

Reproductive Behavior in *Cyprinodon variegatus* Lacépède, in Florida

EDWARD C. RANEY¹, RICHARD H. BACKUS, RONALD W. CRAWFORD & C. RICHARD ROBINS

Department of Conservation, Cornell University, Ithaca, New York

(Plates I & II)

WHILE on an ichthyological reconnaissance in southern Florida during late March, 1952, we had unusually good opportunities on two occasions to study the nest building and reproductive behavior of the variegated cyprinodon, *Cyprinodon variegatus*, under natural conditions. A total of 17 man-hours of observation produced the data recorded below which supplement the observations made in aquaria by Newman (1907). As expected, the reproductive behavior in nature differs markedly from that observed in tanks. Our experience indicates that *Cyprinodon* may easily be observed at close hand during spawning activity and it is recommended as an excellent subject for further detailed behavioral study in the field. An account of its general habits and ecology was given by Hildebrand & Schroeder (1928: 135). It is a handsome aquarium fish and its active and often ferocious behavior is well known.

Several brief notices of the reproductive behavior of other species of *Cyprinodon* have been noted. Breder (1934: 69) reported that in quiet pools on Andros Island, Bahamas, males of *Cyprinodon baconi* Breder could frequently be seen in pursuit of females, in a manner not unlike that of *Cyprinodon variegatus* in the latitude of New York, a short time before full nuptial colors were assumed. Cowles (1934: 41) noted station holding by a male of *Cyprinodon macularis* Baird & Girard in the aquarium. Additional spawning data on this species were given by Miller (1942: 96).

Our thanks go to Charles M. Breder, Jr., and Robert R. Miller for suggestions regarding refer-

ences and to Royal D. Suttkus for his assistance in critically reading the manuscript.

RANGE, HABITAT AND ASSOCIATES

Cyprinodon variegatus is a coastal species found in brackish or nearby fresh waters. According to Hubbs (1936: 224), it ranges from Cape Cod to the Gulf of Mexico as far as the vicinity of Brownsville, Texas. Within this extensive range Hubbs (1936: 223-224) recognized two subspecies, *Cyprinodon variegatus ovinus* (Mitchill) which occurs from Massachusetts to Virginia, and *C. variegatus variegatus* Lacépède which is distributed from North Carolina to near Brownsville, Texas. It seems probable that the populations reported on herein are to be considered as the latter subspecies. Additional systematic studies in southern Florida may disclose the presence of other well-defined taxonomic units perhaps including the Cuban subspecies *C. variegatus riverendi* (Poey).

Observations of spawning behavior were first made in a shallow, quiet mangrove lagoon, 3.2 miles north of Everglades, just west of Florida Highway 29, Collier Co., on March 20, 1952. The water was clear, slightly brown, without perceptible flow and brackish. The area was seldom over 1 foot deep and was bordered by mangrove thickets except on the roadside where a few emergent plants were noted. The bottom was covered with blackish silt which varied from a depth of about 2 inches near shore to over a foot in the deepest part of the lagoon. Where cleared by the action of *Cyprinodon* the white sand underneath was evident. The weather was clear and conditions for observation were excellent from 5 P.M. to dusk at 6:40 P.M. Activity gradually diminished and by dusk spawning had ceased and practically all fishes had moved off the spawning area. At that time

¹A grant from the Faculty Research Grants Committee, Cornell University, which covered transportation costs on the ichthyological expedition during which this study was made, is gratefully acknowledged.

TABLE 1. SEXUAL DIMORPHISM IN COLORATION IN *Cyprinodon variegatus* IN BREEDING CONDITION AS NOTED ON LIVING AND FRESHLY PRESERVED SPECIMENS TAKEN NEAR EVERGLADES AND AT ALVA, FLORIDA, MARCH 20-21, 1952

