* Hartman closely resemble *B. hamata* but each is a distinct species. *Boccardia redeki (sensu* Rullier, 1960) has long glandular lobes on the pygidium and the larval development is different. *Boccardia truncata* has no posterior notopodial hooks and the pygidium is collar-like (Hartman, 1936).

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EQUID REMAINS FROM THE SONOMA VOLCANICS, CALIFORNIA

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Sparse remains of a primitive member of the equid subgenus *Plesippus* have been found in rocks probably representing the Sonoma volcanics (Weaver, 1949) south of Calistoga, California. The fossils are important in that they tend to indicate a probable Blancan age for the rocks from which they were recovered.

The fossil material consists of a left upper molar and a right third metatarsal, collected by Mr. James H. Greene, Assistant Park Supervisor, Bothe-Napa Valley State Park. Mr. Greene generously loaned the specimens to the Museum of Paleontology (UCMP) for purposes of study and description.

The rocks in which the fossils were found consist of a moderately indurated, light brownish gray, tuffaceous agglomerate including abundant rounded to subrounded chert clasts of the Franciscan/Knoxville Formation. The fossil site, Locality V-6317, is located on a small ledge high above the north side of Ritchie Creek in the southwestern part of the NW ¼, SW ¼, sec. 17, T.8N., R. 6 W, Napa County, California. The ledge is at an elevation of 1480 feet. The bed strikes N 88° W and dips 13° NE.

Although the rocks at the site in question have not been mapped, there seems to be little doubt that the provenance of the fossils is from the Sonoma volcanics. "In the area surrounding Calistoga, the geologic sequence consists of the Franciscan/Knoxville Formation which is unconformably overlain by the Sonoma Volcanic Group." (Johnson, 1948). Rocks of the Sonoma volcanics have been mapped (Kunkel and Upson, 1960: pl. 2) as occurring within 0.3 mile south and 0.4 mile east of the fossil site. Kunkel and Upson apparently did not extend their observations to the north side of Ritchie Creek in the critical area, but from the lithologies represented, it seems highly probable that rocks at V-6317 also pertain to the Sonoma volcanics.

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Equus (Plesippus) sp.
Figure 1

Material: UCMP 64730, left upper molar (M^1 or M^2) and UCMP 63731, right third metatarsal.

Locality: Ritchie Creek, V-6317, probably from the Sonoma volcanics.

Age: Blancan, late Pliocene or early Pleistocene.

The enamel of the parastyle, mesostyle and metastyle is missing at the occlusal surface of the upper molar. Farther down, the mesostyle is broad, the parastyle is narrow and rib-like (Fig. 1B). The prefossette, postfossette and other features of the lingual portion of the occlusal surface are preserved. The tooth is relatively hypsodont, being 49.8 mm. high at the protocone and 57.8 mm. high just labial to the posterolabial edge of the prefossette. The length of the occlusal

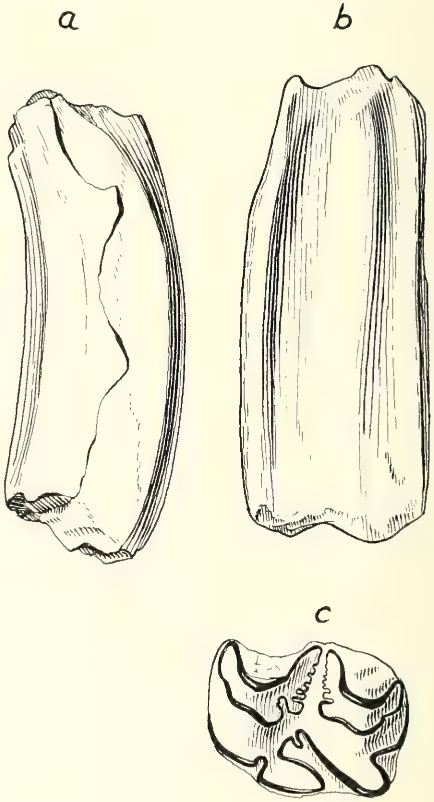

Figure 1. Equus (Plesippus) sp. A. anterior; B. labial; C. occlusal view of UCMP 64730, left upper molar. Natural size.

surface is 25.7 mm. The width, from the lingual edge of the protocone to the preserved labial edge of the tooth, is 19.2 mm. In anterior view (Fig. 1A) the radius of curvature of the mesostyle is 114.2 mm.; that of the parastyle is 76.1 mm. In labial view (Fig. 1B) the tooth curves slightly posteriorly from crown to base.

The greatest length of the prefossette is 12.8 mm.; that of the postfossette is about 10.4 mm. The labial border of both of the fossettes is strongly concave. The transverse diameter of the prefossette, measured through the point of the greatest curvature of its labial border, is 4.8 mm. A comparable measurement for the postfossette is 5.0 mm. The posterior border of the prefossette consists of a number of crenulations which diminish in amplitude labially. A pli prefossette is not developed as a distinct inflection. The pli protoconule is 3.2 mm. long (measured as in Downs, 1961: 19 and fig. 4; other terminology is after Downs, 1961; Stirton, 1941; and Cooke, 1950). A slight indentation of the enamel at the anterior surface of the prefossette suggests that a more distinct pli protoloph would be present in an earlier stage of wear.

The anterior border of the postfossette is also extensively crenulated. The pli postfossette is 1.4 mm. long. The pli hypostyle is present as a slight indentation in the posterior enamel of the postfossette.

The enamel forming the lingual border of the protoselene is nearly straight. The protoglyph, or pre-protoconal groove, is only 1.3 mm. wide and 2.9 mm. deep. The protocone has a slight heel. Its labial and lingual borders are slightly convex, and meet in a slender apex posteriorly. The medivallum, between the protocone and hypocone, is constricted to a minimum diameter of only 1.5 mm. At the anterolabial end of the medivallum the narrow pli caballin is 2.2 mm. long. The enamel of the lingual border of the metaselene is straight. The hypoglyph is chevron-shaped; its greatest transverse diameter is 4.5 mm.; its anteroposterior depth is 3.2 mm.

In summary, this is a medium-sized hypsodont tooth, probably an M^1 or M^2, with a nearly straight labial surface, moderately complex fossette borders, an incipiently shoe-shaped protocone and, apparently, a broad mesostyle. Although a certain resemblance to the Ritchie Creek specimen is shown by various specimens of *Pliohippus* with complex enamel patterns [*e.g., P. (P.) mexicanus* of the Yepomera fauna (see Lance, 1950: fig. 4b (M^2) in particular)], the aggregate of characters displayed by UCMP 64730 is more commonly encountered in specimens of the equid subgenus *Plesippus*. In particular, small members of this subgenus such as those in collections of the Hagerman fauna from Idaho are nearly identical to the Ritchie Creek tooth. The small size of this tooth and the incipient development of its protocone heel reflect an earlier stage of evolution than that seen in larger, "typical" species of *Equus (Plesippus)* such as *E.* (*Plesippus*) *shoshoensis* and *E.* (*P.*) *simplicidens*. The Ritchie Creek specimen is slightly smaller than but otherwise essentially identical to upper molars (UCMP 42415) which have been collected from the Petaluma Formation. These teeth have been termed as representing "a species of intermediate relationships between *Pliohippus* and *Equus*" (Stirton, 1952: 2025). Although the Ritchie Creek tooth might represent an advanced species of *Pliohippus*, it has been placed in the equine subgenus *Plesippus* because such an assignment seems to be more consistent with the totality of its characters. No matter which assignment should ultimately prove to be correct, equid species with dental characters similar to those of the Ritchie Creek specimen are commonly found in assemblages of Blancan age.

The metatarsal is 253.9 mm. long. The transverse width across the distal tubercles is 50.2 mm. In distal view the medial condyle is deeper than the lateral condyle. The width of the proximal surface is 54.5 mm. The anteroposterior diameter of that surface is 46.5 mm. In outline, the proximal surface is strongly arched; there is a slight inflection in the anterolateral border between the cuboid and ectocuneiform facettes. The posterior ectocuneiform facette is relatively elongate transversely. The non-articular depression is deep and subcircular; it leads posterolaterally through the deep non-articular notch. The facette for the meso-entocuneiform is not preserved. It may have been present only as a small area on the tip of the strongly concave posteromedial corner of the ectocuneiform facette.

Material similar to this element has been found among metatarsals pertaining to small unnamed plesippines in the collections from the Hagerman fauna. The Ritchie Creek specimen is slightly more massive than the small Hagerman form. It is also more massive and slightly larger than third metatarsals of typical pliohippines such as *Pliohippus interpolatus*. Moreover, the shape and construction of the Ritchie Creek specimen is quite unlike that found in either subgenera of *Pliohippus*. Although this element cannot be definitely associated with the isolated molar at V-6317, both specimens suggest the presence of a small, somewhat primitive plesippine equid.

In conclusion, a moderately small, primitive plesippine equid is represented by the material from Ritchie Creek. Horses of this character are commonly found in assemblages pertaining to the Blancan

North American Land Mammal Age. If, as is probable, the provenance of these fossils is from the Sonoma volcanics, the Blancan age thereby suggested for the deposits is compatible with the fact that the Sonoma volcanics overlie rocks of the Petaluma Formation (Weaver, 1949:128). Equid remains pertaining to an advanced species of *Neohipparion (N. gidleyi)* and an unnamed species which is intermediate between *Pliohippus* and *Equus* indicate that the age of the Petaluma Formation is "transitional between middle Pliocene (Hemphillian) and late Pliocene (Blancan)" (Stirton, 1952).

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A NEW GENUS, *FONSECULA*, AND A NEW SUBGENUS *(PARASECIA)* OF THE GENUS *FONSECIA* (ACARINA, TROMBICULIDAE).[1]

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Studies of the chiggers currently included in the genus *Fonsecia* Radford, 1942, of the subfamily Trombiculinae have revealed the necessity of proposing a new genus for the Old World species. In addition, *Trombicula gurneyi* Ewing and related New World species are placed into a new subgenus of the genus *Fonsecia*. For illustrations and descriptions of the species of the genus *Fonsecia*, see Brennan and Loomis (1959). A discussion of *Trombicula gurneyi* and related species can be found in a paper by Loomis (1955). Because there will be a delay in publishing the detailed descriptions of larval and post-larval stages of the species in these two genera, the following names are proposed in advance:

Fonsecula, new genus

Type species: Fonsecia celesteae Audy, 1957.

Referred species: Fonsecia colubrina Radford, 1946, and *Fonsecia ptyasi* Rao and Hiregaudar, 1956.

Larvae of all three species examined.

Diagnosis: (Larva): Similar to *Fonsecia* (type species *Trombicula ewingi* Fonseca, 1932) in having peglike AL scutal setae; palpal tarsus with 7 B.S.; sensilla flagelliform; galeal seta nude; and 3 genualae I; but differing from it in the subpentagonal shape of the scutum (concave posterior margin in *Fonsecia*); expanded bases of PL scutal and dorsal body setae (not expanded in *Fonsecia*); bifurcate palpotibial claw (trifurcate in subgenus *Fonsecia*); and the Old World distribution (*Fonsecia* in the New World only). Similar to, and closely related to, the Old World genera *Babiangia* Southcott, 1954, and *Siseca* Audy, 1956, but differing from them in having peglike AL scutal setae.

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[1] Studies upon which this paper is based were supported by a U.S. Public Health Service Research Grant, AI3407, from the National Institute of Allergy and Infectious Diseases. Contribution from the Department of Biology, California State College at Long Beach.

Genus *Fonsecia* Radford, 1942
Parasecia, new subgenus

Type species: Trombicula gurneyi Ewing, 1937.

Referred species: Trombicula aitkeni Brennan and Jones, 1960; *T. gurneyi campestris* Loomis, 1955; *T. kansasensis* Loomis, 1955; *T. longicalcar* Brennan and Jones, 1960; *T. manueli* Brennan and Jones, 1960; and *T. universitatis* Hoffmann, 1963; larval stage of each species examined.

Other possible referred species, not seen: Trombicula chara Wharton, 1948; and *T. psittaci* Floch and Abonnenc, 1949.

Diagnosis: (Larva): Similar to the subgenus *Fonsecia* Radford, 1942, in having scutum with anterior setae set back from margin; AL<AM<PL; sensilla flagelliform; galeal seta nude; palpal tarsus with 7 B.S.; 2 or 3 prongs on palpotibial claw; usually 3 genualae I; differing from subgenus *Fonsecia* in having normal AL scutal setae (peglike in *Fonsecia*).

Comments: All of the species referred to the genus *Fonsecia* are from the New World, ranging from eastern and central United States southward into Mexico, Central and South America.

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ORIGIN OF THE ENAMEL MATRIX IN DEVELOPING AMPHIBIAN TEETH

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Since the year 1946, several papers have been published dealing with the development of the teeth in various species of fish, amphibia, and reptiles. Prominent among these are the papers of Kvam (1946, 1950, 1953a, 1953b, 1953c, 1960a, 1960b) and Kerr (1955, 1960).

There is, in general, close agreement as to the mode of tooth development in fishes and reptiles. It seems well established by Kvam and by Kerr that enamel is developed from mesenchymal tissues in teleost fishes and elasmobranchs. Kvam (1946) proposed the term "mesodermal enamel" for this type of enamel. In reptiles, the enamel develops from the epithelial cells of the enamel organ and is an "ectodermal enamel." Dentin arises from the mesenchymal dental papilla in these groups. In mammalian teeth, as is well known, the enamel is an epithelial product of the enamel organ and the dentin arises as a mesodermal derivative from cells produced by the dental papilla.

There are two schools of thought with regard to the development of teeth in the amphibians. Kvam (1946, 1960a) stated that the amphibia have mesodermal enamel, while Kerr (1960) indicated that the amphibia have ectodermal enamel.

Kvam (1960b:515) distinguished mesodermal enamel from ectodermal enamel with the following statement: "The difference between mesodermal enamel (Durodentin) and ectodermal enamel is that the former comes into existence by a further calcification, connected with the loss of collegenous fibers, of the dentinal tooth tip, probably with the assistance of the elongated inner epithelial cells of the tooth germ, whereas the latter tissue is developed by the epithelial part of the tooth germ first laying down its organic matrix and then bringing about its calcification."

Kvam's (1946, 1960a, 1960b) data for amphibian tooth development was drawn from the newts, *Triton cristatus*, *Triton punctatus*, and a frog, *Rana plathyrrhinus*. Based upon Kvam (1960a, 1960b), the theory of mesodermal enamel in amphibia can be briefly summarized. From the dental lamina a new tooth germ proliferates. The epithelial cells invaginate, forming a groove filled with a cluster of "mesodermal" cells. The epithelium of the newly formed tooth germ consists of two cell layers, an outer layer of cuboidal cells and an inner layer of columnar cells as seen in the "cap stage." Further growth produces the "bell stage" with a rounded tip and a dental papilla. Alteration of the shape of the "bell stage" produces a pointed tip and sloping sides. Accompanying this is a change in orientation of the tooth germ so that the pointed tip comes to face the same direction as the mature functional teeth in the jaw. The junction between the inner epithelium of the tooth germ and the dental papilla takes on the shape of the tooth tip before dentin development starts. Dentinogenesis is initiated with the inner epithelium in contact with the dentin, a contact that is broken shortly by the appearance of a fissure between the dentin and the epithelium.

Kvam (1960b) describing material stained with the hematoxylin and eosin technique noted that in some of the early tooth germs, the tooth tip ends in a darker zone which is in contact with the inner epithelium of the tooth germ. Kvam (1960b:512) stated "This darker zone can be the dentin tip which is stained differentially, perhaps as a transition to a more strongly calcified mesodermal enamel." And further, p. 513, "The dark zone cannot be the organic matrix of an ectodermal enamel. In that case the dark zone would have been lying outside the original, very pointed, dentin tip, and this is not so."

Kvam (1960b:518) summarizes his stand on amphibian tooth development: "The first deposited tooth substance in *Triton cristatus* Laur. is formed by the dental papilla and has the outline of the finished tooth tip with two pointed cusps and a groove in the occlusal surface between the cusps. In its further development, the tooth tip changes to a strongly calcified mesodermal enamel with a rounded border line toward the dentin. In some sections, the outermost layer of the mesodermal enamel is kept after decalcification and lies in close contact with the inner epithelium of the tooth germ showing that an ectodermal enamel did not develop."

Kerr (1960:412) in studies of tooth development in urodeles utilized the salamander *Salamandra maculosa*, the hellbender *Cryptobranchus alleghaniensis*, and the smooth newt *Molge vulgaris*. A dental lamina is found in each jaw, from which the tooth germ is derived. This forms a disc of epithelial cells which in turn forms a shallow cup. Within the concavity of the cup are mesenchymal cells. The cup is the enamel organ and the connective tissue forms the dental papilla. The enamel organ has an inner dental epithelium and an outer (external) dental epithelium with a few cells in between the two layers with no tendency to form a stellate reticulum. Odontoblasts differentiate and dentin is deposited. After sufficient dentin has been formed to outline the tip of the tooth, a second substance appears on the outer surface. This appears to be ectodermal enamel, staining red with azan, pink with trichrome, and is sharply differentiated from the underlying dentin.

Kerr (1960) presents no evidence that suggests conversion of the early formed dentin to mesodermal enamel, but rather a secondary formation of an enamel of a different type. He suggested that the strong azan reaction indicated that the substance was probably keratin, which is of an epithelial (ectodermal) origin. The ground substance of this layer disappears with subsequent calcification leaving an enamel space.

The current study includes developing teeth in the "bell" and "appositional" stage from adult amphibians, *Rana catesbeiana*, *Rana pipiens*, and *Taricha (Triturus) torosa*, fixed in neutral formalin. Sections at 6 microns were studied in series stained with hematoxylin and eosin (Humason, 1962), Mallory's azan (Humason, 1962), gold chloride (Soule, 1962), Schmorl's thionin (Ambrogi, 1960), and toluidine blue (Humason, 1962). Carefully deparaffinized sections were mounted for fluorescence studies, utilizing a mercury vapor type, HB 200 high pressure lamp as a source of ultraviolet light and a UG-1 filter. Comparative material from fetal pig *(Sus domestica)* and the alligator lizard *(Gerrhonotus scincicauda)* was treated in a like manner.

RESULTS

Hematoxylin and eosin stained sections of the developing teeth in the appostitional stage of *Rana catesbeiana*, *Rana pipiens*, and *Taricha torosa* clearly show odontoblasts, pre-dentin, dentin, ameloblasts and early enamel matrix. The outer limits of the tooth germ are bounded by a thin layer of connective tissue composed of flattened fibroblasts and collagenic fibers. Immediately inside this layer are the ameloblasts. Each ameloblast is elongated and columnar in appearance, with an acidophilic granular cytoplasm containing scattered irregular vesicles. The ameloblast nucleus is located basally in the end of the cell away from the future dentino-enamel junction. Each nucleus is irregularly oval to spheroid with diffuse, scattered, moderately stained chromatin. Two nucleoli are often present. Proximal and distal terminal bars are present between the ends of each ameloblast. In amphibian teeth (Fig. 1), stained with hematoxylin and eosin, the early enamel matrix appears dark purple and homogenous. It is identical in appearance with the enamel matrix of developing teeth in the fetal pig and the alligator lizard stained with hematoxylin and eosin.