Character	Male	Female
Nape to dorsal origin	Iridescent bluish-green	Olivaceous or brown
Dark bars on sides and dorsum	Not prominent	Prominent
Lower sides and venter	Yellow or orange	Whitish
Black border on posterior margin of caudal	Present	Absent
Pelvic and anal fins	Yellow with much dark near tip	Clear, occasionally with some dark on anal
Dark ocellated spots in posterior dorsal membrane	None, or occasionally one small dusky spot	One or two, well developed
Pectoral fin	Black at tip blending to brownish-red near insertion	Clear

the water temperature was 84° F. and the air 85° F. The area was then vigorously seined and the following species were taken (number of specimens in parentheses): *Cyprinodon v. variegatus* Lacépède (61), *Adinia multifasciata* Girard (3), *Gambusia affinis holbrooki* (Girard) (20), *Lucania parva* (Baird & Girard) (12), *Mollienesia latipinna* LeSueur (41), *Menidia beryllina* (Cope) (1) and *Microgobius gulosus* (Girard) (2).

On March 21, 1952, spawning of *Cyprinodon* was again seen in a small tributary of the Caloosahatchee River at the east edge of Alva, at Florida Highway 80, Lee Co. Observations were made at a shallow pool just below the road. No large shore cover was present but low emergent aquatic plants were common along the edges of the pool. The water was fresh, white and clear. The flow was approximately one cfs., with slight current. The depth of water was up to 2 feet in the pool where the observations were made but was much shallower in other parts of the stream. The width was usually 1 to 2 feet but up to 15 feet in the pool. The bottom was of light brown sand overlain, where not cleared by action of *Cyprinodon*, with several inches of silt. The water temperature was 76° F., the air 88° F. at 3:20 P.M. Observations were made from 2 to 4:35 P.M. after which a collection was made that yielded the following fishes: *Notemigonus crysoleucas bosci* (Valenciennes) (88), *Notropis maculatus* (Hay) (1), *Notropis petersoni* Fowler (4), *Cyprinodon v. variegatus* Lacépède (10) *Fundulus chrysotus* Günther (8), *Fundulus confluentus* Goode & Bean (7), *Fundulus seminolis* Girard (2), *Mollienesia latipinna* LeSueur (180), *Gambusia affinis holbrooki* (Girard)

(120), *Heterandria formosa* Agassiz (2), *Jordanella floridae* Goode & Bean (20), *Chriopeops goodei* (Jordan) (6), *Chaenobryttus coronarius* (Bartram) (10), *Lepomis punctatus punctatus* (Cuvier) (25), *Lepomis macrochirus purpurascens* Cope (72) and *Labidesthes sicculus vanhyningi* Bean & Reid (1).

Apparently these situations are much like those utilized for spawning in other parts of the range of *Cyprinodon*. At Beaufort, N. C., they were observed breeding by Hildebrand (1919) in shallow brackish ponds. In the vicinity of New York City, Nichols & Breder (1927: 56) reported that spawning occurred in the shallow and usually brackish arms of the smaller bays. Here many were entrapped in the larger tide pools, apparently when in search of a spawning place.

SEXUAL DIMORPHISM

The sexes were easily separated by observation under natural conditions at distances up to 10 feet or more by the difference in coloration. The bright bluish-green and orange of the male immediately separated him from the more subdued female which was predominantly dull greenish-yellow and marked with prominent dark blotches. Outstanding features are noted in Table 1. Jordan & Evermann (1896: 672) gave a detailed description of the spawning colors in both sexes and Newman (1907: 341) described the other details of sexual dimorphism, such as breeding tubercles or contact organs, fin size and body depth.

When observed in the field males seemed to be much larger than females. However, measurement of all specimens of *Cyprinodon* collected showed that the largest male slightly ex-

ceeded the length of the largest female and that males barely averaged larger than females. Three mature males collected at Alva ranged from 36 to 44 mm (mean 40.3) in standard length and 6 mature females ranged from 36 to 41 mm (mean 38.9). In the sample taken near Everglades the 15 mature males ranged from 33 to 44 mm (mean 37.4) while 18 mature females ranged from 33 to 42 mm (mean 36.7). The 28 immature specimens from Everglades ranged from 15 to 32 mm. The illusion of larger size in males is chiefly due to the greater body depth, brighter colors and greater activity of the male. These data regarding size differences in the sexes are in general agreement with those given for Beaufort, N. C., by Hildebrand (1919) who reported that breeding males averaged 48 mm and females 45 mm in standard length. The extreme size for this species was recorded by Gunter (1945: 45) for the Texas coast. Of more than 6,000 specimens only 3 were more than 55 mm long, the longest being 93 mm. It is interesting to note the correlation of the larger size in the male with the nest building habit, a correlation also noted in many Cyprinidae.

TERRITORY

Territoriality in males of *Cyprinodon variegatus* was well developed. The larger territories were 1½ to 2 feet in diameter. In a few cases the territory was limited to a very small area surrounding the nest or depression. Each territory was roughly circular or oval although local obstructions such as roots of aquatic plants, logs and stones served to modify both the shape and size of the territory (see Plate I, Figure 1). The territory was easily recognized by its cleaned appearance. The constant movement of the many individuals of *Cyprinodon* close to the bottom cleared away the blackish silt.

Near Everglades the territories for the most part were located at depths of 1 to 6 inches and immediately adjacent to the bank. A few territories were noted to be as much as 10 feet from shore and were usually located near the side of a submerged palm log or rock where an examination revealed that the silt was not as thick as it was over the adjacent lagoon bottom. These outside territories which were generally occupied by large aggressive males were often very successful spawning sites since gravid females coming inshore from deeper water first came near them. Territories were absent elsewhere because of the extreme depth of silt which seemed to prevent males of *Cyprinodon* from clearing a territory.

After a period of a minute or so, guarding males seemed to have little or no fear of observers standing on the bank only a foot or so

from the nearest territories. Indeed, some never left their territories as we approached and sat or stood above them. When disturbed by a quick movement of an observer the males of *Cyprinodon* and associated species beat a quick retreat to the deeper part of the lagoon, some 20 feet away, or quickly burrowed into the silt or sand where they remained completely covered or with only the eyes visible. However, in less than a minute they were normally back guarding territories.

With few exceptions a single male occupied a territory. His behavior was characteristic. Any *Cyprinodon*, or other species of fish, that approached or came into his territory was immediately met by a strong drive. Even fishes much larger than the defender usually beat a hasty retreat when faced with this pugnacious onslaught. Other males of *Cyprinodon* normally turned away without a blow being struck. In some cases where males were of approximately equal size some tight circling was noted. On one occasion a large male was noted to replace a slightly smaller one which was guarding a nest. There was no dispute, the smaller male merely swimming away. No case was noted of a male escorting another male from the territory in what has been noted and called "deferred combat" in Cyprinidae by Reighard (1910: 1128) and Raney (1947: 127).

Occasionally in nature two males may make contact when guarding territories although nothing of this sort was seen near Everglades or at Alva. The senior writer noted males of *Cyprinodon* butting other males that attempted to enter a territory at the western end of West Lake in Everglades National Park, Florida, on December 29, 1949. Here the territories were small and located very close to shore. The population was abundant and 63 specimens were captured with a few drags of a seine. No spawning was noted (or looked for). The females were greatly swollen with eggs and both sexes were very likely in a high stage of development. Nichols & Breder (1927: 56) also reported of the New York City area that "in the breeding season males are commonly found several together, swimming actively about, fighting and chasing one another in circles, their steel-blue backs flashing."

At close quarters in an aquarium this butting by males has been seen occasionally. Newman (1907: 337) observed several combats where males butted heads, grasped jaws and shook powerfully from side to side. These encounters were of short duration and invariably the challenger retired. None of the combatants seemed to receive any injury in these battles. The breeding tubercles that are present on the head, fins

and body of the male (see figure in Newman, 1907: 327) are small and useful only during the spawning contact, and would seem of little or no value in the fights that occur between males.

Both large and small males held territories. The former were practically all successful at one time or another in securing mates, but none of the very small males were seen to spawn. Some variation in the behavior of males of *Cyprinodon* when holding a territory was noted. Those in a high state of sexual development stayed closer to the territory and spawned more often than other males which were apparently tired and which may have been spawning over a long period. Occasionally a male strayed from a territory as much as 5 or 6 feet but returned shortly. Often males were observed to scrape the belly and lower sides against twigs and rocks. This was done by a rather quick twisting motion. This may be associated with display, since the orange sides and belly flashed conspicuously in the sun. There is also the remote possibility that this may be a device for getting rid of parasites. However, this behavior seemed limited to males, which favors the former explanation.