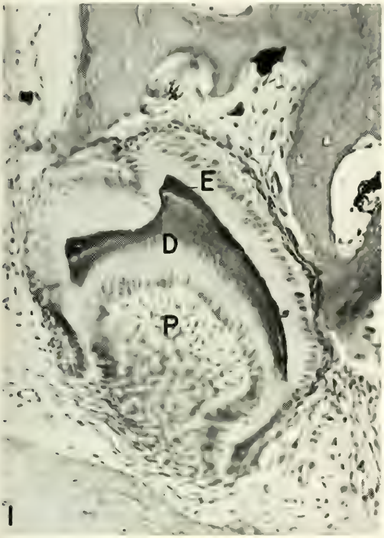
The odontoblasts of the amphibian material examined are elongated, forming the outer peripheral layer of the dental pulp. They are shorter and narrower, than the ameloblasts, appearing columnar in the sections. Stained with hematoxylin and eosin, the odontoblast cytoplasm is pale pink and granular. Cytoplasmic extensions may be seen entering the dentinal tubules. The nuclei, which are toward the pulpal end of the odontoblasts, show diffuse chromatin moderately stained, with one or more nucleoli. Stained with hematoxylin and eosin, the pre-dentin is pale pink in color, while the older mineralizing dentin is rendered purple. Dentinal tubules are readily visible. In the fetal pig and the alligator lizard, the predentin stained with hematoxylin and eosin is pink and the mineralizing dentin is stained purple.

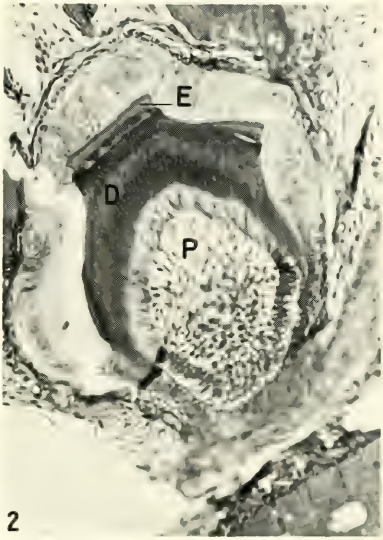
The dental pulp of developing amphibian teeth is composed of a mixture of stellate and fusiform fibroblasts with elongated cytoplasmic extensions. Eosinophilic with hematoxylin and eosin, the collagen fibrillae are thin and sparse.

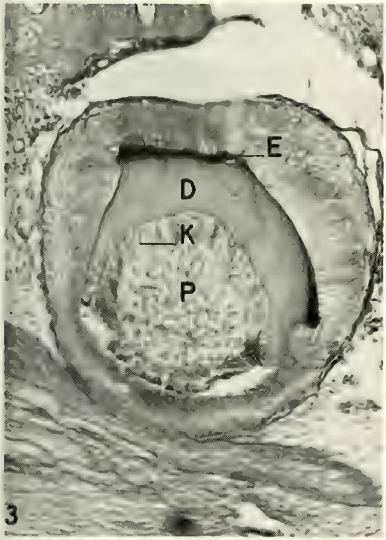
With Mallory's azan technique, in *Rana catesbeiana*, *Rana pipiens*, and *Taricha torosa*, the ameloblasts and odontoblasts appear columnar, with dark red nuclei and pale blue cytoplasm possessing reddish-blue coarse granules of variable size. The newly formed enamel matrix stains bright red. It is homogenous with faint indications of enamel prism formation. The pre-dentin is blue, the older mineralizing dentin orange-pink in color. Dentinal tubules are distinct, radiating toward the dentino-enamel junction.

The dental pulp of amphibian teeth as seen in the Mallory's azan

(Fig. 2) sections shows fusiform or stellate fibroblasts with red nuclei and elongated cytoplasmic projections. Delicate collagenic







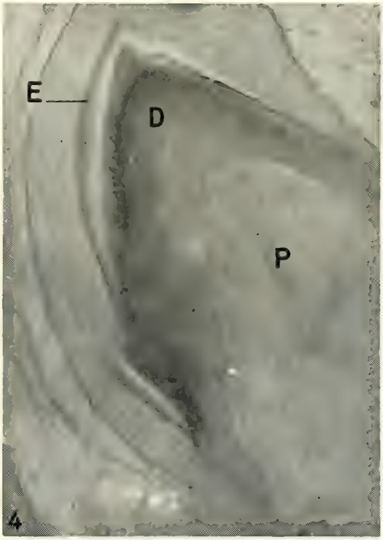


Figure 1. Rana catesbeiana developing tooth. Hematoxylin and eosin. *Figure 2. Rana catesbeiana* developing tooth. Mallory's azan. *Figure 3. Rana catesbeiana* developing tooth. Soule's gold chloride. *Figure 4. Rana catesbeiana* developing tooth. Toluidine blue. *Legend*: E-enamel; D dentin; P-dental pulp; K-von Korff's fibers.

and pre-collagenic fibrillae arranged in an irregular meshwork, stain blue. Some spiral von Korff's fibrillae terminate in the pre-dentin.

With Mallory's technique in the fetal pig and alligator lizard, the enamel matrix is bright red, the pre-dentin is blue, and older dentin orange-pink.

The thionin technique (Schmorl's) stained the amphibian teeth dentin pale purple. The walls of the dentinal tubules are rendered dark purple. These dentinal tubules radiate from the pre-dentin toward the dentino-enamel junction where they terminate. Arborization of the dentinal tubules into delicate branching tubiculi occurs near the dentino-enamel junction. Young enamel matrix of the amphibian material stains a light sky blue color with the thionin method. It is homogenous with a clear line of demarcation at the dentino-enamel junction. The developing tooth of the fetal pig when stained with the thionin technique shows pale purple dentin, dark purple dentinal tubules, and enamel matrix that stains pale blue.

The gold chloride technique applied to developing teeth in *Rana catesbeiana*, *Rana pipiens*, and *Taricha torosa* shows within the dental pulp an irregular meshwork of delicate reticular fibrillae among which are interspersed the fibroblasts. Spiral von Koff's fibrillae are seen between adjacent odontoblasts. These fibrillae arborize upon entrance into the pre-dentin. The early "bell" stage, prior to dentinogenesis, stained by the gold chloride technique, shows a fine reticular meshwork separating the row of ameloblasts from the underlying odontoblastic layer. The young enamel matrix stains a deep maroon red with gold chloride method. With this same method, (Fig. 3) the pre-dentin and young dentin is stained a pale lavender purple. Dentinal tubules are seen. An identical staining reaction occurs in the early enamel matrix, dentin and pre-dentin of the fetal pig and the alligator lizard.

Sections stained with toluidine blue failed to produce a discernible metachromasia of the dentinal pulp in the amphibian material. However, the early enamel matrix stained a light bright blue and reveals enamel prism formation and cross striae (Fig. 4). The pre-dentin stained a pale blue while the older maturing dentin was rendered a dark blue. Dentinal tubules were visible, regular and radiating toward dentino-enamel junctions. Metachromasia in the form of a pale pink staining reaction appeared in the pulp of material from the fetal pig. The early enamel matrix stained light blue, pre-dentin pale blue and maturing dental matrix dark blue.

Deparaffinized and mounted unstained sections of amphibian material examined with ultraviolet light and the UG-1 filter revealed autofluoresence. There was little difference in the predentin, maturing dentin and bone; all fluoresce a gray-blue color. However, the young enamel matrix showed a bright, pale, green-yellow autofluoresence as did the epithelial cells of the amphibian skin. In the fetal pig and the alligator lizard, the pre-dentin, dentin and bone fluoresces gray blue, while the enamel matrix appears pale green-yellow in color.

TABLE 1

Reaction to several stain's of early enamel matrix, pre-dentin and dentin of Amphibia, Reptilia and Mammalia.

		Hematoxylin & eosin	Mallory's azan	Soule's gold chloride	Schmorl's thionin	Toluidine blue	Autofluorescence
AMPHIBIA	enamel matrix	dark purple	bright red	maroon red	pale blue	light blue	bright pale green-yellow
	pre-dentin	pale pink	blue			pale blue	gray-blue
	dentin	purple	orange-pink	lavender	pale purple	dark blue	gray-blue
REPTILIA MAMMALIA	enamel matrix	dark purple	bright red	maroon red	pale blue	light blue	pale green-yellow
	pre-dentin	pale pink	blue			pale blue	gray-blue
	dentin	purple	orange-pink	lavender	pale purple	dark blue	gray-blue

CONCLUSIONS

By means of various staining procedures and by autofluorescence, the early enamel matrix, dentin and pre-dentin of the amphibian teeth used in this study are shown to react identically to the early enamel matrix, dentin, and pre-dentin of developing teeth of the fetal pig and alligator lizard (Table 1).

A red color reaction produced by Mallory's azan stain in the early enamel matrix indicates keratin, a product of epithelial origin. Kerr (1960) recorded this reaction in the enamel matrix of the amphibians.

In addition to the matching of staining reactions of the amphibian early enamel matrix with those of the fetal pig and alligator lizard, the thionin technique revealed the presence of dentinal tubules in both the amphibian dentin and the dentin of the fetal pig and lizard. The dentinal tubules of the amphibian teeth radiate toward the dentino-enamel junction where they arborize and terminate. There is no evidence at any stage of tubules in the early enamel matrix.

Mallory's azan and the toluidine blue technique revealed the presence of enamel prisms (rods) in amphibian teeth that are similar to those seen in mammalian teeth. The latter technique gives evidence of regular cross striae on the amphibian enamel prisms.

The staining reactions and the morphological findings are confirmed by the consistent pale green-yellow autofluorescence of the early enamel matrix in the amphibia, the fetal pig, and the alligator lizard that contrasts with the less intense gray-blue autofluorescence of the pre-dentin, dentin, and bone.

SUMMARY

Conflicting reports in the recent literature indicate that developing amphibian teeth have mesodermal enamel, or conversely that amphibian teeth have ectodermal enamel.

Careful comparisons were made of developing teeth in amphibians with teeth in comparable developmental stages from the fetal pig and alligator lizard, using hematoxylin and eosin, Mallory's azan, Soule's gold chloride, Schmorl's thionin, and toluidine blue stains. A similar comparison of developing amphibian, reptilian and mammalian teeth was made under ultra-violet light and a UG-1 filter to produce autofluorescence. The histochemical and fluorescent comparisons combined with morphological similarities strongly indicate that the development of enamel in mature amphibians is identical to that found in reptiles and mammals. The presented evidence shows that in adult amphibians the enamel develops from ameloblasts formed from the inner enamel (dental) epithelium of the enamel organ and is "ectodermal enamel."

The author wishes to express his gratitude to Mrs. Renee Z. Bertolino for her technical assistance.

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THE POPULATION OF GRAY WHALES (*ESCHRICHTIUS GIBBOSUS*) ON THE SOUTHERN COASTS OF PENINSULA DE BAJA CALIFORNIA, MEXICO

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Whalers easily traced annual migrations of the gray whale (*Eschrichtius gibbosus*) along the Pacific coast of North America, and during the peak whaling days of 1830-1880, they drew heavily on the stocks. Subsequently rampant exploitation led to protection of the species by international treaty. These migrations remain a relatively easily-observed coastal phenomenon and consequently continue to attract the general public. Another unique situation has led to study of the gray. This is the incidence of "false targets" in undersea warfare operations, since the noise and behavior of several forms of nekton have led to confusion in the identification of submarines. Within this latter sense, Lockheed-California Company biologists have conducted experiments with these animals as well as made a tally of their numbers since 1961. These whales habitually congregate *en masse* in the vicinity of Bahia Magdalena, Baja California del Sur, Mexico, at 24°40′N, 112°00′ W. This circumstance very greatly aids in the task of censusing this portion of the "false target" population.

The entire Pacific coast of Baja California peninsula can be checked from an airplane within a six-hour period, and consequently a tally taken from a plane can be more representative of the total number in the gray whale population than that taken from a ship. However, more detailed observations in a local area can be made from a research ship. Aerial tallies were taken from an altitude of 800 to 1,000 feet on both sides of the peninsula. Table 1 refers specifically to counts made in the area where the greatest number of whales congregate.

Adult gray whales are 44 to 48 feet long, and consequently are easily seen from aloft. Calves born early in the year are from 12 to 17 feet long (Eberhardt and Norris, 1965; however, they double in length during the first year. Grays generally move at three to five knots during their migration but can sustain a speed of seven knots and, for short periods, will swim at 13 to 14 knots. Customarily, they breathe for three to five minutes and then dive for 10 to 15 minutes.

The population of Baja California herd was reported to be 3000 early in the fifties and 4500 in 1960 (Gilmore, 1960). Counts made at San Diego indicated a 1959-1960 population of 6,000 (Rice, 1961). Since 1938 the species has been protected by international treaty and has not regularly entered landing statistics.

A ship-board count was made by the author in late January, 1962, of the local population at Laguna Ojo de Liebre (Scammon Lagoon), and less than 800 whales were estimated to be present. During combined ship and plane operations by Lockheed late in February, 1963, along both coasts of the peninsula, a total of 333 grays were seen. During a survey flight in late January, 1964, only 49 grays were

TABLE 1.

Gray whales (*Eschrichtius gibbosus*) sighted by biologists of Lockheed-California Company near Bahia Magdalena, Baja California, Mexico, between 23 to 28 degrees North during the calving seasons of 1963, 1964, and 1965 (Robert L. Eberhardt).

	1963	1964	1965
Vicinity	22-24 Feb.	23-24 Jan.	18-19 Feb.
Laguna Guerrero	12	3	29
Laguna Ojo de Liebre (27°45′ N, 114°10′ W) (See Note)	175	26	170
Punta San Eugenio	—	0	0
Punta San Pablo	—	0	0
Punta Abreojos	1	0	1
Laguna San Ignacio (26°50′ N, 113°15′ W)	54	8	23
Punta Santo Domingo	0	0	23
Punta San Juanico	32	0	12
Boca de Soledad	27	0	52
Bahia Magdalena (24°40′ N, 112°00′ W)	0	0	114
Bahia Almejas	0	0	26
Boca Flor de Malva	0	0	2
Punta Marquez	0	0	5
Boca del Carrizal	2	0	10
Boca de Las Matancitas	5	0	11
Cabo San Lucas (22°50′ N, 109°55′ W)	0	2	7
Bahia de La Paz	0	0	4

Note: During a spot-check in Scammon Lagoon in January, 1962, 747 were estimated to be present.

counted below the U.S.-Mexican border and along both peninsular coasts. Subsequently, a report was received from a reliable source (P. J. Cutting, *pers. comm.*, 1964) that 800 were seen in mid-February in Laguna Ojo de Liebre alone. One year later, an aerial tally of 501 was made between Ensenada, Baja California del Nord and Bahia de Las Paz via Cabo San Lucas. Again, a late report was received, informally, that 100 lay off Cabo San Lucas after we had passed (William Craig, *pers. comm.*, 1965).

It appears from information collected during a four-year period that more than 3000 gray whales gather annually in and off the lagoons of central Baja California between 28° N and 23° N. Because of the repeated breaching and sounding that is typical of a gam, observers conservatively accept a ratio of 1:5 for those seen to those not sighted. (Carl and Laura Hubbs, *pers. comm.*, 1963). When this ratio is used, the Baja California herd seen by our group during 1962 to 1965 can be estimated to have been 4000, 1500, 4500, and 3000 whales respectively. The bulk of these whales occurred in two localities: Laguna Ojo de Liebre and the vicinity of the northern portion of Bahia Magdalena.

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GONIONEMUS VERTENS L. AGASSIZ (HYDROZOA: LIMNOMEDUSAE) IN SOUTHERN CALIFORNIA[1]

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Introduction

The olindiid genus of small medusae and tiny polyps, *Gonionemus*, has recently been shown to comprise but a single circumglobal species, *G. vertens*, which is distributed disjunctly in north temperate coastal waters (*e.g.*, *Kramp*, 1959, 1961; Tambs-Lyche, 1964). In its natural habitat it usually occurs littorally in beds of sea grasses and prefers brackish or even fresh water. The asexual polyp stage is about 2 mm. high, and may live for years without producing medusae, which measure some 14 mm. in bell diameter (Tambs-Lyche, 1964). Normally, sexual reproduction occurs during the summer months (reviewed in Johnson and Snook, 1935; Gwilliam, 1961; Ricketts and Calvin, 1962). Eggs are laid during the evening and hatch 12 hours later into ciliated planula larvae, which later metamorphose into actinulas. Normally, in about 3 weeks the larva settles and develops into a tiny polyp; subsequently its base buds new sexual stages, which mature directly into tentacled medusae(Perkins, 1926; Werner, 1950). Using the adhesive disks on the aboral side of the tentacles, the medusa moves about on the blades of the eel grass *Zostera* (Tambs-Lyche, 1964) or pulsates up and down in large groups among the seaweed (A. Agassiz, 1865, quoted in Russell, 1953). It shuns direct sunlight and is most commonly seen on overcast days or at dusk (Johnson and Snook, 1935; Ricketts and Calvin, 1962).

Off the American Pacific Coast, *G. vertens* reportedly ranges from Sitka, Alaska, to Puget Sound, Washington, mainly inhabiting clear water in the eel grass beds of sheltered bays and other coastal areas (Johnson and Snook, 1935; Gwilliam, 1961; Ricketts and Calvin, 1962). Here, it is most abundant during July (A. Agassiz, 1865, quoted in Russell, 1953) and annually off British Columbia may tolerate surface temperatures and salinities that vary as much as 6 to 18° and 0 to 34‰, respectively (data from Pichard and McLeod,

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1953). In the present study we shall: (1) record *G. vertens* from southern California, (2) relate its ecology here to the hydrobiological regime in the lagoon where it occurs, and (3) speculate as to its origin in this lagoon.

LAGOON HYDROLOGY

During the years 1964-65, we observed medusae, but not polyps, in an artificially maintained, enclosed saline lagoon at the University of California, Santa Barbara almost 1000 miles south of Puget Sound. This lagoon, which is kept at constant level by the seawater effluent from a nearby marine laboratory, contains 90 acre-feet of water, covers 27.4 acres, and has been continuously filled for 12 years. Because of its relatively small size and present complete isolation from the nearby ocean, it is strongly influenced by local climatic fluctuations. We monitored the resulting wide fluctuations in hydrography through weekly measurements of various pertinent physical, chemical, and biological parameters at prescribed depths among several stations throughout the lagoon. Temperatures and salinities were measured electrically with a small salinometer, dissolved oxygens with a galvanic-cell oxygen-electrode. The relative abundance of *G. vertens* was visually estimated. In 1964, average salinity decreased from a high of 45 $^0/_{00}$ during the summer to 10 $^0/_{00}$ after the winter rains, while temperature varied between the winter low of 11°C and the summer high of 27°C. In summer, daytime oxygen concentration varied from a supersaturated 20 mg./l. in floating mats of algae at the surface to almost 0 at the stagnant bottom, although in winter the surface and intermediate waters are uniformly saturated at 7 to 8 mg./l. Water transparency measured by Secchi disk increased from one to 4 feet from December to February, but decreased to a few inches in the stagnant and turbid downwind (eastern) end of the lagoon during the downwelling period of spring and summer westerly winds.

ASSOCIATION WITH *Enteromorpha*

In the lagoon, medusae are closely associated with the green alga *Enteromorpha*, whose cyclic abundance, in turn, is correlated with hydrological fluctuations. Overwintering as benthic filaments, the alga expands during the spring and floats to the surface as elongate gas-filled bladders, which accumulate and form large floating mats, 7 to 8 cm. thick, trailing a tangle of finer filaments below. During both years the increase in water transparency during December-

February preceded a bloom of *Enteromorpha* during January-March. The mat creates a shaded shelter for the medusae suggestive of that under the broad *Zostera* blades. Closely following the rise and decline of *Enteromorpha*, medusae, including many gravid individuals, appeared during February-April (Fig. 1). Furthermore,

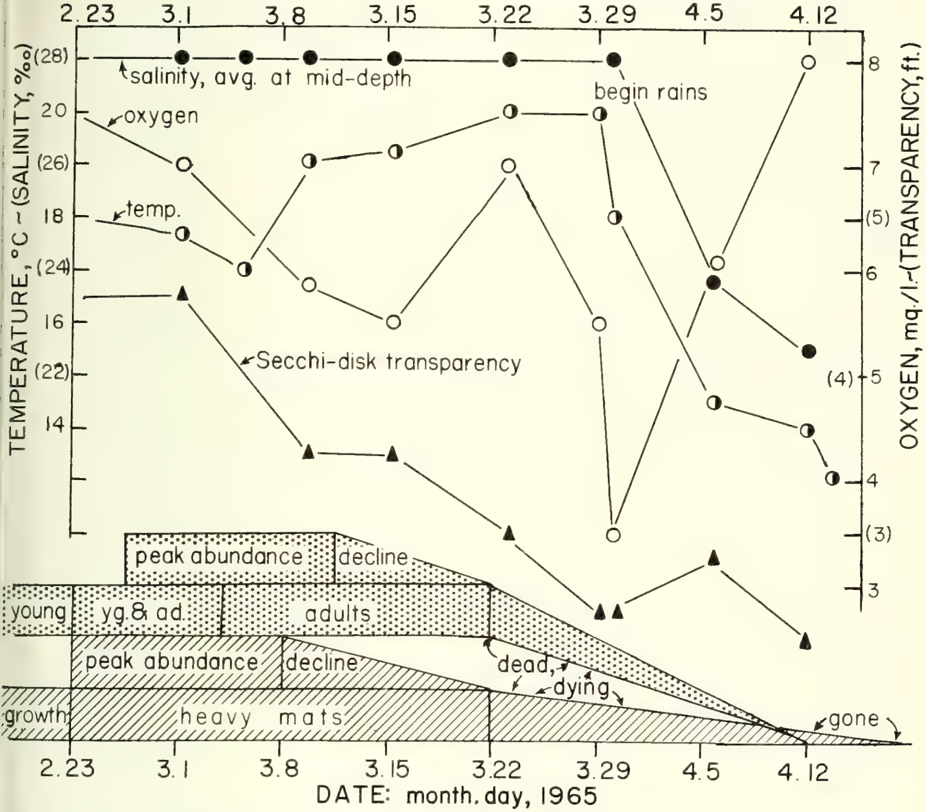

Figure 1. Occurrence of *Gonionemus* medusae (stippled blocks) relative to formation of surface algal mats of *Enteromorpha* (hatched blocks), compared with variations in physical and chemical parameters in the U. C. S. B. campus lagoon during February-April, 1965.

medusae inhabiting the *Enteromorpha* mats that declined first, vanished first, with dead and moribund individuals observable in the fading mats. Conversely, vigorous mats continued to support healthy medusae. When the mats disintegrate, medusae are not only critically exposed, but presumably are subjected to unhealthy pollution in the decaying algae, which is indicated by near-anoxic benthic conditions continuing from March through the summer. The concomitant changes of decreasing oxygen concentration and transparency and rising temperature preceded the disappearance of medusae by almost 20 days; a decrease in salinity after heavy April rains followed it by 14 days (Fig. 1). Food is probably not limiting because their principal food sources, the copepod *Pseudodiaptomus euryhalinus* and larvae of the mudsucker fish *Gillichthys mirabilis* were present in vast numbers both during and after their occurrence. Therefore, we suggest that the presence of healthy medusae is more directly dependent on vigorous *Enteromorpha* (or other sheltering plants) than the varying physicochemical parameters measured.

ORIGIN IN LAGOON

How did *G. vertens* invade the lagoon and how does it survive? Tambs-Lyche (1964) suspected that the tiny-polyp generation, which apparently may exist for years without budding medusae, might (1) cause the species to be abundant in a given area without its being noticed and (2) provide for it an artificial means of broad distribution. The sudden appearance of medusae, therefore, does not necessarily imply a recent introduction of the species, which may have previously lingered unobserved as covert polyps during much of the current lentic period of the lagoon.

Tambs-Lyche (1964) believes that because the medusae are almost never taken pelagically, the most obvious means of dispersal for *G. vertens* would have been by transport of the polyps on wooden sailing ships, which would have had easy access to weeded shallows suitable for the re-establishment of the medusal generation. He remarked that, "In this case, the conditions of life for the species have, through the means of civilization, been reversed . . . (in that it has) . . . a relatively 'sedentary' medusa, but . . . a polyp which, as a member of a fouling community on ships hulls, is carried around the world." Indeed, after L. Agassiz (1862) originally described the species from Puget Sound, it has been recorded as several nominal species from such distant localities as the Mediterranean, the Berlin Aquarium, the east coast of the United States (Woods Hole, Massachusetts), the east coast of England, Norway, the Skagerrak of Sweden, the Indo-Pacific, Brittany, and Russia (summarized in Kramp, 1959, 1961; Tambs-Lyche, 1964). Therefore, the fortuitous transport of the polyps to southern California from the north is quite probable. They could have been conveyed by boats or wafted on flotsam and detached seaweed by the south-flowing California Current. The polyps could have then been introduced into the lagoon by various agencies, including man, animal, and tidal wash. To our knowledge, however, live specimens of *Gonionemus* have never been purposely maintained in the U.C.S.B. Marine Laboratory.

If such transport is likely, however, why is not the species prevalent throughout the marine littoral (especially in the vicinity of marine laboratories) of southern California? That the lagoon was the only chance recipient of polyps (or, perhaps, even of medusae and eggs) seems improbable and, to be sure, other unreported populations may exist here. But because locally it does not inhabit estuaries, even those with vigorous *Enteromorpha* mats, it may be uniquely compatible with the biological regime of the lagoon, which differs from the estuarine habitat in its lack of tidal flushing, lack of serious predators, and continuously high standing crop of potential food. The delicate medusae, which prefer quiet water, therefore are not lost in tidal movements and are relatively free from predation. (The only potential predators are small fishes, the killifish *Fundulus parvipinnis* and mudsucker, *Gillichthys mirabilis*, and various insects, all of which exploit other abundant, continuously available food sources.) This protection is especially important for the continued survival of a species like *G. vertens* that has invaded a marginal habitat outside its optimal temperate range. And, as the lagoon continues to evolve, noxious conditions of eutrophic deterioration may very well eliminate the species here.

CONCLUSIONS

In an enclosed lagoon at the Santa Barbara Campus of the University of California, medusae of the limnomedusiod hydrozoan *Gonionemus vertens* have been observed for 2 years, where they are found in the shelter of the green alga *Enteromorpha*, whose existence as thick surface mats in the winter and spring apparently determines their cyclic occurrence. Originally it was most likely introduced into the lagoon as an asexual polyp generation, transported from the north either as part of the fouling community on boat hulls or wafted on flotsam or detached seaweed by the California Current. Thus, as tiny polyps it may have remained undetected for years before conditions became favorable for the establishment of a sexual generation of medusae. Also, the introduction of polyps or medusae into the lagoon by humans is quite possible, although neither ontogenetic stage has been used as a laboratory animal in the U.C.S.B. Marine Laboratory. The lagoon protects it from the ravages of predation and tidal flushing, which may have precluded its colonization of local estuaries.

ACKNOWLEDGMENTS

We thank Dr. Vernon I. Cheadle, Chancellor of the Campus, for his interest and support of our lagoon studies, and Dr. Michael Neushul, algologist, for pertinent information concerning the lagoon plants.

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NEW SPECIES AND NEW RECORDS OF *EUSCHOENGASTIA* (ACARINA, TROMBICULIDAE) FROM WESTERN MEXICO

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Introduction

Investigations of the chiggers from mammals taken in the Mexican states of Baja California Norte, Sonora, Sinaloa and Durango, revealed seven species of *Euschoengastia.* Three of these species are new and are described below and the other four, *Euschoengastia californica, E. criceticola, E. otophila* and *E. radfordi*, are reported from Mexico for the first time.

This genus, as currently defined by Vercammen-Grandjean (1960), contains approximately 50 species. Most of the species occur in the Nearctic Region and *Euschoengastia barrerai* Hoffmann (1960) is the only species reported previously from Mexico. A closely related genus and species, *Anahuacia robertraubi* Hoffmann (1963), also has been described from larvae found on mammals from the vicinity of Mexico City, at the southern border of the Mexican plateau, in temperate habitats. Our seven species also were taken in the Nearctic Region, including the Sonoran Desert, the Oak-Chaparral and the Oak-Pine Plant Associations. The localities, hosts, dates and notes on habitats are included in the discussion of each species.

Acknowledgments

The numerous mammals and their chiggers have been assembled by many persons, and for their assistance we wish to extend special thanks to Dr. Elbert L. Sleeper, and several students, S. William Agnew, Richard M. Davis, Alan R. Hardy, Kenneth D. Peyton, Robert C. Stephens, and William J. Wrenn all of California State College at Long Beach. We are grateful for the permits to obtain mammals in Mexico issued by Sr. Dr. Rodolfo Hernández Corzo, el Director General, Dirección General de Caza, Departamento de Conservación de la Fauna Silvestre, Secretaría de Agricultura y Ganadería.

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ACCOUNTS OF THE SPECIES

The terminology used to describe the species usually follows that of Wharton, *et al.* (1951). All of the specimens listed below are larvae, mounted in PVA-LP, and studied by means of a phase-contrast microscope. All measurements are in microns, and each description is based on the holotype with differences among the paratypes noted in parentheses.

The slides listed below currently are in The Chigger Research Collection, California State College at Long Beach. The holotype and one paratype will be deposited in the Rocky Mountain Laboratory, Hamilton, Montana, and other paratypes will be distributed to: the United States National Museum; The University of Kansas; The Hooper Foundation, University of California Medical Center, San Francisco; the Los Angeles County Museum of Natural History; the Institute of Acarology, Ohio State University; Dr. Anita Hoffmann, Escuela Nacional de Ciencias Biológicas, México, D. F.; and to other appropriate institutions and individuals.

Genus *Euschoengastia* Ewing

The genus *Euschoengastia, sensu stricto*, of the subfamily Trombiculinae, has been redefined by Vercammen-Grandjean (1960), based on these larval charateristics: Seven branched setae on the palpal tarsus (subterminala present only in the subgenus *Brunehaldia* Vercammen-Grandjean, 1960); sensilla expanded; leg segments 7-7-7, leg III without mastisetae; cheliceral blade with distal tricuspid cap; 5 scutal setae; scutum not submerged under cuticular striae; legs terminating in two claws (without tenent hairs) and claw-like empodium.

Although several subgenera have been proposed (Vercammen-Grandjean, 1960), only the subgenus *Euschoengastia* is defined below.

Subgenus *Euschoengastia* Ewing

Type Species: *Schoengastia americana* Ewing (=*E. sciuricola* Ewing)

Included Species: Approximately 50 species, mostly in the Nearctic Region of North America.

Diagnosis: Larvae with characteristics of genus and without an enlarged plate around the base of any dorsal body seta; puncta frequently reduced or absent on leg segments and scutum; without prominent pits on dorsal surfaces of genu I, II and III; usually one branched seta on coxa III; galeal seta usually branched; palpal setae (except laterotibial) usually branched; palpal claw with 3 to 5 prongs; usually 2 genualae I.

Species described below share the following: AL setae shorter than PL setae; bases of PL's anterior to SB's; 2 genualae I; 1 genuala III; tibiala III absent; galeal seta branched; palpal femoral, genual, dorso- and ventrotibial setae branched; eyes 2/2, without ocular plate.

Remarks: Two subgenera, *Farrellia* and *Fascutella* proposed by Vercammen-Grandjean (1960) are included in the subgenus *Euschoengastia*. Additional studies of larval and postlarval stages may reveal that this subgenus should be divided into two or more subgenera.

Euschoengastia ampliseta, new species

Figure 1

Types: Total, 27 larvae: Holotype and 16 paratopotypes from one mi. W Buenos Aires, 8300 ft. (33 mi. W El Salto), Durango, host *Peromyscus melanotis*, field number WJW620706-7, collected 6 July 1962, by Wm. J. Wrenn, R. B. Loomis, R. E. Somerby and others; 10 paratopotypes from same host, 18 August 1963, taken by E. L. Sleeper.

Diagnosis: Member of criceticola group with 3-pronged papal claw; more than 100 enlarged, elongate, and plumose, (but not expanded or flattened) dorsal body setae; subterminala and parasubterminala I present; sensilla clavate, tip nude and pointed; body and leg setae with many pronounced setules. Closely related to *E. barrerai* Hoffmann, and *E. multisetosa* sp. n., but differs in having enlarged dorsal setae with setules distributed normally (rather than having different setule pattern on dorsal and ventral sides).

Description of Holotype: Body: Slightly engorged, length 321, width 198, ovoid to ellipsoid in shape, color in life, whitish to pale yellow; two pair of subequal nearly contiguous eyes, ocular plate lacking. Dorsal setae: 2-15-8-13-13-13-14-15-11-8-8-3 (range for first posthumeral row, 15-18). Approximately 123 dorsal setae ar-

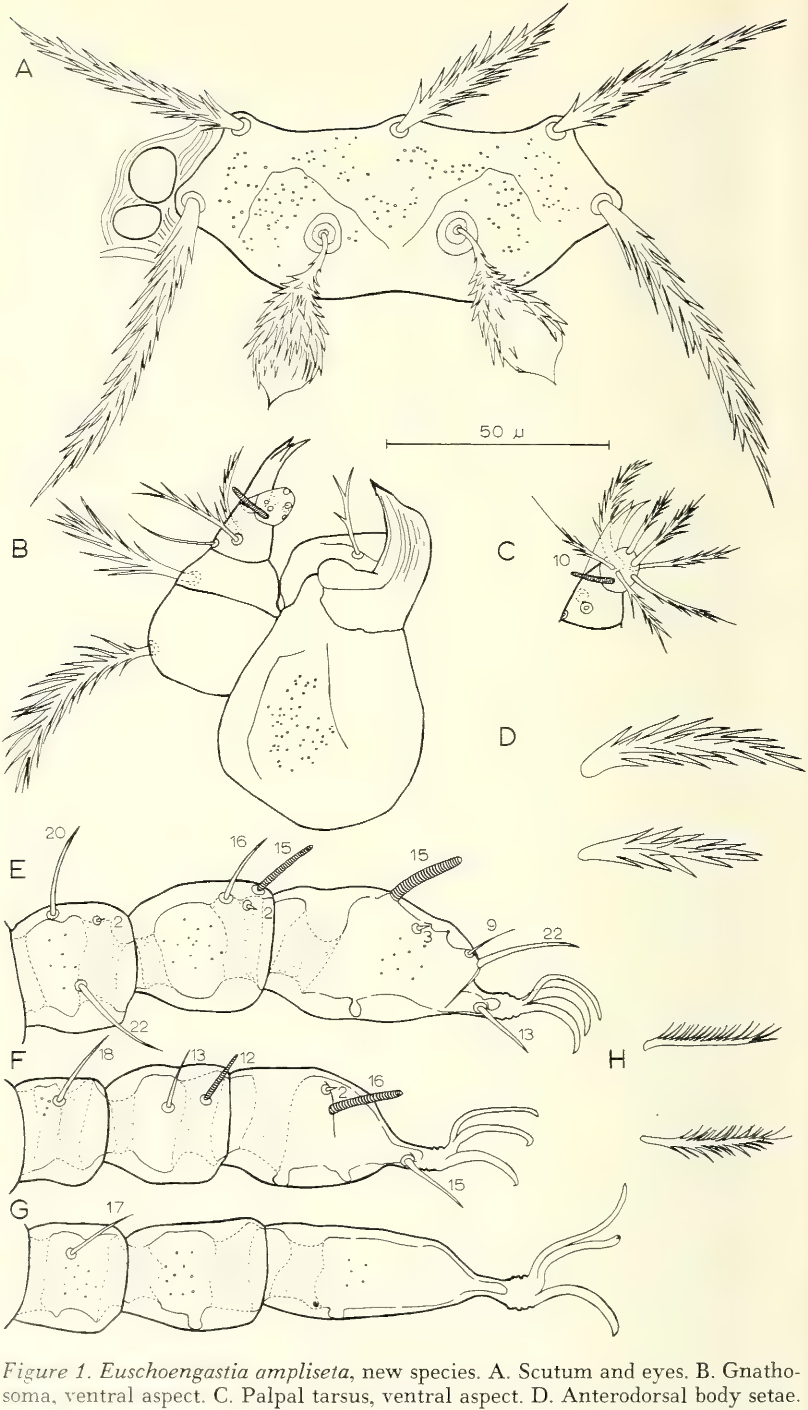

Figure 1. Euschoengastia ampliseta, new species. A. Scutum and eyes. B. Gnathosoma, ventral aspect. C. Palpal tarsus, ventral aspect. D. Anterodorsal body setae. E-G. Distal segments of legs I, II and III, respectively showing nude setae only. H. Leg setae from distal segments.

ranged irregularly. Length of dorsal setae (single measurements); humeral seta, 61; anterior dorsal seta, 42; posterior dorsal seta, 36. Sternal setae, 2-2, and approximately 86 ventral setae, 52 posterior to anus. Ventral setae shorter (30) than sternal setae, anterior 62, posterior 45.

Gnathosoma: Cheliceral base and palpal femur with conspicuous puncta. Palpal formula, B/B/BNB; tibial claw three-pronged.

Scutum: With many puncta, approximately 2.75 times wider than long; PL base anterior to SB's; cuticular fold partially surrounding SB's (see Fig. 1). Sensilla clavate ending distally in a sharp point, posterior surface with a medial bare area. Scutal setae strongly plumose with thickened setules. Scutal measurements of holotype (with mean, range, and number of specimens from type locality): AW, 69 (69, 65-75, 15), PW, 86 (87.7, 82-93, 15), SB, 29 (28.8, 25-32, 15), ASB, 27 (29.1, 24-32, 15), PSB, 13 (13.6, 12-17, 14), AP, 19 (17, 14-19, 15), AM, 46 (41.7, 38-46, 12), AL, 54 (48.7, 40-55, 15), PL, 75 (65.5, 59-75, 11), SL, 37 (35, 32-38, 5), SW, 16 (15.6, 14-16, 5).