Females were rather generally distributed throughout the spawning area. They swam deliberately, either scattered singly or in small groups of 6 to 10. When a female entered a territory she was attacked by a male, and immediately retreated unless ready to spawn at that moment. She appeared to be constantly in search of food and occasionally picked up objects from the bottom.

The territorial holdings and behavior of individuals of *Cyprinodon* were somewhat different in the small stream situation at Alva. Territoriality was much less pronounced and there were fewer nests. The total bottom area suitable for spawning was largely limited to the sides of the pool below the culvert but because of the small *Cyprinodon* population there was actually more space available per individual male. A male *Cyprinodon* often moved about the bottom of the pool investigating and circling a female which he encountered. Only occasionally did he return to his territory. There was little pursuit and near contact between males. Perhaps this was true because only 6 to 8 males were present and active at any one time, whereas near Everglades several dozen males were usually guarding territories during the period of observation. More mature females than males were present both at Alva and near Everglades. At Alva many large males of *Mollienesia* were present and actively displaying. The opportunity for meeting of these two species was limited

since individuals of *Cyprinodon* remained mostly near the bottom while most of the display of the molly was at the upper or median levels. When a male molly came close to the territory of a male *Cyprinodon*, the former was quickly rebuffed.

A summary of the behavior of the male *Cyprinodon* within his territory follows. Most of the time he chased intruding fishes including females of his own kind, rested on the bottom, occasionally rose to the nearby surface to eat small objects, worked on the nest but rarely and spawned when the opportunity occurred.

NEST BUILDING

One nest was located in each territory. These nests were shallow saucer-shaped pits normally circular or oval in shape and usually from 4 to 6 inches in diameter. They varied in depth from 1 to 1.5 inches. Usually the nest was located somewhat near the center of a territory although local conditions and obstructions modified this so that occasionally the nesting depression was even located at the periphery of a territory.

Near Everglades there was one excellent spawning area not used at the time of our observations although it was apparent that it had recently been used. Approximately 100 nests were counted here in an area of 12 square feet and territories probably were limited in size to a very small area that hardly exceeded the extent of the nest depression. In the area where most spawning occurred at the time of our observations, 12 inches was the minimum distance between lips of adjacent nests.

In practically all cases the nest was built by the male *Cyprinodon*. Nest building consisted of two operations. The male took silt and small stones with the mouth from near the bottom of the depression and blew them toward the periphery of the nest. However, the most effective type of nest building occurred when a male dipped downward into the pit and vibrated his body rapidly against the bottom of the depression. This stirred up the sand and silt and brushed it to either side by the body undulations. During this series of vibrations, the body of the male usually moved forward and upward and the tail functioned effectively in moving sand and detritus. The time involved in the nest building vibrations was usually from one to three seconds. On a few occasions this activity was repeated two or three times in quick succession. The time spent by any male in nest building was very limited. All observed building was in nests already partially excavated. Possibly at the start of nest building or of territorial behavior in any given locality more time

was given to this activity. Nesting activity was noted briefly by Nichols & Breder (1927: 56) who reported that "a male was observed to go repeatedly to the bottom and wriggle vigorously with its belly against the mud so that little clouds of the same rose on either side (Mastic, June 18)."

On several occasions at Alva a female was seen working on a nest by dipping down into the cavity and vibrating rapidly from side to side (see Plate II, Figure 4.) On one occasion a female also acted like a male as far as territoriality was concerned. She completed nest building behavior as described above, with the exception of picking up sand in the mouth, which no female was observed to do. She chased another female away from the nest and otherwise assumed the pugnacious attitude and activity of a male. However, she soon deserted and resumed the typical female behavior of slowly swimming about near the bottom. This type of behavior is similar to that reported by Noble (1938: 136) for the jewel fish, *Hemichromis bimaculatus* Gill. Under exceptional circumstances the female of this cichlid may select a territory and even stimulate a male by courtship movements.