Legs: Proximal segments (especially coxae) with more distinct puncta than distal segments. One kind of branched leg seta with thin abundant setules. Number of branched setae per segment typical of genus; tarsi of legs I, II, III with approximately 18, 14, 13 branched setae respectively. Leg index: I, 241; II, 233; III, 250; total, 724. Measurements of nude setae: Leg I; dorsal genuala 20 (18.8, 17-22, 12), posterior genuala 22(19.6, 18-22, 14), proximal tibiala 16 (16.1, 14-18, 15), distal tibiala 15 (15, 14-16, 15), tarsala 15 (16.7, 15-19, 15), parasubterminala 9 (10, 7-12, 14), subterminala 22 (21.9, 21-25, 15); leg II; genuala 18 (17.6, 16-20, 14), proximal tibiala 13 (13.3, 13-16, 15), and distal tibiala 12 (12.1, 11-14, 15), tarsala 16 (16.3, 15-19, 14); leg III; genuala 15 (14.7, 12-16, 15).

Ecological Notes: The two localities are along Mexican Highway 40 at 8300 to 8700 feet in Oak-Pine habitat, where a parklike stand of tall pines (*Pinus* ssp.) has a luxuriant understory of shrubs, mosses, and grasses. Mice and chipmunks were taken around rock outcroppings and in piles of rotting cut timber. Baker and Greer (1962) discuss the general area and the mammals.

Specimens Examined: Total, 59 larvae: DURANGO: 1 mi. W Buenos Aires, (33 mi. W El Salto), *Peromyscus melanotis*, 6 July 1962 (25), and 18 Aug. 1963 (2), and *Peromyscus boylii*, 6 July 1962 (7); 1 mi. W El Salto, *Peromyscus melanotis*, 19-20 Aug. 1963 (24).

Euschoengastia barrerai Hoffmann: MEXICO: Popocatepetl, 250 m W Paso de Cortez, *Peromyscus maniculatus*, 26 Dec. 1959 (1 paratopotype).

Euschoengastia multisetosa, new species
Figure 2

Types: Total, 33 larvae: Holotype and 32 paratopotypes from 9 mi. S El Rayo, 5400 ft., Baja California Norte, Mexico. Holotype and 27 paratypes from *Peromyscus truei*, field number WJW621231-6, collected 28 December 1962, by E. L. Sleeper. Additional 5 paratopotypes, with same host and date.

Diagnosis: Member of criceticola group, and closely related to *E. ampliseta*, sp. n., *E. barrerai*, *E. criceticola* and *E. obesa*, in having 3-pronged papal claw, 126 dorsal body setae with both long and short setules, not heavily branched (60 or less in *E. criceticola* and *E. obesa*), without puncta on leg segments and scutum (punctate in *E. ampliseta* and *E. barrerai*), palpal laterotibial seta forked or branched (nude in *E. ampliseta* and *E. barrerai*).

Description of Holotype: Body: Slightly engorged, length 248, width 166, ovoid to ellipsoid, color in life, whitish to yellowish; two pairs of nearly contiguous eyes; ocular plate lacking. Dorsal setae: 2-15-8-8-18-11-17-9-15-5-9-3-6. Dorsal setae irregular, total about 126; first posthumeral row typically with 15 or 16 setae; humeral seta, 45; anterior dorsal seta, 42; posterior dorsal seta, 31; succeeding rows of dorsal setae similar to humerals, but shorter posteriorly. Anterior sternal seta, 43; posterior sternal seta, 31; ventral setae short, 24. Approximately 80 ventral setae; 42 of them posterior to anus, resembling dorsal setae.

Gnathosoma: Cheliceral base and palpal femur lacking puncta. Palpal formula B/B/BBB; palpal laterotibial seta forked or branched; tibial claw with three prongs.

Scutum: With few light, medial puncta; approximately 2.5 times wider than long; PL bases anterior to SB's; prominent cuticular fold partially surrounding SB's. Sensilla clavate with distal, medial bare area. Scutal measurements of holotype (and mean, range, and number of specimens from type locality): AW, 55 (58.7, 53-73, 7), PW, 72 (74.6, 42-82, 8), SB, 26 (28.5, 26-32, 8), ASB, 25 (22.4, 20-26, 9), PSB, 13 (13.7, 13-15, 9), AP, 13 (15.8, 13-19, 9), AM, 34 (31, 27-34, 5), AL, 33 (30.7, 29-35, 7), PL, 49 (48.6, 43-53, 9), SL, 31 (32, 2), SW, 16 (16, 16-17, 3).

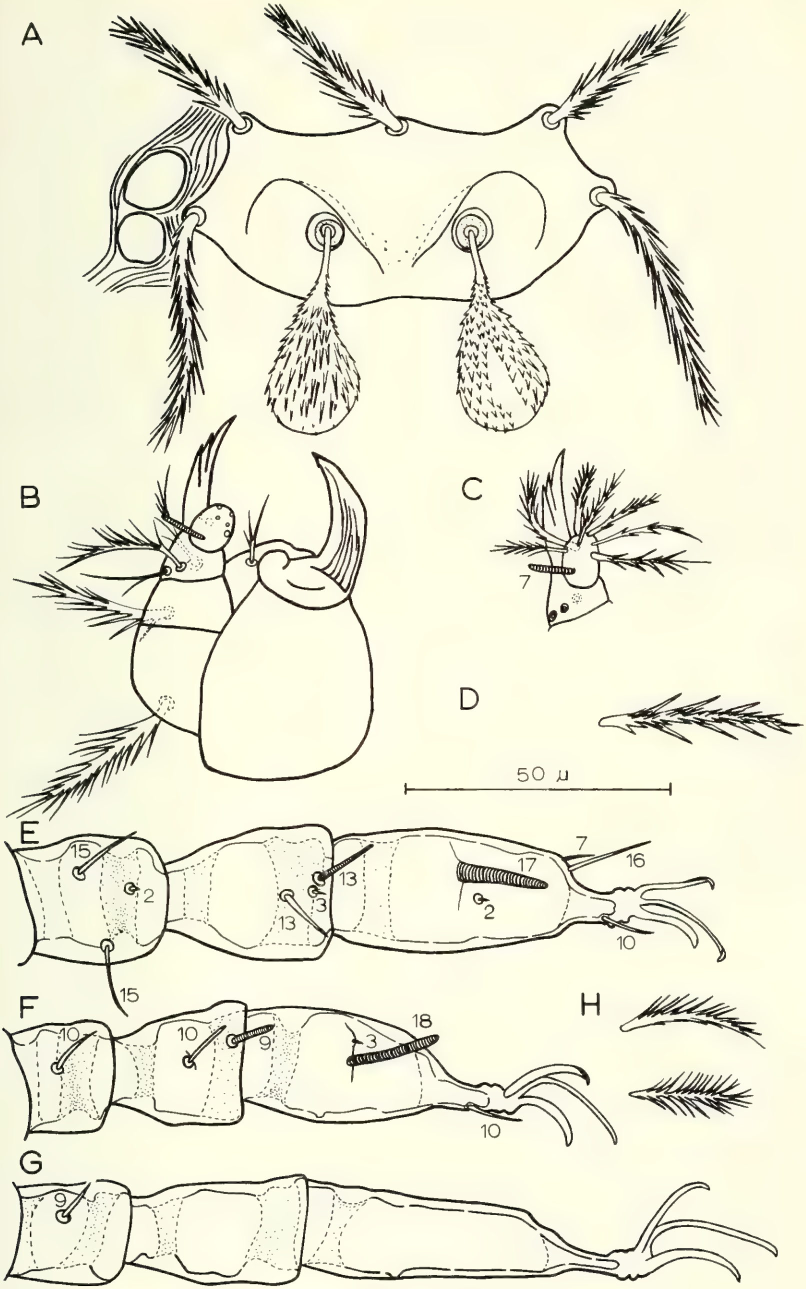

Figure 2. Euschoengastia multisetosa, new species. A. Scutum and eyes. B. Gnathosoma, ventral aspect. C. Palpal tarsus, ventral aspect. D. Anterodorsal body seta showing short thin dorsal setules and long thick ventral setules. E-G. Distal segments of legs I, II and III respectively showing nude setae only. H. Leg setae from distal segments.

Legs: Segments apparently without puncta; plumose leg setae of one kind; tarsi of legs I, II, III with approximately 22, 14, 15 branched setae respectively. Leg index: I, 213; II, 195; III, 235; total 643. Measurements of nude setae: Leg I; dorsal genuala 15 (13.9, 13-15, 8), posterior genuala 15 (14.7, 13-16, 9), proximal tibiala 13 (13.1, 12-15, 9), distal tibiala 13 (12.9, 12-14, 9), tarsala 17 (17.4, 17-18, 8), parasubterminala 7 (6.4, 6-7, 8), and subterminala 16 (16, 15-17, 9); leg II; genuala 10 (10.2, 9-11, 8), proximal tibiala 10 (9.3, 8-10, 9), distal tibiala 9 (9.1, 8-10, 9), tarsala 18 (18.3, 18-19, 9); leg III; genuala 9 (8.9, 7-10, 8).

Taxonomic Remarks: Two other species *E. ampliseta* and *E. barrerai* from Mexico have approximately 100 or more dorsal body setae. The species *E. multisetosa* is probably most closely related to *E. barrerai*, but is separated on the basis of a clavate sensilla covered with setules (except for the median bare area), leg segments not discernibly punctate, laterotibial seta forked or branched, and approximately 126 dorsal body setae. *E. barrerai* has a pyriform sensilla with the posterior distal surface nude, leg segments punctate, laterotibial seta nude, and approximately 90 to 100 dorsal setae.

Ecological Notes: The type locality is located 115° 58′ W longitude and 32° 09′ N latitude at an elevation of 5400 feet in the Sierra Juarez. Some of the plants in the area reported by Dr. Sleeper were Scrub Oak (*Quercus dumosa*), Englemann Oak (*Quercus englemannii*), Jeffrey Pine (*Pinus jeffreyi*), Willow (*Salix* sp.), Rattle Weed (*Chrysothamnus* sp.), and Elderberry (*Sambucus* sp.). The other localities possessed similar vegetation, and additional plants not mentioned for the type locality were: Canyon Oak (*Quercus chrysolepis*), Pinyon Pine (*Pinus* sp.), Manzanita (*Arctostaphylos* sp.), Yerba Santa (*Eriodictyon* sp.), and Yarrow(*Achillea* sp.).

Hosts: Fourteen mice had larvae of *E. multisetosa* attached to the edges of the ears. Eight of these mice possessed only this species whereas the other six mice also were parasitized by *Euschoengastia californica* and *E. criceticola*.

Specimens Examined: Total, 65 larvae; BAJA CALIFORNIA NORTE: 9 mi. S El Rayo, *Peromyscus truei*, 28 Dec. 1962 (39); 4 mi. S El Topo, 9 Dec. 1962, *Perognathus californicus* (9), *Peromyscus truei* (4); La Rumorosa, 2 Dec. 1963, *Perognathus fallax* (1), *Peromyscus* sp. (6), *Peromyscus eremicus* (2), and *Peromyscus maniculatus* (4).

Euschoengastia stephensi, new species
Figure 3

Types: Total, 12 larvae: Holotype and 11 paratypes from 9 mi. NW Guaymas, Sonora, Mexico, host *Onychomys torridus*, field number RBL600706-8, taken 6 July 1960, by R. B. Loomis and Robert C. Stephens.

Diagnosis: Closely related to *Euschoengastia enemi* Brennan and Jones, 1954, in having 4 prongs on palpal claw, lacking subterminala and parasubterminala I, and sensilla elongate clavate, with large setules on stem; but differing in the shape of scutum, (PL's not so far anterior in *E. stephensi*) and in having genualae I, II, and III short, 3-5, (longer in *E. enemi*) and in position of genualae and microgenuala I (dorsal genuala proximal to microgenuala in *E. stephensi*, dorsal to microgenuala in *E. enemi*).

Description of Holotype: Body: Engorged, length 567, width 395, shape ovoid, color in life, yellow; eyes 2/2, anterior distinct, posterior indistinct, ocular plate absent. Dorsal setae: 2-12-10-2-7-5-2, total approximately 40. Number of setae in first and second posthumeral rows usually 12 and 10 respectively (of 17 larvae; first posthumeral row, 12% with 10, 12% with 11, 65% with 12, 5% with 13, 5% with 14; second posthumeral row, 13% with 9, 67% with 10, 7% with 11, 13% with 12). Length of dorsal setae (mostly single measurements); humeral setae 39 (of 22 specimens; mean 38.5, SE 0.42, range 35-43), anterior dorsal seta, 40; posterior dorsal seta, 33. Dorsal setae shorter posteriorly. Anterior sternal seta, 35; posterior, 24 and approximately 24 ventral setae. Ventral setae posterior to anus resembling dorsal setae.

Gnathosoma: Cheliceral base and palpal femur lacking discernible. Palpal formula; B/B/BFB; tibial claw with 4 prongs.

Scutum: Without discernible puncta; approximately two times wider than long; PL base well anterior to SB's; prominent, J-shaped, cuticular fold partially surrounding SB's. Sensilla clavate, with posterior distal surface having median bare area. Scutal setae moderately plumose. Scutal measurements of holotype (followed by mean, ± standard error, range, and number of specimens from type locality and southern California): AW, 43 (46.1, ±0.59, 42-53, 23), PW, 59 (64.9, ±0.8, 59-72, 24), SB, 26 (28.7, ±0.65, 25-36, 25), ASB, 19 (18, ±0.26, 16-21, 23), PSB, 9 (10.9, ±0.27, 8-13, 18), AP, 10 (10.4, ±0.24, 9-14, 23), AM, 27 (24.4, ±0.36, 21-27,

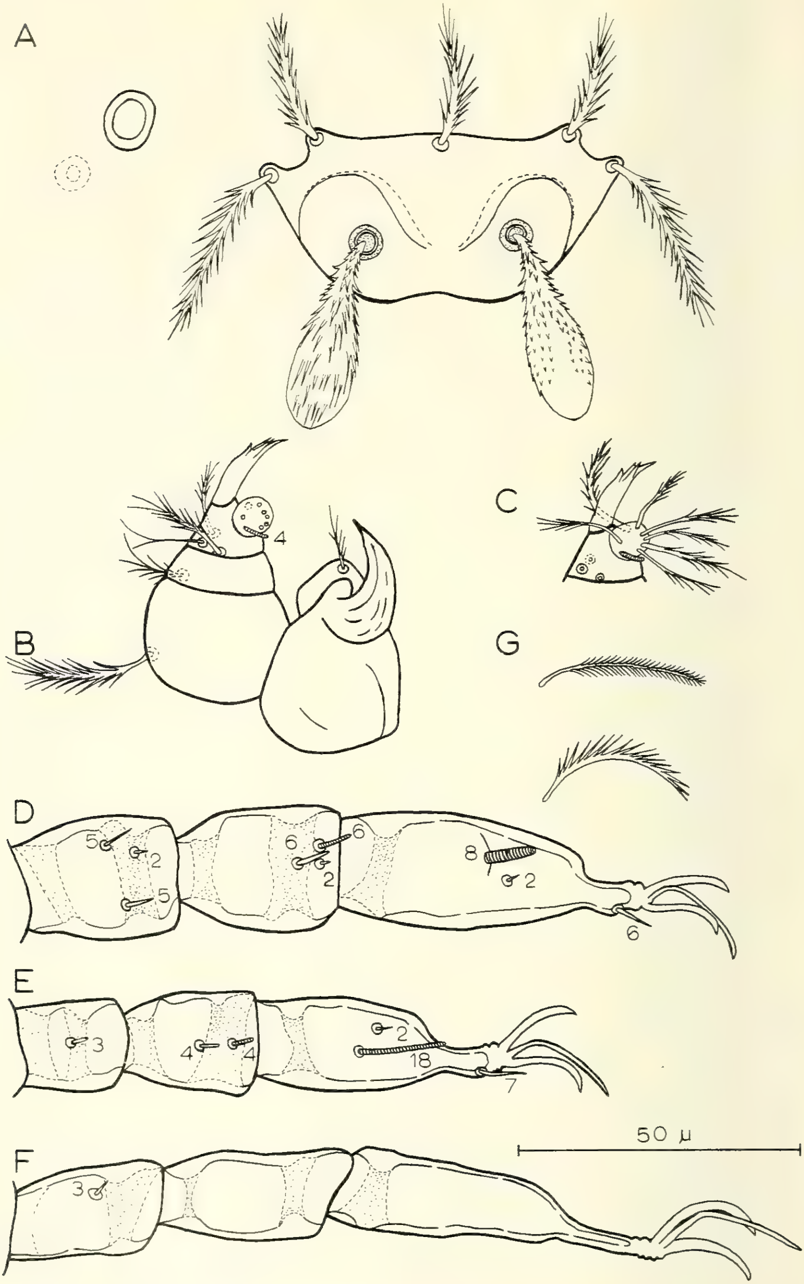

Figure 3. Euschoengastia stephensi, new species. A. Scutum and eyes. B. Gnathosoma, ventral aspect. C. Palpal tarsus, ventral aspect. D-F. Distal segments of legs I, II and III, respectively showing nude setae only. G. Two kinds of leg setae from distal segments.

32), AL, 25 (26, ±0.47, 21-32, 24), PL, 35 (36.6, ±0.39, 34-40, 24), SL, 33 (36.4, ±0.4, 34-39, 17), SW, 11(11.8, ±0.42, 11-12, 18).

Legs: Segments lacking puncta; two kinds of branched setae, one with many short, fine setules, the other with few, long, thick setules; tarsi of legs I, II, III with approximately 22, 16, 14 branched setae respectively. Leg index; I, 196; II, 188; III, 211; total 595. Measurements of nude setae: Leg I; dorsal genuala 5 (5.4, ±0.1, 5-6, 23), posterior genuala 5 (5.4 ±0.1, 5-6, 3), proximal tibiala 6 (5.9, ±0.13, 5-7, 22), distal tibiala 6 (5.4 ±0.12, 5-7, 24), and tarsala 8 (9.1, ±0.27, 7-12, 25); leg II, genuala 3 (3.3, ±0.14, 3-5, 16), proximal tibiala 4 (3.7, ±0.13, 3-5, 23), distal tibiala 4 (4.3, ±0.12, 3-5, 21) and tarsala 18 (18.3, ±0.12, 17-19, 21); leg III, genuala 3 (3.2, ±0.49, 3-4, 9).

Taxonomic Remarks: This species is most closely related to *E. enemi* and may be a subspecies. The larvae are similar to *E. enemi* in lacking puncta on the scutum, having four palpal claws, one distinct pairs of eyes, the same two kinds of leg setae, and lacking parasubterminala and subterminala I.

Geographic Distribution: Larvae have been taken in the southern desert area of California (Los Angeles and Riverside counties) and the Sonoran Desert of Mexico (Sonora).

Seasonal Occurrence: This species, taken in the spring and summer (April, June through September) when the weather is hot, differs from other desert inhabiting *Euschoengastia*, which have the greatest larval abundance during the cooler periods.

Hosts: Larvae have been recovered from the flat surface of the pinna and medial surface of the thigh of *Perognathus longimembris* and *Onychomys torridus*.

Specimens Examined: Total, 31 larvae: U.S.A., CALIFORNIA: *LOS ANGELES CO.*: 7 mi. W Pearblossom, *Perognathus longimembris*, 30 July 1962 (2). *RIVERSIDE CO.*: Joshua Tree National Monument: Squaw Tank, 3600 ft., *Perognathus longimembris*, 24 June 1960 (12); Lower Covington Flat Camp, 4700 ft., *Perognathus longimembris*, 2 April 1960 (2), 6 Sept. 1960 (2), and 9 Aug. 1960 (1). MEXICO, SONORA: 9 mi. NW Guaymas, *Onychomys torridus*, 6 July 1960 (12, type series).

Derivation of Name: Named for Mr. Robert C. Stephens of El Camino College, California, in appreciation for his help in the assembly of many vertebrate hosts and their chiggers from the United States and Mexico.

Euschoengastia californica (Ewing)

Geographic Distribution: The localities in Baja California extend the range of this species approximately 150 miles southward from the Santa Ana Mountains to southern California (Loomis and Bunnell, 1963:182).

Taxonomic Remarks: There was little difference noted between the larvae from Mexico and those from California. This species closely resembles the species of the peromysci group and probably is a western member which lacks tibiala III.

Specimens Examined: Total, 71 larvae: BAJA CALIFORNIA NORTE: 9 mi. S El Rayo, 5400 ft., *Peromyscus truei*, 28 Dec. 1962 (55); 4 mi. S El Topo, 28 Dec. 1962, *Perognathus californicus* (1), *Peromyscus truei* (9), and *Dipodomys agilis* (5); La Rumorosa, 4370 ft., *Peromyscus eremicus*, 2 Dec. 1963 (1).

Euschoengastia criceticola Brennan

Geographic Distribution: This species is widespread throughout western United States. However, the larvae from Durango represent a range extension of more than 800 miles to the south, and along with those from Baja California and Sonora are the first records from Mexico.

Hosts: The larvae usually attach to the inner and occasionally outer surfaces of the ears of cricetid rodents.

Taxonomic Remarks: There is a north-south clinal variation in some characters, such as the increase in lengths of the tibialae I (4-5 microns longer), genualae I, and PL's (7 microns longer).

Specimens Examined: Total, 75 larvae: BAJA CALIFORNIA NORTE: 9 mi. S El Rayo, 5400 ft., *Peromyscus truei*, 28 Dec. 1962 (9); 4 mi. S El Topo, 5500 ft., 28 Dec. 1962, *Dipodomys agilis* (3), *Neotoma fuscipes* (1), *Neotoma lepida* (6), *Perognathus californicus* (3), *Peromyscus truei* (3); La Rumorosa, 4370 ft., 29 Nov. 1963, *Perognathus fallax* (3), *Peromyscus eremicus* (6), and *Peromyscus maniculatus* (2); 8 mi. W, 7 mi. S La Rumorosa, *Dipodomys agilis*, 29 Dec. 1962 (21); Sierra San Pedro Mártir, El Socorro, 4000 ft., (=10 mi. E Jose del Castillo, *Dipodomys agilis*, 25 June 1963 (1); 14.3 mi. W Santo Tomas, *Peromyscus californicus*, 24 Feb. 1958 (8). SONORA: 8 mi. SSE Alamos, Rio Cuchujaqui, *Peromyscus eremicus*, 4 Dec. 1964 (1). DURANGO: 1 mi. W Buenos Aires, 8300 ft., (=33 mi. W El Salto), *Peromyscus melanotis*, 6 July 1962 (8).

Euschoengastia otophila Loomis and Bunnell

Geographic Distribution: This species originally was described from larvae taken in the Santa Ana Mountains of southern California. These new records from Baja California, Durango, Sinaloa, and Sonora include a range extension of nearly 800 miles to the southeast.

Taxonomic Remarks: These larvae from Mexico identified as *E. otophila* may represent a separate subspecies. Additional studies are underway to determine the correct allocation.

Specimens Examined: Total, 39 larvae: BAJA CALIFORNIA NORTE: 9 mi. S El Rayo, *Peromyscus truei*, 28 Dec. 1962 (1). DURANGO: 1 mi. W Buenos Aires (=33 mi. W El Salto), *Eutamias bulleri*, 6 July 1962 (32). SINALOA: 1.2 mi. NE Santa Lucia, 3800 ft., 9 Dec. 1964, *Peromyscus boylii* (6). SONORA: 7 mi. S, 2 mi. W Naco, 5700 ft., 8 July 1965, *Peromyscus boylii* (1).

Euschoengastia radfordi Brennan and Jones

Geographical Distribution: This species is known from numerous localities in California and other western states, but has not been reported previously from Mexico. The locality in Durango extends the range approximately 800 miles to the southeast.

Ecology: In Sonora, larvae were found on the belly of a kangaroo rat, *Dipodomys merriami*, taken in the Sonoran Desert. The sparse vegetation growing in the gravelly substrate included creosote bushes, ironwood, brittle bush, ocotillo, and saguaro cactus. The Durango locality is in Oak-Pine Woodland, and is discussed under *E. ampliseta*.

Specimens Examined: Total, 53 larvae: BAJA CALIFORNIA NORTE: La Rumorosa, 4370 ft., *Dipodomys agilis*, 2 Dec. 1963 (1); 8 mi. W, 7 mi. S La Rumorosa, *Dipodomys agilis*, 31 Dec. 1962 (32). DURANGO: 1 mi. W Buenos Aires, 8300 ft., (=33 mi. W El Salto), *Peromyscus boylii*, 6 July 1962 (10). SONORA: 52 mi. SE San Luis, 700 ft., *Dipodomys merriami*, 30 Nov. 1964 (10).

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CERIOCAVA EASTONI, SP. NOV., THE FIRST DESCRIBED SPECIES OF BRYOZOA FROM THE CRETACEOUS OF CALIFORNIA

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Contained herein is the description of a new species of cyclostome bryozoa belonging to the genus *Ceriocava* d'Orbigny, 1849. The material, consisting of a boulder about 25 cm. in diameter containing many zoarial fragments, was collected by Dr. William H. Easton, Department of Geology, University of Southern California, in 1959. This fossiliferous rock was collected 0.50 mile east of Santiago Canyon Road on the private Williams Canyon Road, Santa Ana Mountains, California. The boulder was found loose on the ground among oak trees about fifty feet west of a fence line crossing the road and thirty feet below beds of fossiliferous sandstone and conglomerate north of the road. Owing to the slope of the hillside, the loose boulder seems to have come from the zone of fossiliferous strata. These strata contain abundant specimens of *Turritella chicoensis* Gabb, 1864, and *Glycymeris veatchii* (Gabb), 1864, and comprise a lens in the Holz Shale Member of the Ladd Formation of Late Cretaceous age (Chico Epoch). The stratigraphy and paleontology for the area have been discussed by Popenoe (1937, 1960).

The specimens were made available to the writer in 1965 by Dr. Easton. On return to the collecting locality in April, 1966 no further material was found, either loose or on the outcrop.

Order CYCLOSTOMATA Busk, 1852
Suborder CERIPORINA Hagenow, 1851
Family CAVIDAE d' Orbigny, 1854
Genus *CERIOCAVA* d'Orbigny, 1849

Generic Description: "Ramose solid stems; long zoecial tubes with diaphragms in the cylindrical part and vesicular walls in the outer, wider portion. Ovicell a transverse smooth vesicle." (Bassler, 1953: G70).

Genotype: *Ceriocava* (*Millepora*) *corymbosa* Lamouroux, 1821.

Ceriocava eastoni, new species

Figure 1

Syntypes: Los Angeles County Museum of Natural History no. 1148; consisting of the three slides, tangential, transverse, and longitudinal sections, used in Figure 1.

Topotypes: Portions of the original boulder containing many zoarial fragments are deposited in the following;

Los Angeles County Museum of Natural History no. 1149
United States National Museum no. 155207
Department of Geology, University of Southern California no. 5896

Description: *Ceriocava eastoni* forms ramose colonies with cylindrical branches 3.0 mm. to 4.0 mm. in diameter. No basal portions with intact zoaria were found in the specimens examined. Longitudinal and transverse sections (Figs. 1A and C) show that the branches are divided into two parts. The outer portions are composed of densely packed autozoids which are evenly distributed over the zoarial surface (Fig. 1B). Apertures are polygonal in shape, ranging in diameter from 0.17 mm. to 0.26 mm. The inner portions are composed of straight cylindrical zoecia 0.14 mm. to 0.31 mm. in diameter with diaphragms distributed 0.6 mm. to 1.0 mm. apart over some sections but entirely wanting from others. The walls of these inner zoecia are non-porous. Peripheral zoecia start from the inner zoecia and rapidly expand up to the apertural diameter. The outer zoecia arise abruptly at right angles to the longitudinal axes of the central zoecia. Vesiculation of the outer zoecial walls starts as crenulations near the proximal end of the zoecia and progresses in strength towards the distal end but never developing more than moderately. Horizontal striations in the outer zoecia occasionally appear but are never abundant.

No ovicells were found.

Discussion: *Ceriocava eastoni* differs from other species of the genus in having a slight amount of horizontal striation in the outer zoecia and only moderate development of vesiculation in the outer zoecial walls. It is unfortunate that the specimens examined lacked ovicells because knowledge of their character would enable a more nearly complete description of the species.

Cretaceous bryozoa have been described from the western interior of the United States (Toots and Cutler, 1962) but none has been

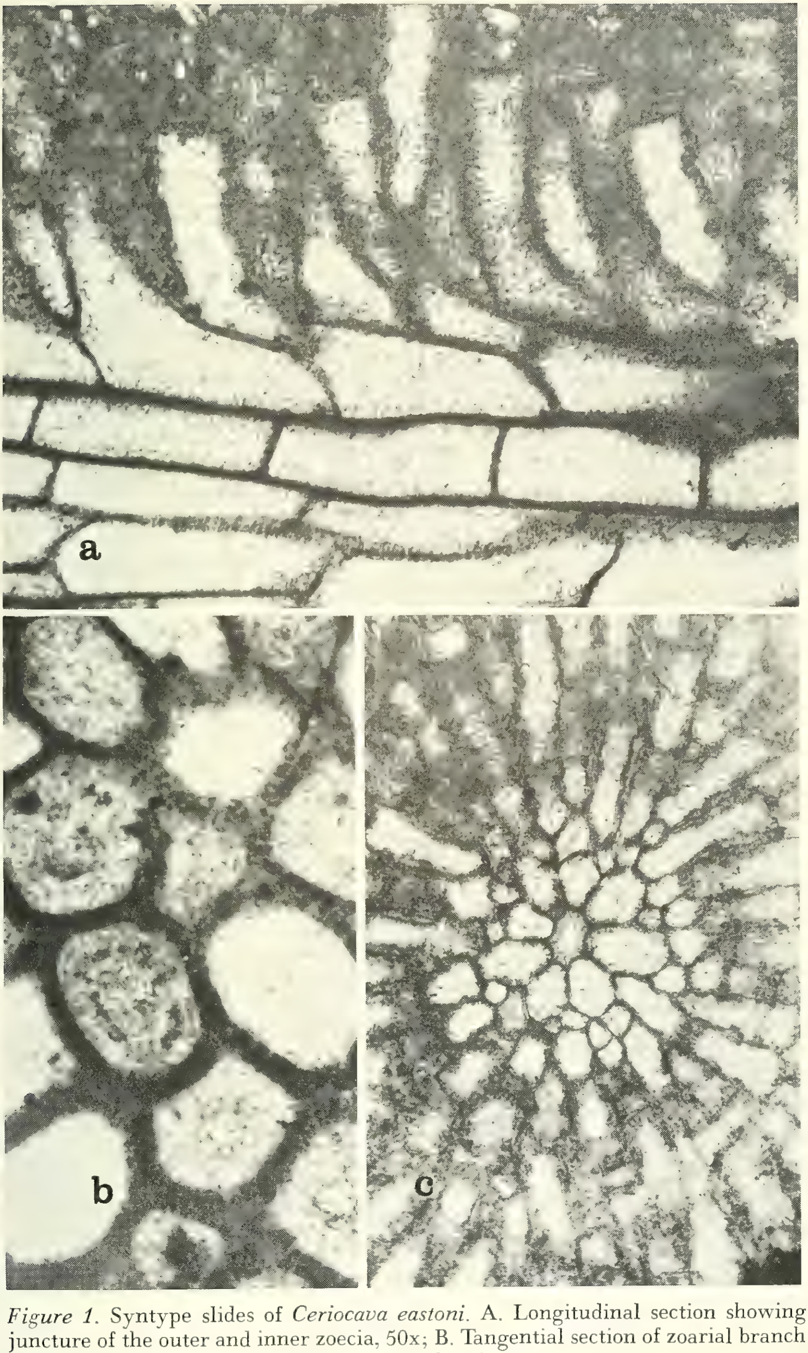

Figure 1. Syntype slides of *Ceriocava eastoni.* A. Longitudinal section showing juncture of the outer and inner zoecia, 50x; B. Tangential section of zoarial branch 145x; C. Transverse section of zoarial branch, 35x.

described from California (W. P. Popenoe, *pers. communication*, April 15, 1966; W. A. Cobban, *pers. communication*, April 18, 1966). E. C. Allison (1955:408) reported *Reptomulticava* sp. from the Middle Cretaceous of Punta China, Baja California, Mexico but did not describe the material. *Ceriocava eastoni* is then the first species of bryozoan to be described from the Cretaceous of California.

Remarks: It gives me great pleasure to name *Ceriocava eastoni* in honor of Professor William H. Easton. He collected all known material of this species and first recognized its possible significance. Dr. Easton first introduced me to the fascinating world of paleontology.

ACKNOWLEDGMENTS

I am grateful to E. C. Allison, W. A. Cobban, and W. P. Popenoe for their correspondence concerning the distribution of Cretaceous bryozoa in the western United States. I would like to thank the following people at the Department of Biological Sciences, University of Southern California: Drs. Russel L. Zimmer and Robert F. Bils for the photography and technical assistance with Figure 1; Messrs. William C. Banta, John S. Bullivant, Roger R. Seapy, and Dr. Zimmer for reviewing portions of the manuscript.

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THE MICROCOMPOSITION OF SOME FOSSIL INSECTS OF MIOCENE AGE

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The petroliferous nodules of Miocene age found in ancient fresh water lake beds in the Calico Mountains of San Bernardino County, California, are extraordinarily rich in well preserved fossilized insects. These fossils have been studied in detail and classified with great care by Palmer (1957) and in a continuing series of studies by Pierce (1959). In our laboratory we have been employing several physical techniques, notably electron microscopy, electron probe analysis and micro-radiography, to determine the microstructure and composition of a wide variety of fossil teeth and bones. Because of the excellence of their preservation and the amount of structural detail visible in these fossil insects as seen under the optical microscope, we have been making a preliminary study of them to see if the techniques we are using can help materially in the investigation of this different type of fossil.

Experimental

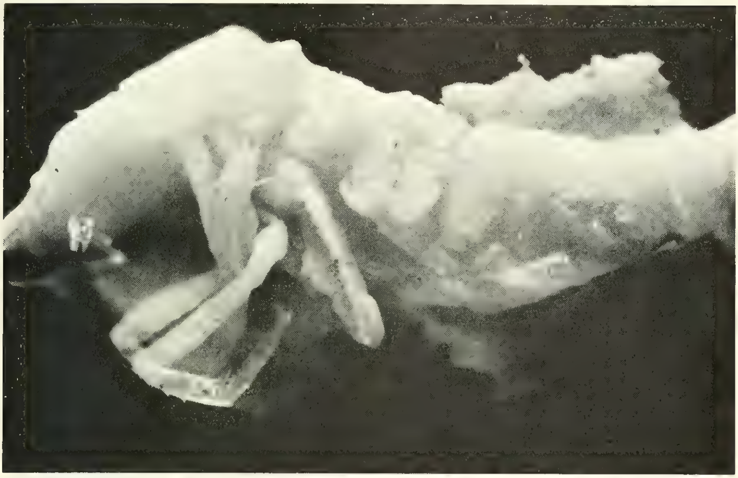
The nodules examined, about fifty in number, have been made available through the courtesy of Dr. W. Dwight Pierce of the Los Angeles County Museum of Natural History. As he and Palmer (1957) have reported, these nodules are predominantly calcareous and disintegrate readily in weak acid to liberate the fossils disseminated throughout them. Since it has not been our purpose at this time to make an extensive study of these fossils, no special effort was made to determine the exact positions within the source area of the nodules used, or to identify the fossils examined. Nevertheless the insect most frequently found by other investigators has been *Schistomerus californense* Palmer (1957:259), and most of our observations have been made on examples of this species. The different insects that have been found, as well as the general nature of the nodules themselves and the source areas, have been fully described by Palmer (1957) and by Pierce (1961, 1962).

Each nodule was placed in a flask containing 5% formic acid and this acid was changed daily until disintegration was complete. The time required depended on its size but could be as much as four days. The insoluble residue was washed repeatedly with distilled water, dried and the fossils it contained removed under a dissecting microscope using a camel hair brush. Fossil remains varied from minute fragments of less than a millimeter up to complete specimens 4 to 5 mm. in maximum dimension. Each insect fossil chosen for further study was washed again with water to remove salts and other soluble material. The foregoing procedure, with minor modifications, is that employed by Pierce.

Optical Microscopy and Microradiography: We invariably began our investigation with a careful optical microscopic examination, partly for the sake of the information it gives concerning details that merit study by other techniques and partly because these techniques frequently require special treatment of the specimen. Promising, well preserved fossils have been photographed under reflected light with a Zeiss Universal microscope using Eastman Panatomic-X film. The type of micrograph obtained in this way is shown in Figure 1.

Because of the large amount of internal detail visible in many of these fossil insects, it has been found rewarding to make microradiographs of the intact insects for comparison with their optical micrographs. The opacity and relatively large size of many of the specimens makes it necessary to use moderately hard X-rays. In our work they were provided by a Philips FA-60 tungsten target tube operated at 40 Kv and 25 mA from a standard high voltage supply. In order to obtain the small effective source needed to give the desired resolution, the tube window was closed with a lead cover pierced with a one-mm. hole. The combined specimen and film holder was located four feet from the tube. For microradiography the fossil was placed in direct contact with a photographic plate coated with Eastman type 648 ultrafine-grained emulsion. Because of the insensitivity of this emulsion, long exposures of four to eight hours were needed but, as Figure 2 indicates, much internal detail can be visualized through its use. As in all contact microradiography, the image has the size of the object; the detail it contains is seen by examining and photographing the original negative under an optical microscope.

Electron Probe Analysis: The electron probe is an instrument for making an X-ray spectroscopic analysis of minute volumes of a sample. In it a concentrated beam of electrons bombards the area in question and excites the X-rays characteristic of the chemical ele-



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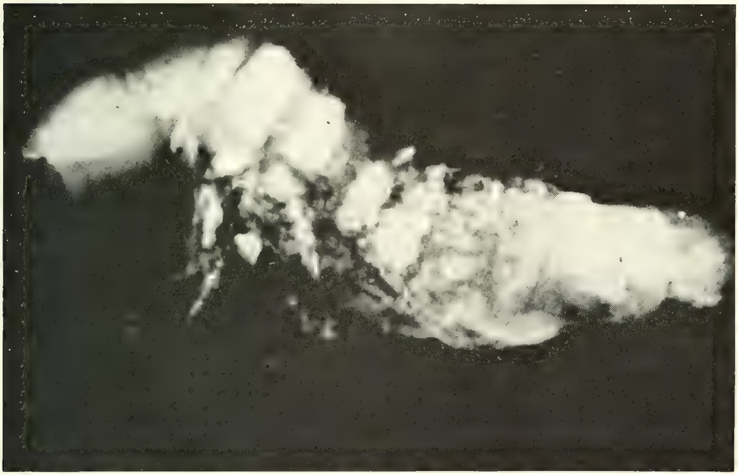

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Figure 1. A photomicrograph of a fossilized insect obtained from a petroliferous nodule of Miocene age. X70.