Another instance of interesting behavior in a female *Cyprinodon* was noted in one case at Alva. She burrowed into the sand by wriggling the body. This activity at first looked like the preliminaries of nest building. However, she continued to burrow until only the eyes and upper dorsum could be seen. She remained in this position for about 15 minutes, not leaving even when investigated by several other females that nosed her.

Spawning within the nest was unusual and any spot within or even outside the territory was used. In this respect the behavior is much like that of the eastern blacknose dace as reported by Raney (1940: 402).

SPAWNING

When on or near the territory and often when at a distance from it, the male may be ready to spawn. Females were rather generally distributed over the area but mostly outside the territories. They swam about slowly in small groups of six to ten or were scattered singly. When a female came inshore toward a territory she was met by the attack of a male. When ready to spawn she held her position, retreated hesitantly to be overtaken by the male or circled back and came to rest. Thus the male recognized her and came quickly alongside (see Plate I, Figure 2). Herein is one of the main differences in behavior from that observed in an aquarium by Newman (1907: 338). In the confines of a

tank the male usually followed a female until he cornered her at the bottom, or side of the tank and there spawned with her. Cornering also takes place occasionally in nature but extensive following was not observed.

At the time of spawning, as shown in Plate II, Figure 3, the sexes assumed a parallel course with their venters near the bottom. The male inclined his body toward that of the female, so as to make an angle of somewhat more than 45 degrees with the bottom. The female inclined slightly but held her position against the male. This contact was probably aided by the presence of breeding tubercles on the side of the male. The dorsal fin was erect and probably in contact with the female at least near its base. In the aquarium Newman (1907: 338) noted that the male held the female forward of her caudal fin chiefly by using his strong dorsal fin. The function of the anal fin was not observed by us but considering the well-developed tubercles that cover its surface it seems likely that it was in contact with the female. The pectoral fins which normally were in constant motion were now appressed at least on the free side of the male. The other pectoral may have been used as a grasping organ but this was not observed. At this moment the male threw his body into an S-shaped curve with the more prominent bend in the posterior half of the body closely appressed to the female so that the two genital openings were in apposition. Part of the time his caudal fin appeared to be in contact with the bottom. A rapid vibration of the bodies occurred which lasted for one or often as much as two seconds, during which the eggs were presumably laid although they were not visible. The bottom was not disturbed much during the spawning act. Occasionally the spawning act was repeated after only a second or two of rest, being sometimes preceded by a forward movement of several inches during which each sex maintained its relative position. It seemed to matter little whether the male spawned on the right or left side of the female. One male spawned three times in rapid succession and changed sides each time. Commonly the act was repeated as often as two to five times within a half minute. One of the successful males was observed to spawn 20 times in a 30-minute period. Occasionally between spawning acts a male rose to the surface and took food.

In all but one case spawning by a pair was the rule. In the exception, spawning occurred in the usual way and, as the male moved away for an instant, another male took position alongside the female. The first male immediately returned to the other side of the female and the three spawned. Near Everglades occasionally,

outside a territory, a male chased a female, cornered her against a log or stone and spawned. At Alva it seemed to be the general rule that spawning occurred wherever a male met a ready female. This was often on the top or at the side of a rock.

When a female finished spawning, she usually retreated from the area but doubtless returned a short time later although no data were obtained on the number of times a female spawned or to what territory she returned. However, a male continued to spawn as long as females moved into his territory. Small males were not observed to spawn.

Although the eggs were not visible to the observers, there was little doubt that they were laid, for often mollies, mosquito fishes and other species including females of *Cyprinodon* rushed to the precise spot, where they were presumed to eat the eggs. This behavior is also typical of many sunfishes and cyprinids (see Raney, 1947: 127) which seem to recognize the spawning act.

Males and females of *Cyprinodon* captured from the spawning area were both ripe. The females were stripped easily; the eggs were translucent and yellow. Kuntz (1916: 410) gave figures of the eggs which are demersal, 1.2-1.4 mm in diameter, and covered by many adhesive threads which cause them to adhere to each other in small groups and to the sand. He also figured the larvae and young at stages from 4 to 12 mm total length.