Figure 2. A microradiograph of the insect of Figure 1 showing details of internal structure. X70.

ments that are present; these are measured with an X-ray spectrometer. When one is interested in the distribution of a particular element of a specimen, the spectrometer can be set for the element and the electron beam swept over the chosen area. The output of

X-rays from the spectrometer is recorded on an oscilloscope synchronized with the movement of the electron beam. There thus appears on the screen of the oscilloscope a picture of the distribution of the chosen element. Both methods of observation have been applied to individual fossil insects. When examining specimens that are electrically nonconducting, they must first be coated with a layer of conducting aluminum or carbon to dissipate the charge that would otherwise be built up by absorbed electrons. After being microradiographed, our specimens have accordingly been vacuum coated with carbon to prepare them for probe examination.

X-Ray Diffraction: The probe will show the principal chemical elements present in a fossil and usually the fossilizing mineral can be deduced from this information. If the insect is small enough or if a larger one is powdered, the mineral can also be identified by X-ray powder diffraction. We have done this by mounting the specimen in a standard 57.3 mm. powder camera and exposing to copper Kα radiation for a period which varied between 15 and 90 minutes.

Results and Discussion

Since it has been the primary objective of our work thus far to ascertain the kind of useful information about fossil insects to be obtained by the techniques discussed above, typical examples only of their application will be given here. It is proposed later, when many more nodules have been studied, to present the generalizations they make possible.

Figures 1 and 2 illustrate the different kinds of information to be gained through the optical microscopy and microradiography of a single specimen. Very clearly the optical examination shows much more of the surface detail, especially of the small appendages, but it is equally obvious that microradiographs can show many details of internal structure difficult to see with light, even when the specimen is immersed in a liquid of suitable refractive index. This is particularly important in the study of these fossil insects because, as Dr. Pierce has shown, one sees within them much detail suggesting the preservation of internal organs. The exposure time for Figure 2 was chosen to bring out some of the detail in the thicker parts of the insect without losing entirely a view of the more transparent parts; with a series of exposures including ones both longer and shorter than this, still more internal structure is revealed. A similar microradiograph of another insect in which the true state of preservation of its body is more apparent is given in Figure 3.

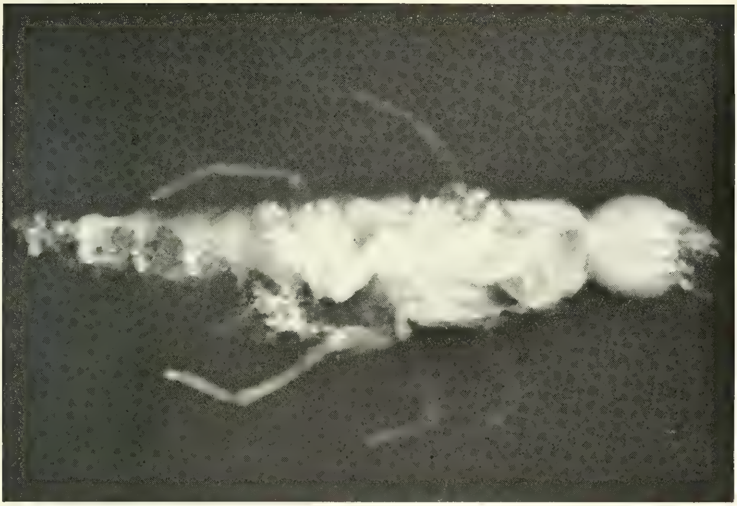

Figure 3. Microradiograph of a fossil insect different from Figures 1 and 2, showing internal structure in both body segments and head. X70.

When the insect of Figures 1 and 2 was examined under the probe, the principal elements found were strontium and sulfur together with small amounts of silicon. As can be seen from Figure 4, which is a scan of a portion of this fossil, strontium and sulfur occur together. A scan of the same area for silicon showed it concentrated in regions devoid of these two elements. By setting the electron beam on regions rich in sulfur and measuring the ratio of sulfur to strontium and then comparing this ratio with that found for pure $SrSO_4$, it can be concluded that this particular fossil consists primarily of celestite with small amounts of silica. This conclusion was verified by powdering the insect and analyzing its X-ray diffraction pattern (Fig. 5). This pattern is, in fact, one of practically pure celestite. Nearly all the fossil specimens we have isolated and examined have proved to be either of celestite or of quartz, or occasionally of a mixture of these two minerals. The only other constituent found in appreciable amounts has been gypsum, though no insect has consisted predominantly of the latter.

By making X-ray diffraction patterns using the intact fossil, one can gain an idea of the size of the crystals that have formed as replacements for the original organic matter. Most of these patterns have contained many spots indicative of crystals of relatively large size. Usually these spots have been distributed rather haphazardly

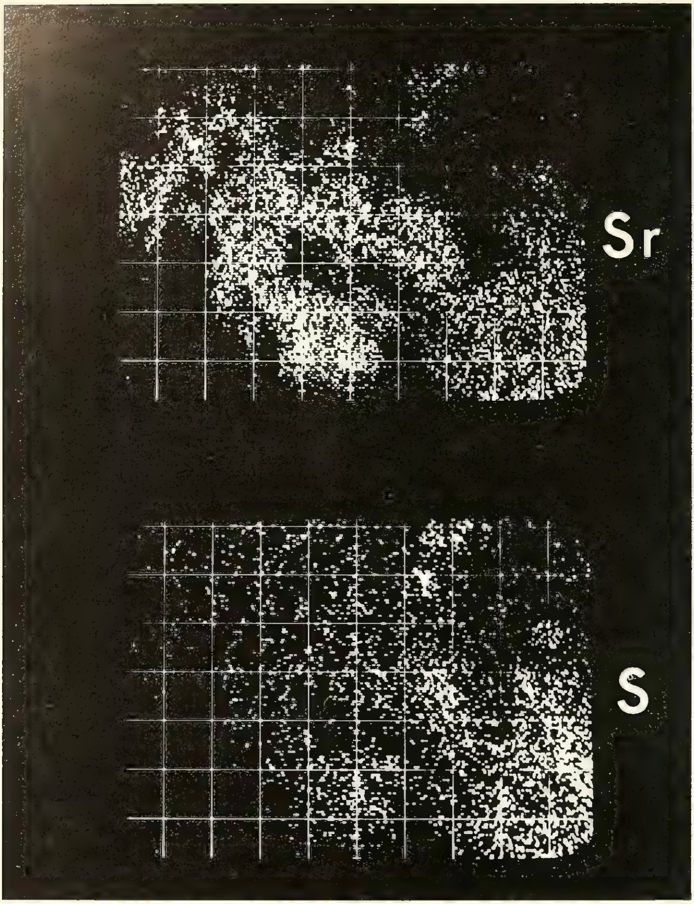

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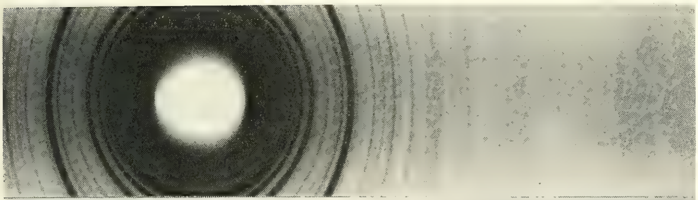
Figure 4. X-ray electron probe scan of the distribution of strontium and sulfur in an insect (area 320 micron square).

but occasionally they have had an arrangement indicating that mineralization proceeded by the formation of a few large, parallel oriented crystals (Fig. 6). The size of the individual crystals can be estimated from the size of the spots they produce; they commonly range between 10^{-2} and 10^{-3} cm. in diameter, the celestite fossils being composed of crystals larger than those of quartz. In a few cases the mean crystallite size has been so small that the powder patterns have been completely devoid of spots. For many of the celestite insects, the crystallites have been so big and numerous that identification could



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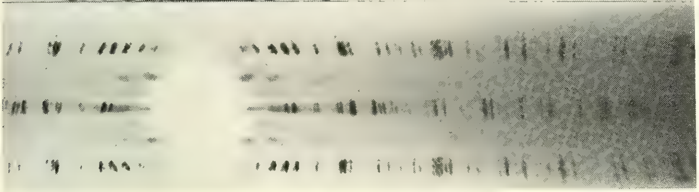

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Figure 5. X-ray powder picture of celestite from one insect.

Figure 6. X-ray picture of entire (a) insect head and (b) insect body.

be made only after the specimen had been powdered. It is particularly interesting that a mass of such relatively big crystals can faithfully reproduce the small details of structure in an insect they mineralize.

The results we have described above are in accord with those given by Palmer (1957), including X-ray observations which he states were carried out at the Geological Survey in Washington. Most of his mineral identifications were made by the usual petrographic procedures; nevertheless we believe that the added information the foregoing examples provide, demonstrates that the physical techniques we have been describing can contribute very materially to the further investigation of these and other insect fossils.

ACKNOWLEDGMENTS

We are indebted to Stephen Dye for much help in the photography and microradiography of specimens.

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PERIODICITY OF VOCAL ACTIVITY OF CAPTIVE ATLANTIC BOTTLENOSE DOLPHINS: *TURSIOPS TRUNCATUS*

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Introduction

The vocalizations of *Tursiops truncatus* (Montagu) have been reported extensively and recently reviewed in detail (Tavolga, 1965; Evans 1966). There are no reports of the possible effects that noise, personnel movement, or feeding schedules may have on the vocal activity of Atlantic bottlenose dolphins. Most studies have reported vocalization data collected during the normal human work day; none have reported data collected over a long term continuous period.

It would be surprising if *T. truncatus* did not function in cyclic rhythms based on some natural environmental cycles such as photo period, tidal fluctuations, or temperature changes. It seems, therefore, that an understanding of their vocal behavior might be aided by observations of vocal activity patterns under conditions lacking excessive external stimuli.

Inasmuch as *T. truncatus* is a highly vocal species and studies previously reported have of necessity dealt with the analysis of specific, usually short in duration, samples of the vocal activity of the animal, a series of long term tests were conducted to determine the presence, if any, of periodicity of vocal activity in captive animals under various conditions.

Procedure

The vocal activity monitoring system utilized in each of four experimental situations described below consisted of a Clevite hydrophone, Model 1H for acoustical pickup with signal passed through a Krohnhite variable band pass filter Model 315A set at upper pass 50 kc, lower pass 5 kc (to reduce triggering of the system from extraneous, non-animal, sounds). The signal was then passed to an acoustically-operated relay (voice-operated switch) which activated an Esterline Angus graphic level ammeter, Model AW, thereby recording the acoustical events. In addition, random spot recordings of the vocal activity were made using an Atlantic Research, LC-10, hydrophone, Ballantine Model 220C preamplifier and Uher Model 784 tape recorder at 7½ i.p.s. Analysis of taped vocal activity was done on a Kay Sona-Graph Model 6061A.

Vocal activity data collected during the tests were compared with the random spot recordings made on the Uher tape recorder. Approximately 80 per cent of the events recorded on the Esterline Angus were the results of whistles produced by the animals. The majority of the remaining percentage was the result of unusually loud echo-locating click trains. Less than three per cent of the recorded events were caused by non-animal-produced sounds.

Experimental situations Nos. 1, 2 and 3 took place in a round plastic-lined tank approximately six meters in diameter, and one meter deep. A screen 2.5 meters high constructed from bamboo porch screening was erected around the tank one meter from the tank sides to visually isolate the experimental animals. Attempts, not altogether successful, were made to keep personnel away from the tank during the data collection periods.

Situation 1:

The experimental animals were a newly captured male and female *T. truncatus* each estimated to be approximately two years old. They were shipped to Point Mugu on 25 June 1965 where the tests were conducted. Both animals were placed in the described tank upon arrival. Their vocal activity was monitored for five days commencing on 1 July 1965. Each animal was fed, by hand, approximately 16 pounds of Pacific mackerel per day, on a random daylight hour schedule.

Situation 2:

The experimental animal was the female described above in Situation 1. Vocal activity was monitored continuously for 15 days during which time the following feeding schedule was maintained. The animal was fed seven pounds of Pacific mackerel at 1000 and 1400 hours and as much as it would consume in 15 minutes at 1600 hours each day for four consecutive days. The schedule was then changed to seven pounds of Pacific mackerel at 2200, 0200 hours, and to satiation, which usually occurred in less than 15 minutes, at 0400 hours, for a period of six days. The schedule was then changed to one feeding to satiation each 24 hours at 1200 hours for an additional five days. Daily food intake varied between 15 and 19 pounds.

Situation 3:

A mature five-to-six-year-old female *T. truncatus* that had been used in several experiments, some involving sound production for reward, and who had been in captivity for approximately three years was used. She was fed 15 pounds of Pacific mackerel once each day at 1200 hours. Vocal activity was monitored for seven days.

Situation 4:

Data were collected from a round concrete community tank 15.25 meters in diameter, approximately 1.8 meters in depth. No visual screening was utilized. A large amount of work activity by personnel at the Facility occurred throughout the daylight hours. The experimental animals, all *T. truncatus*, were two recently captured (less than two months in captivity), females approximately two years old, one mature male with approximately three years captive experience, one mature female with approximately three years captive experience and one recently captured (less than two months in captivity) male approximately two years old. Feeding was done on a random schedule during daylight hours. Approximately 15 pounds of Pacific mackerel per animal per day was fed. Vocal activity was monitored for seven days.

The raw data collected from the vocal activity monitoring system were analyzed per five minute intervals. One interval was considered to be filled with vocal activity if it contained vocal events at a rate in excess of six per minute (rates as high as 30 events per minute were recorded).

RESULTS

Analysis of the data collected during the five-day period of Experimental Situation 1 indicated a degree of periodicity in the vocal activity of the two animals (Fig. 1). The level of vocal activity showed a considerable rise at approximately 0500 hours each day. It remained high until approximately 1300 hours, with peaks occurring on successive days at 0500, 0900, 0800, 1000 and 0900 hours. This was generally followed by a decline in activity level for two to three hours and a definite rise, but not to the morning level, in the afternoon centering on 1630 hours. Thereafter there developed a steady decline in activity to a low point occurring between 2200 and 2400 hours each day.

The first four days of monitored vocal activity-levels of the isolated female in Experimental Situation 2 produced dramatic results

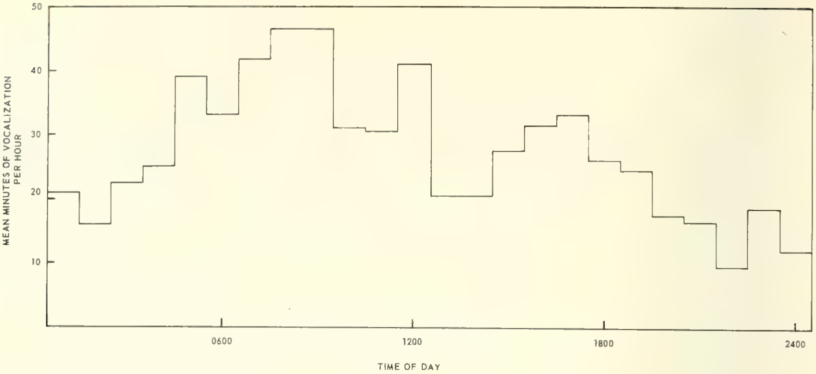

Figure 1. Mean levels of vocal activity in relation to time of day. The vocalizations of two captive *T. truncatus*, fed on a random daylight schedule, were monitored for five days.

(Fig. 2). The basic pattern was that of the first experimental situation but both onset and termination of periods of high activity were more marked. Periods of intense vocal activity centered around 0600 hours and in four out of four mornings the level dropped to a minimum level following the 1000 hour feeding. An early afternoon rise in activity level from the low each day around 1200 hours was followed by another period of low activity at approximately 1500-1600 hours. This was followed by a moderate rise in activity level to a nighttime high around 2000 hours which declined to a minimum level at 2300 to 2400 hours.

The changed feeding schedule to 2200, 0200 and 0400 hours for the next six days effected the pattern established during the first four

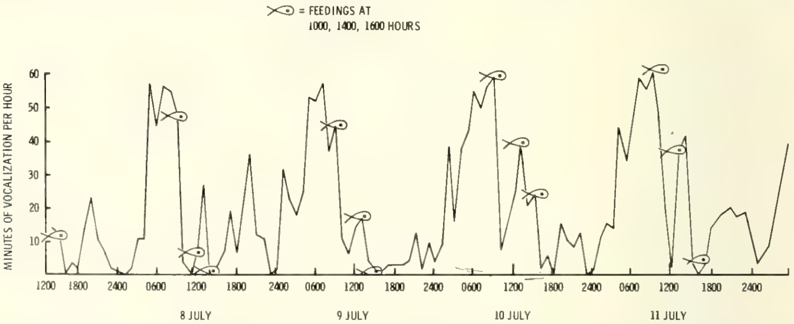

Figure 2. Record of hourly levels of vocal activity for isolated female *T. truncatus*. Small fish indicate feedings.

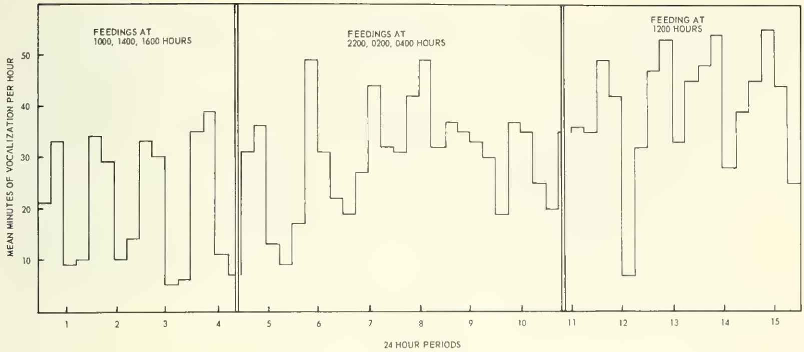

Figure 3. Levels of vocal activity of isolated *T. truncatus* over 15 day period as feeding schedule changed from day to night to day. Each 24-hour period is divided into four six-hour intervals (0001 to 0600, 0601 to 1200, 1201 to 1800, 1801 to 2400 hours). Mean minutes of vocalization per hour for each interval are indicated.

days. No pattern was recognizable during this period (Fig. 3). The vocal activity levels of the last five days of this situation wherein the feeding schedule was shifted back to daylight hours appeared to begin to establish a periodic pattern.

Figure 4 shows sonagrams of whistles taken at random from the spot recordings made during Situation 2, the isolated young female. Seventeen five minute spot recordings made during the 15 day period were analyzed by ear at ⅛th real time play back. Of significance is the fact that over 95 per cent of the several hundred whistles recorded were to the author's ears almost identical. This is in agreement with observations by Caldwell and Caldwell (1965) of individualized whistle contours produced by several isolated *T. truncatus*. The only detectable difference being that many were accompanied by the echo-locating click train shown in the upper sonagram in Figure 4.

The vocal activity levels of Situation 3, the single mature female, are shown in Figure 5. Periodicity is present and again the period of highest activity is at approximately 0500 hours. The levels of vocal activity do not approach those of Situations 1 and 2 in terms of intensity or amount of vocalization.

The analysis of data collected under Situation 4 is shown in Figure 6. The five animals it will be remembered were not isolated from personnel at the facility site. All persons entering or leaving the area walked by the community tank. Of note is the time of day when the

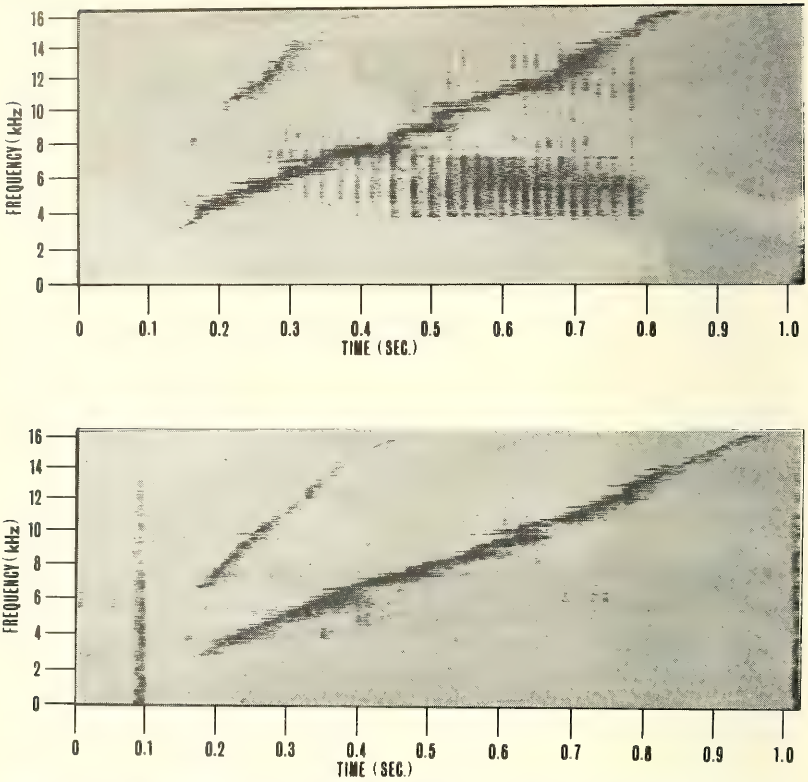

Figure 4. Sonagrams of the two most common whistles emitted by the isolated female *T. truncatus* during Situation 2. (600-cycle bandwidth filter.)

Facility personnel came to work. One or two of the personnel came at 0715 to 0730 hours to begin thawing food for the day. The remaining employees, approximately 15 each day, began showing up at approximately 0830 hours. The workday ended at 1630 hours.

DISCUSSION

The results of this series of tests suggest the hypothesis that captive *T. truncatus* exhibit a vocal activity periodicity which is related to light-dark cycles. In each Experimental Situation a considerable increase in vocal activity was recorded during the one half to one hour period preceding sunrise. The activity levels generally were lowest during the period from 2100 to 0300 hours.

Considerable attention should be given, however, to any sugges-

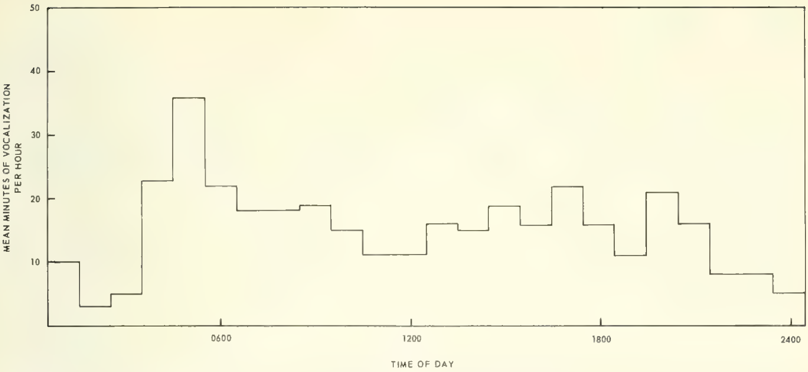

Figure 5. Mean levels of vocal activity in relation to time of day of an isolated mature female *T. truncatus* fed at noon each day for seven days.

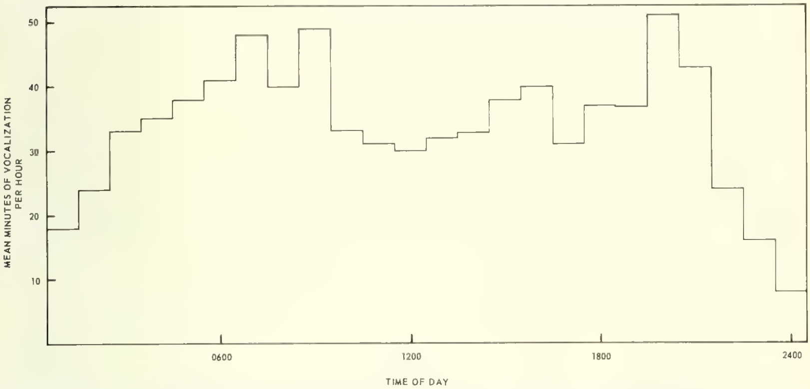

Figure 6. Mean levels of vocal activity in relation to time of day of five *T. truncatus* fed on a random daylight hour schedule.

tion that the photoperiod is solely responsible for the periodicity in vocal activity in view of the results obtained in Situation 2 during the shift in feeding schedule. Although the changed feeding time appeared to result in almost random vocal activity throughout the 24-hour periods, analysis of the data indicated a trend toward a new pattern of periodicity. It is now apparent that the altered feeding schedule should have been continued until the trend could be either confirmed or rejected.

A comparison of the vocal activity levels of the young and recently-acquired animals with those of the long-time captive suggests several possibilities. Bottlenose dolphins may become less vocal in the captive environment. Also they may become conditioned to human work days and their vocalization may assume a pattern reflecting the regimen of the captive environment.

SUMMARY AND CONCLUSIONS

The tests reported were exploratory in nature. Sufficient results were obtained, however, to suggest that the vocal activity of captive *T. truncatus* is periodic and should be considered in studies of their vocalizations.

1. The vocal activity of several captive *T. truncatus* was monitored for extended periods and found to be periodic.

2. The vocal periodicity in captive animals fed during daylight hours was related to a 24 hour day.

3. Nighttime feeding of a captive animal affected greatly the periodicity of vocal activity established during daytime feedings.

4. The isolated female showed marked vocal stereotypy during all periods of observation.

ACKNOWLEDGMENTS

I wish to thank Mr. William E. Evans, Naval Ordnance Test Station, China Lake, California, for invaluable suggestions in setting up the series of tests and Mr. Gary Blanc, Naval Ordnance Test Station, China Lake, for providing the acoustical relays used in the monitoring system. I also wish to thank Mr. F. G. Wood, Naval Missile Center, Point Mugu, California; Dr. David K. Caldwell, Los Angeles County Museum of Natural History; Mrs. Melba C. Caldwell, Allan Hancock Foundation, University of Southern California; and Mr. Evans, for their constructive comments on this manuscript.

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PRODUCTION OF PULSED SOUNDS BY THE PIGMY SPERM WHALE, *KOGIA BREVICEPS*[1]

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In recent summaries of the knowledge of sound production by cetaceans (Schevill, 1964; Tavolga, 1965; Evans, *In press*), no mention has been made of sounds produced by the pigmy sperm whale, *Kogia breviceps* (Blainville). However, Wood (1966) mentioned that individuals of this species possess "a beautiful little noisemaker," and Norris (1964: 325, 329) suggested, in part on Wood's dissections, that *Kogia breviceps* might be expected to be an echolocator.

On July 13, 1966, a 242-cm. (Straight-line measurement, snout to caudal notch) male pigmy sperm whale (Fig. 1) stranded alive at Playa del Rey, Los Angeles County, California. This animal was transported to Marineland of the Pacific where it remained alive for about 48 hours. While at Marineland, the obviously-sick animal was removed from its tank for purposes of medication and forced feeding.

Inasmuch as removal from water frequently elicits vocalizations from cetaceans, a recorder was held in readiness. During the 30-minute period that the animal was out of water no audible sounds were produced. However, with the fingers one could detect movements in the region of the blowhole that suggested that the animal might be producing sound. This was confirmed with a stethoscope held against the skin of the animal in that region. Recordings were subsequently made by placing a microphone against the skin in this region.

Analysis of the tape revealed that at least five of the sounds of the type that had been heard with the stethoscope had been recorded. The sounds are of the kind usually associated with echolocation in species of odontocete cetaceans in which that phenomenon has been

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[1] Contribution number 25 from the Marineland of the Pacific Research Laboratory.

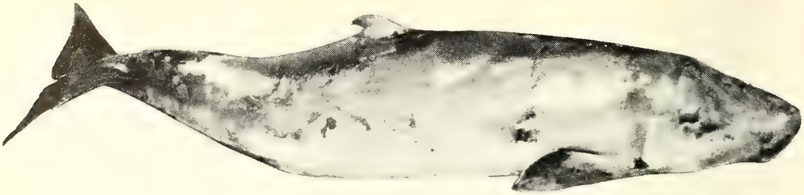

Figure 1. Kogia breviceps (Blainville), pigmy sperm whale. Male, 242 cm. in snout to caudal-notch length, alive at Marineland of the Pacific, California. Stranded at Playa del Rey, Los Angeles County, California, on July 13, 1966, and sound-recorded the following day. Skeleton now preserved in the marine mammal collections of the Los Angeles County Museum of Natural History, number 27068.

shown experimentally (see summaries of this evidence in Norris, 1964, and in Evans, *In press.*)

The sounds that we recorded (Fig. 2) are low in intensity and low in frequency (almost all of the recorded energy below two kHz, and mostly one kHz or less). While we do not choose to postulate how these results might compare with sounds produced by normal animals of this species in the water in the wild, the sounds produced by our captive animal, even though out of water, suggest that *Kogia breviceps*, like many cetaceans, is indeed capable of producing pulsed sounds, at variable repetition rates, in a series usually termed Click Trains. Thus the actual recording of such sounds correlates positively with the anatomical evidence suggested earlier by Wood and by Norris.

Recording Equipment

The sounds reported here were recorded with an air microphone and a Uher model 4000 Report-S tape recorder operating at a tape speed of 7.5 inches (19 cm.) per second. At this tape speed the recorder had a flat response of 40 to 20,000 cycles per second. The Sonagrams (sound spectrograms) were prepared on a Kay Sona-Graph model 662A Sound Spectrograph Analyzer calibrated from 85 to 6000 cps.

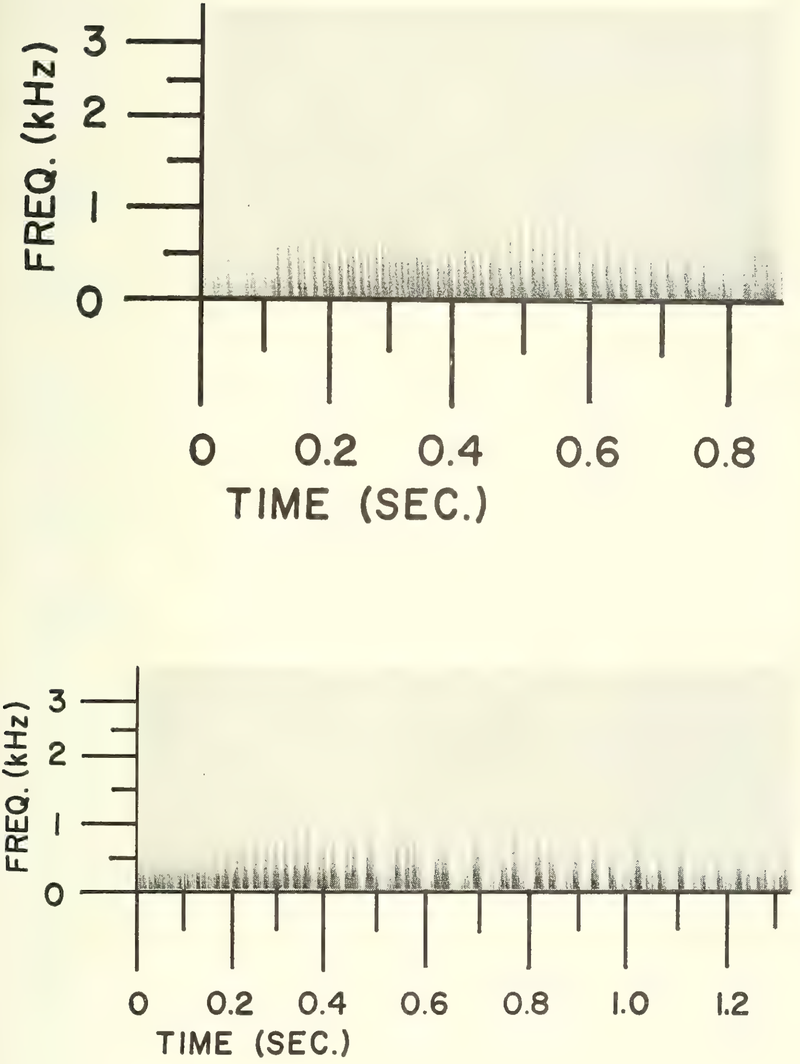

Figure 2. Sonagrams (sound spectrograms) showing pulsed sounds of two different repetition rates produced while out of water by the pigmy sperm whale illustrated in Figure 1. (Effective filter bandwidth 300 cycles.)

ACKNOWLEDGMENTS

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LONGEVITY RECORD OF A SPIDER OF THE GENUS *FILISTATA*

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Records of spider longevity are very few. Baerg (1945) has kept a tarantula in the laboratory for over twenty years. Most spiders are assumed to become mature in one or two years and to live only a few months beyond that time. Summaries of the literature on the subject are to be found in articles and books by Berland (1922, 1932), Savory (1928) and Bonnet (1945). Berland reports on captivity observations on *Filistata insidiatrix* (Forskäl), the common Eurasian and North African representative of this genus. He kept a female for ten years and suggested that it probably lives as much as 20 years since that specimen was mature when he collected it.

On the 22nd of March, 1959, the author brought back to the laboratory a good sized female specimen of the genus *Filistata*. It was collected in a rocky desert area in Borrego Springs Valley and was probably a year or two old but was still immature. It was fed on occasion but no notes were made as to molting though it molted several times during the ensuing period. A couple of years later the specimen was still alive. At that time it was given more careful attention. It was fed more regularly and it was noted weekly whether it was still alive. It finally died in early February, 1966, thus living for at least a seven year period. It had been kept in a small plastic box in which a web was built but to which no water was added. Mealworm larvae and adults were presented to it irregularly and it fed every few weeks for the period of its captivity. At the time it died it was destroyed by one of the mealworms. Whether it was killed by the mealworm or simply fed upon after death is not known. From its size and observations on other specimens it was at least a year old when caught so we have a record then that one of the North American specimens of this world-wide genus lives for a minimum of seven years.

Females of this genus are not easily identified and this one was not identified. At least three species and *Filistata hibernalis* of the south have been described or found in California. It may have been the *Filistata geophila* of Chamberlain and Ivie but since the specimen was destroyed before it could be identified this assumption cannot be verified. In addition the taxonomy of this group is not well worked out in North America. In spite of the questionable data as to the species involved it seems valid to publish this data as this further establishes the fact that this genus is long-lived. This is the first record of longevity of a North American species of this genus.

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THE PLIOCENE-PLEISTOCENE *MEDICINE ROOT GRAVEL*[1] OF SOUTHWESTERN SOUTH DAKOTA[2]

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Introduction

The drainage pattern of South Dakota has undergone considerable modification since late Pliocene time. Not only has stream piracy changed the course of the smaller streams, but continental glaciation has shifted the continental divide a distance measurable in hundreds of miles. The sizable changes possible within a relatively short period of geologic time, both through the action of stream piracy and through glaciation, are well exemplified in South Dakota. The drainage transformations of the eastern part of the State have been recently discussed by Flint (1955), White (1964), and summarized by Lemke and others (1965). While these papers have contributed to our present knowledge of the glaciated part of the State, little work of recent date has been done on the drainage modifications in the area west of the Missouri River.

It has long been known that throughout the medial and late Cenozoic the Black Hills of South Dakota and Wyoming were drained by a series of eastward-flowing streams. These streams flowed from the Black Hills to join a larger drainage in the central part of eastern South Dakota. Along this 300 mile route the streams, with the help of wind, deposited nearly 1,000 feet of strata, referable to the White River, Arikaree, Ogallala, and other groups over most of central and western South Dakota. These streams were constantly shifting their channels, undergoing undulatory movements while they slowly deposited their load on a flat, wide plain. This type of deposition, which resulted in formations of generally uniform thickness that extended for many hundreds of miles, existed throughout the Oligocene and early Miocene Epochs. During the middle Myo-

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[1] Name cleared by the Geologic Names Committee, United States Geological Survey.

[2] Publication approved by the Director, South Dakota Geological Survey.

[3] Associate Geologist; also Research Associate, Los Angeles County Museum of Natural History.

cene a new type of deposition was initiated, one of restricted cut and fill. Thereafter, a series of fluctuations in stream base level resulted in the streams eroding narrow channels several score of feet deep, and then refilling them before beginning a new sequence of cut and fill at some distance from the previous channel. This sequence of cut and fill occurred as many as ten times in the pliocene of western South Dakota. Near the Pliocene-Pleistocene boundary, the base level of western South Dakota was lowered by a considerable degree. The ancestral Cheyenne River was apparently stimulated more than its contemporary drainages, for at this time through a series of stream piracies, it monopolized the entire Black Hills drainage system.

Remnants of the pre-Cheyenne, Black Hills drainages can be found capping the divides at many localities in western South Dakota. One such series of channel remnants, occurring near Medicine Root Creek in Shannon and Washabaugh Counties, South Dakota, forms the basis for this paper.

ACKNOWLEDGMENTS

Critical reviews of the manuscript were made by J. R. Macdonald, Los Angeles County Museum of Natural History; Morris Skinner, American Museum of Natural History; and Richard Bruce, Cleo M. Christensen, Duncan J. McGregor, and M. J. Tipton, South Dakota Geological Survey. Figures 1 and 2 were drafted by Dennis W. Johnson. However, the author alone is responsible for the interpretations presented in this paper.

PREVIOUS GEOLOGIC WORK

Despite the privations and the lack of "modern" transportation known by the early geologists in South Dakota, the work done by individuals such as N. H. Darton and J. E. Todd has proven to be remarkably sound. One of the first references in the literature to materials of, or derived from, the Medicine Root gravel of this paper was made by Todd (1894) when he remarked on a unit which he called "Aqueous Drift." He stated, "Under this head we would include an extensive deposit of boulders and gravel overspreading quite generally the country around the Black Hills for a distance of from 100 to 150 miles. It seems to have been nearly continuous at first over the whole country. It is found usually capping the high pinnacles of the Badlands between the Cheyenne and White Rivers."