The spawning season extends over a period of considerably more than half a year when the data from the known range are considered. They were observed in spawning condition in late December in the southern part of Everglades National Park, Florida. In the vicinity of New York City ripe specimens of *Cyprinodon* have been found from May until September according to Nichols & Breder (1927: 56). At Beaufort, N. C., Hildebrand (1919) reported that the spawning season extended from April to October, and noted that a single female spawned in late April, late May, June and numerous times in July and August. Ten days or a month passed between spawnings or in some cases eggs were deposited daily for a short period.

DISPLAY AND BREEDING OF OTHER FISHES

At Alva, *Gambusia affinis holbrooki* was observed to breed and *Mollienesia latipinna* and *Chrioeps goodei* were seen displaying. Individuals of *Jordanella floridae*, a close relative of *Cyprinodon variegatus*, were present but not in breeding condition. They were scattered over and near the bottom where they apparently searched for food. When at rest on the bottom the pectoral fins waved back and forth slowly

in contrast to the very rapid movement noted in *Cyprinodon*.

The numerous large and brilliantly colored males of *Mollienesia* were scattered throughout the pool. They actively displayed at any level but often at or near the surface. The male erected his large dorsal fin and tended to herd any female which crossed his path by crossing back and forth in front of her. The bright blue and orange caudal fin was expanded at this time and was often flashed in the face of the female. The male nudged the female near the vent with his snout. There was no tendency for a male to hold a territory but rather he moved freely about the pool. No contact or display was noted between males. Many males were much larger than any female present.

Males of *Gambusia* were also very numerous and were scattered about the pool, mostly at mid and top levels. The males constantly nudged the larger and slower moving females about the vent. When ready to mate the females moved even more slowly than usual. At this time the male brought the gonopodium forward and made contact. On some occasions several males followed a large female. Males of *Gambusia* were seen to follow and nudge females of *Mollienesia* but under circumstances that suggested they might be interested in newly born young, although no young were actually observed.

Display by a male *Chrioeps goodei* was seen several times although no spawning was observed. It occurred near the surface at the edge of a bed of emergent aquatic plants. The male with its bright dorsal and anal fins fully extended swam in front of a female. As the male continued to display the female followed with her snout just behind his caudal fin. After a short time the male ceased the display and swam away. At this time the male has the orange of the dorsal and anal fin replaced by azure blue and the edging of these fins is somewhat enlarged and is an intense black. Ordinarily the male is orange on the posterior part of the dorsal and anal fins and it seems that the complete development of blue is of very short duration, occurring only at the height of the breeding season.

SUMMARY

Territoriality, nest building, spawning and other phases of the behavior of *Cyprinodon variegatus* was observed in a brackish mangrove lagoon and in a small fresh water stream in southern Florida in late March, 1952. This species is recommended as an excellent subject for further detailed behavioral studies, since one may readily approach and observe its activities in nature.

The mature individuals of either sex are easily identified by their coloration. The male was iridescent bluish-green between the origin of the dorsal fin and the nape whereas the female was conspicuously marked with dark blotches.

Territoriality was well developed in the male. Territories were roughly circular, although modified somewhat by obstructions such as logs and stones, and varied in size up to a maximum of 2 feet. The territory was cleared by a male which by the constant motion of the body swept away the dark silt from the underlying light colored sand. With vigorous rushes, the guarding male drove all intruding fish from the territory although actual contact seldom occurred. The male fed intermittently while guarding the territory.

Within each territory, usually near the center but sometimes near the edge, was a saucer-shaped nest 4 to 6 inches in diameter. This nest was usually dug by the male by means of rapid undulations of the body and tail and by the use of the mouth. Excavation by the female was observed but apparently was rare.

Spawning occurred in or outside the territory but was not observed within a nest. When ready to spawn the female no longer retreated from the rush of the male but held her position or circled back and came to rest near the bottom. The male inclined his body in an S-shaped curve against that of the female so that the vents were in close apposition. Spawning was signalled by the rapid vibration of the bodies for one to two seconds. The act was sometimes repeated after an interval of one or two seconds. Spawning by a pair was the rule.