Todd further stated that the "Aqueous Drift" had been referred by

Professor Jenny to the action of ice floating in a fresh water lake around the Black Hills, while Professor Crosby had concluded it to be residuum left after the removal of the softer portions of the Tertiary beds. Todd personally concluded that the "Aqueous Drift" was desposited by streams flowing from the Black Hills.

In later work Todd (1902) stated that the rivers once draining the Black Hills flowed eastward across the South Fork of the Cheyenne River. Todd claimed that this fact was abundantly attested to by the numerous erratics from the Black Hills capping areas in the valleys of the White and Bad Rivers. However, Todd also pointed out that some of the higher points in the Pine Ridge Indian Reservation and along the divide between the White and Niobrara Rivers were probably not strewn with these erratics.

Ward (1922) advocated the theory that the gravels mantling the surface of the region near Interior, South Dakota, were the more resistant parts of weathered *Protoceras* Channels. However, Wanless (1923) disputed this concept, stating that the size of the individual particles was four or five times larger than any observed in the upper part of the Brule Formation. In general, Wanless upheld the work of Todd (1894, 1898, 1902), disagreeing with him, however, on the age of the material. Todd (1902:31) suggested that the capture of the Black Hills drainages by the Cheyenne River occurred in Pliocene time, while Wanless (1923:266) felt more inclined to place the time of the capture with the Pleistocene. Wanless (1923:263) states that he had not investigated the country south of the White River, the area where the majority of known exposures of the Medicine Root gravel are found (see Figs. 1A and B).

While mapping the geology of the Sharps Corner 15 minute quadrangle in Shannon County, South Dakota, the author first realized the presence and significance of the Medicine Root gravel. In this publication (Harksen, 1965), the Medicine Root gravel was referred to as a Quaternary-Tertiary terrace deposit.

THE MEDICINE ROOT GRAVEL

Mantling many of the topographic highs in northern Shannon and Washabaugh Counties, South Dakota, are remnants of a former major Black Hills drainage (Fig. 1B). To these deposits the name *Medicine Root gravel* (new name) is applied. The name is derived from Medicine Root Creek (Fig. 1B). The name has been cleared by the Geologic Names Committee of the United States Geological Sur-

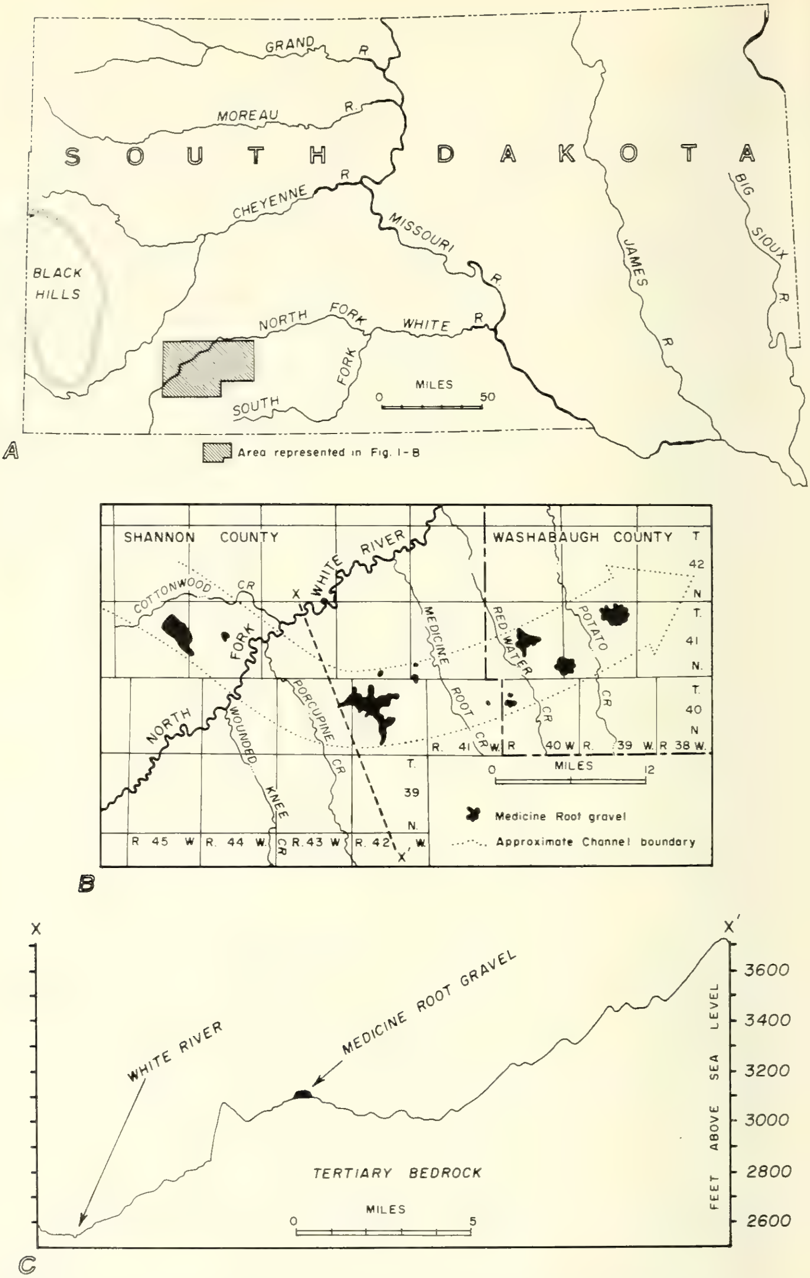

Figure. 1. A. Map of South Dakota showing the Black Hills and the present-day drainage system. The cross-hatched area is that which is represented in Fig. 1B. B. Map showing the known outcrop area of the Medicine Root gravels. The black areas indicate the known deposits of the Medicine Root gravel while the dotted lines delineate the approximate channel boundaries of the Medicine Root River. C. Cross section X to X′. This cross section was taken along the dashed line shown in Fig. 1B. The elevation at X′ represents the top of the Pine Ridge Escarpment.

vey (George V. Cohee, *pers. communication*) and is proposed as an informal name in accordance with the Code of Stratigraphic Nomenclature (American Commission on Stratigraphic Nomenclature, 1961). The type area is here designated as that area represented in Figure 2.

The exposures of the Medicine Root gravel mark the course of an ancient Black Hills drainageway (Fig. 1B). This river was probably the major drainage of the southern Black Hills until the Cheyenne captured the entire Black Hills drainage system. The probable time and possible reasons for the capture of the Black Hills drainages by the Cheyenne River has been discussed by Todd (1902) and Wanless (1923).

In this report there are references to both the Medicine Root River and to Medicine Root Creek. To avoid misunderstanding, it should

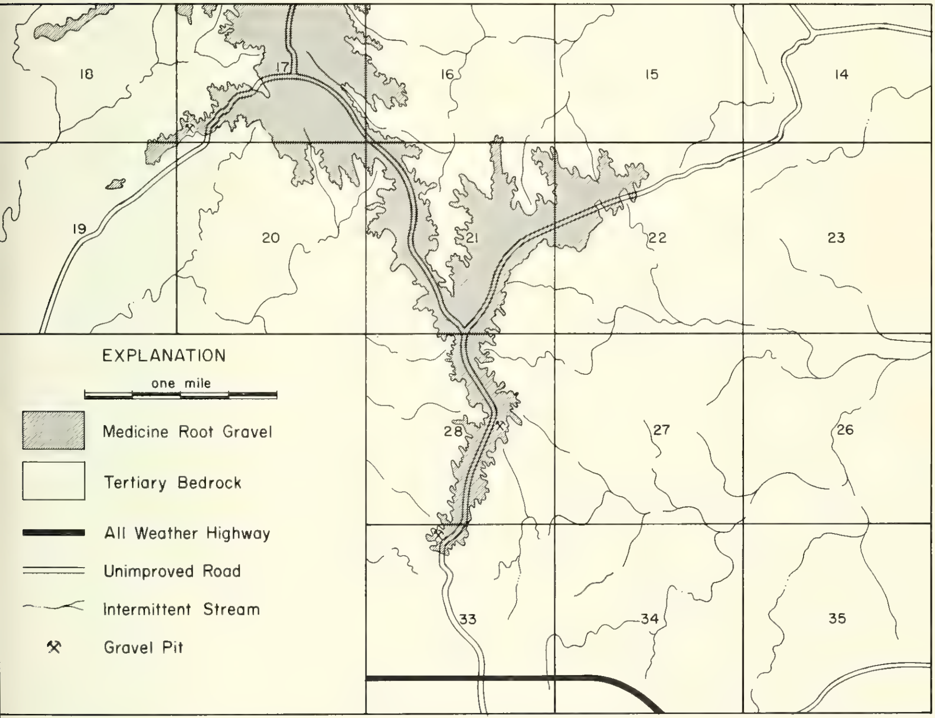

Figure 2. Type area for the Medicine Root gravel. The area represented above is in T. 40 N., R. 42 W., Shannon County, South Dakota.

be stated that Medicine Root Creek is the *present-day* drainage while the Medicine Root River is the old Black Hills drainage that deposited the Medicine Root gravel.

The Medicine Root gravel consists of deposits of sand and gravel. As the name of the unit would imply, gravel forms the major constituent. However, all other size factions from clay to boulders are present. Judging from particle size, this stream was one of the most powerful in regards to carrying capacity that ever existed west of the Missouri River in South Dakota. One blocky piece of sandstone, measuring approximately 204 x 280 x 306 mm, was found in sec. 30, T. 41 N., R. 39 W., Washabaugh County, South Dakota. It is estimated that this block had been transported for more than 70 miles before final deposition.

The gravels contain a high percentage of igneous and metamorphic rock derived from the core of the Black Hills. This ancient drainage, in its course from the central Black Hills out across the Great Plains, flowed across nearly every major formation found in southwestern South Dakota. For this reason it is possible that every form of pre-Quaternary rock found in southwestern South Dakota may be represented in the Medicine Root gravel.

Not only is the Medicine Root gravel extremely heterogeneous in lithology, but it is also heterogeneous in regard to fossil content. Cretaceous *Ostrea* and *Inoceramus* were found adjacent to waterworn fragments of vertebrate remains from the Oligocene and Miocene Epochs. This aglomeration of fossils from pre-existing deposits make difficult any dating of the Medicine Root gravel. Figure 1C shows that the "Medicine Root River" had locally cut down more than 500 feet into the pre-existing late Tertiary bedrock of the Great Plains at the time of deposition of the Medicine Root gravel.

Some horse and camel material, thought to be contemporaneous with the deposition of the Medicine Root gravel, has been collected. While this material shows the age of the Medicine Root gravel to be near the Pliocene-Pleistocene boundary, not enough material has been collected to positively pinpoint this unit in geologic time.

Two deposits of silty sands, occurring below the gravels and above the Tertiary bedrock, have been found. These deposits occur in sec. 17, T. 40 N., R. 42 W., and sec. 30, T. 41 N., R. 44 W., Shannon Country, South Dakota. The relation of these deposits to the overlying gravels is at this moment in question. When this relationship is clarified, the Medicine Root gravel will be proposed as a formal stratigraphic unit and a type section will be designated.

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MAMMAL TRACKWAYS FROM THE BARSTOW FORMATION, CALIFORNIA

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INTRODUCTION

The Barstow formation of the Mojave Desert consists of between 2,000 and 2,800 feet of sedimentary and pyroclastic rocks. Many fossil vertebrates have been described from these beds, and because of their character an upper Miocene age is indicated (Lewis, 1964). Potassium argon analysis gives an age of between 15 and 16 million years.

In the various published articles on the stratigraphy and paleontology of this region, nothing has been mentioned on the occurrance of mammal fossil footprints and trackways, and it is the purpose of this paper to record them. Mammal footprints have been described from Death Valley (Curry, 1941) and from the Avawatz formation (Alf, 1959).

My sincere thanks are extended to the many Webb School boys who have participated in the discovery, removal, and preservation of these interesting fossils. I am grateful to Richard H. Tedford of the Geology Department, University of California, Riverside, and to Dan Guthrie of the Claremont Colleges for helpful suggestions relative to this paper.

LOCATION

Most of the footprints and trackways are from the Badlands, about ten miles north of Barstow, California, particularly in Rainbow Basin, Owl Canyon and eastward from these toward the Camp Irwin Road.

Rainbow Basin is in sec. 24, R.1W., T.11N., Opal Mountain Quadrangle, San Bernardino Co., California.

CARNIVORE TRACKWAY

In the south-east quarter of sec. 9 in Owl Canyon there is an outcrop of friable mudstone on whose upper surface we uncovered a remarkable trackway of a large carnivore.

The mudstone is about four inches thick, buff in color, mud cracked, rough surfaced and characterized by the presence of ostracods as revealed by thin sections. It strikes east-west and dips to the north at about 25°.

There are five pairs of prints in the trackway (Fig. 1). Each pair

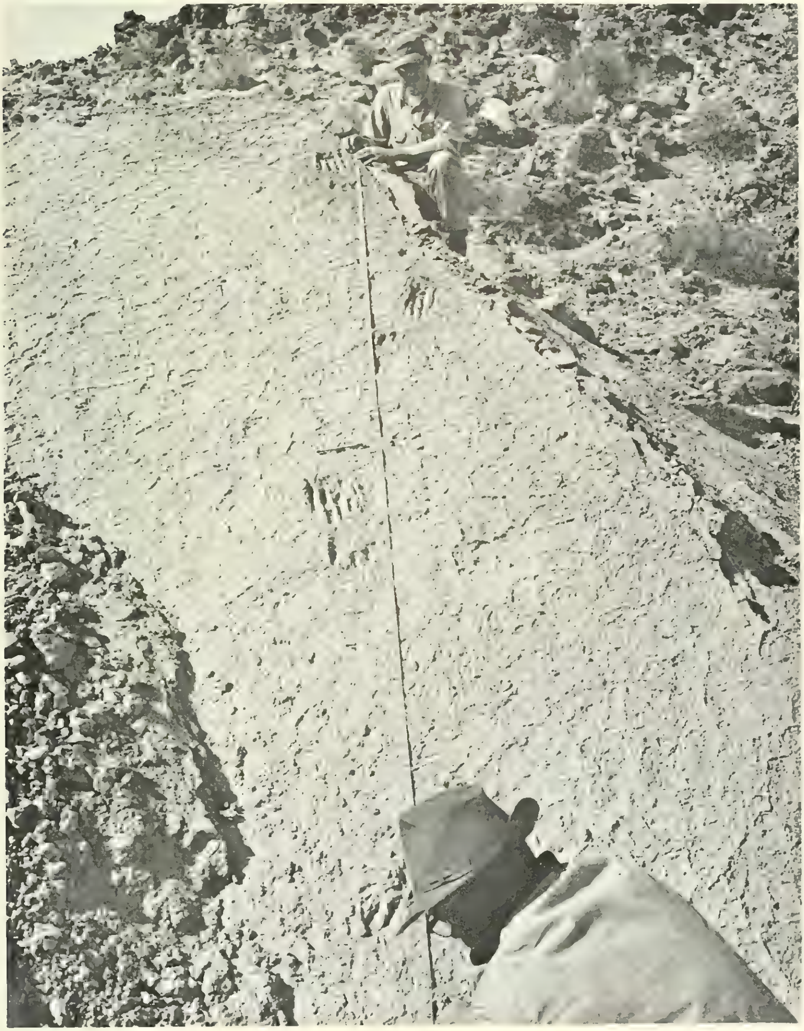

Figure 1. Trackways of large carnivore, probably *Amphicyon.*

Figure 2. Individual front and hind foot impressions from carnivore trackway shown in Figure 1.

(Fig. 2) consists of a relatively faint impression of the front foot showing toe marks but no pads. This is followed by a very conspicuous impression consisting of four deep parallel grooves and one lesser one. The width of the footprints is seven inches and the length of the hind foot marks is eleven inches. A distance of four feet separates one pair of prints from another, so that the ancient beast responsible for the trackway had an eight-foot stride.

The most likely Barstovian animal responsible for this trackway is *Amphicyon*, the bear-dog, and by a simple application of the square-cube law, using trackways of *Canis familaris* (German shepherd, for example), the Miocene beast could have been about five feet high at the shoulder and possibly tipped the scales at more than five hundred pounds. In fact the skeletal material of the *Amphicyon* at the University of California at Berkeley indicates just such proportions.

The removal of the trackway presented logistic problems because of the size (26′ x 5′) and weakness of the rock. A portable generator and skill saw were taken to the site, and about two foot squares were cut to a depth of four inches. Steel bands were then placed around an individual block and cinched with a banding machine. Because of very poor cleavage on the lower surface of the slab, a separation was forced by driving steel slats 24″ x 2″ x ¼″ underneath. These made possible tilting the squares and placing under them plywood boards. All squares were successfully removed and are now waiting to be put together for display.

CAMEL TRACKWAYS

From near the middle of Rainbow Basin and traceable eastward for several miles and relatively high in the section is a crystalline tuff about four inches thick that weathers dark brown and is characterized on its lower surface by very conspicuous natural casts of mud tracks.

Stratigraphically about twelve feet below the tuff is a persistant tuffaceous sandstone three inches thick and mud cracked that weathers dark brown, so that it looks superficially like the above crystalline tuff.

At several localities scattered along the outcrops of this tuffaceous sandstone have been found numerous footprints of camel (Fig. 3), some cat footprints, and a few prints of antelope. In the southeast quarter of sec. 34 in Rainbow Basin we have removed the over-

Figure 3. Natural casts of camel footprints, slightly reduced.

burden of a large area of the sandstone, turned over the exposed tuffaceous rock and have collected five camel trackways with ten prints for the shortest trackway to 26 for the longest.

The print made by the front foot is larger and generally clearer than the one made by the hind foot. It measures 3¼ inches long by 2½ inches wide, while the hind foot measurements are 2½ inches by 2¼ inches. The distance between right front foot to left averages 24 inches. A study of the stride indicates that the camel then as now had an ipsilateral gait as it moved across the ancient Barstovian mud flat. These trackways were probably made by *Procamelus* or *Protolabus*. *Aepycamelus* and *Hesperocamelus* were simply too large.

Other camel footprints have been found from throughout much of the eastern part of the Barstow Syncline as natural casts in sandstone, volcanic ash and limestone.

Figure 4. Natural cast of cat footprint, probably *Pseudaleurus*.

CAT FOOTPRINTS

No trackways of cat have been found, but at two localities, one in Owl Canyon south-west quarter of sec. 19, R.1W., T.11N., Opal Mountain Quadrangle, and one east of Owl Canyon, both in the above described tuffaceous sandstone, some very clear individual prints have been found (Fig. 4). The average length is 3 inches with a maximum width of 2¼ inches. The most likely animal responsible for these prints is *Pseudaleurus*.

In addition to the *Amphicyon*, *Procamelus*, and *Pseudaleurus* footprints there has been found one small carnivore print probably of *Tephrocyon*, a few prints of an artiodactyl, probably *Merycodus*, and several prints of a bird.

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