Differences in behavior at the two localities were believed to be correlated with differences in the available spawning ground in proportion to the abundance of breeding males present.

The display of *Mollienesia latipinna* and *Chriopeops goodei* and breeding of *Gambusia affinis holbrooki* was also observed.

BIBLIOGRAPHY

- BREDER, C. M., JR.
1934. Ecology of an oceanic fresh-water lake, Andros Island, Bahamas, with special reference to its fishes. *Zoologica*, 18 (3): 57-88.
- COWLES, R. B.
1934. Notes on the ecology and breeding habits of the desert minnow, *Cyprinodon macularius* Baird & Girard. *Copeia*, 1934 (1): 40-42.
- GUNTER, GORDON
1945. Studies on marine fishes of Texas. *Publ. Inst. Marine Sci. Univ. Texas*, 1 (1): 1-190.
- HILDEBRAND, S. F.
1919. Notes of the life history of the minnows, *Gambusia affinis* and *Cyprinodon variegatus*. *Rept. U. S. Comm. Fish.*, 1917: 1-14.
- HILDEBRAND, S. F. & W. C. SCHROEDER
1928. Fishes of Chesapeake Bay. *Bull. U. S. Bureau Fish.*, 43 (1927), Pt. 1: 1-366.
- HUBBS, C. L.
1936. Fishes of the Yucatan Peninsula. *Carn. Inst. Wash., Publ.*, 457: 157-287.
- JORDAN, D. S. & B. W. EVERMANN
1896. The fishes of North and Middle America. *Bull. U. S. Nat. Mus.*, 47 (Part 1): 1-1240.
- KUNTZ, ALBERT
1916. Notes on the embryology and larval development of five species of teleostean fishes. *Bull. U. S. Bureau Fish.*, 34 (1914): 409-429.
- MILLER, R. R.
1942. Rearing desert fish in garden pools. *The Aquarium Jour.*, 15 (10): 96-97.
- NEWMAN, H. H.
1907. Spawning behavior and sexual dimorphism in *Fundulus heteroclitus* and allied fish. *Biol. Bull.*, 12: 314-348.
- NICHOLS, J. T. & C. M. BREDER, JR.
1927. The marine fishes of New York and southern New England. *Zoologica*, 9 (1): 1-192.
- NOBLE, G. K.
1938. Sexual selection among fishes. *Biol. Reviews*, 13: 133-158.
- RANEY, E. C.
1940. Comparison of the breeding habits of two subspecies of black-nosed dace, *Rhinichthys atratulus* (Hermann). *Amer. Midl. Nat.*, 23 (2): 399-403.
1947. *Nocomis* nests used by other breeding cyprinid fishes in Virginia. *Zoologica*, 32 (3): 125-133.
- REIGHARD, J.
1910. Methods of studying the habits of fishes, with an account of the breeding habits of the horned dace. *Bull. U. S. Bureau Fish.*, 28 (1908): Pt. 2: 1111-36.

EXPLANATION OF THE PLATES

PLATE I

- FIG. 1. Territory of *Cyprinodon v. variegatus* in a mangrove lagoon near Everglades, Florida, March 20, 1952. The guarding male is located near the upper center. Silt covers the bottom except in the cleared area of the territory which is approximately 2 feet in diameter. The territory is somewhat modified from the usual circular form by the log on the right. The end of the black line marks the center of nest, which is 4 inches in diameter but which is not particularly conspicuous in this territory.
- FIG. 2. Same territory as shown above in FIG. 1. A male *Cyprinodon* (left center) approaches the banded female (right center) just before spawning.

PLATE II

- FIG. 3. The spawning act of *Cyprinodon* in the same territory shown in Plate I. The male (left center) is marked by a black-tipped caudal fin and an iridescent streak between the eye and dorsal fin. His body is in an S-shaped curve and is pressed against the female. The female (right center) is somewhat inclined and her dorsum is notably blotched. Neither is conspicuous over the mottled background of the bottom.
- FIG. 4. Nest building activity by a female *Cyprinodon* at Alva, Florida, March 21, 1952. A cloud of sand surrounds the nesting depression as the female wriggles her body against the bottom. The male, which usually makes the nest, uses the same method.