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A Revision of the Genus Malacosoma Hübner in North America (Lepidoptera: Lasiocampidae): Systematics, Biology, Immatures, and Parasites

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and
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By
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Introduction

The genus *Malacosoma* Hübner, the tent caterpillars, is a group of lasiocampid moths restricted to the temperate regions of the Northern Hemisphere. The adults often are ignored, possibly because they are quite abundant (collectors tend to save rare or unusual specimens), are moderate in size, comparatively drab in color, and have a lifespan of only a few days at the most. The larvae, however, are well known for the conspicuous tents (i.e., webs, nests) which some species construct in early spring soon after the first leaves appear. The hordes of caterpillars (sometimes incorrectly called "armyworms") are perhaps the best-known life stage to the layman.

This present study of the genus *Malacosoma* Hübner in North America is modified from a Ph.D. thesis by Frederick W. Stehr which was submitted to the University of Minnesota in 1964. The literature was

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It should be understood that all changes in nomenclature presented in this publication are the sole responsibility of Stehr (not Stehr and Cook).

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History of the Classification of *Malacosoma* in North America

Most species of North American *Malacosoma* were described prior to 1900, and most of them were described under the generic name *Clisiocampa* Curtis 1828 before it was realized that Hübner had proposed *Malacosoma* in 1820.

Currently, four species of *Malacosoma* generally are recognized in Europe and North Africa (at least one of which extends across Asia all the way to Japan), and two are described from northern India. At the time this study was begun, ten species were recognized in North America. The classification in North America has remained essentially the same for the past 50 years, except that Freeman raised *M. fragile lutescens* (Neumoegen and Dyar) to species rank in 1949.

East of the 95th meridian (roughly a line drawn from the Manitoba-Ontario border to Houston, Texas), the classification has been quite clear-cut, since only two species, *M. americanum* (Fabricius), the eastern tent caterpillar, and *M. disstria* Hübner, the forest tent caterpillar, were recognized until 1937. In that year a third species, the so-called western tent caterpillar, *M. pluviale* (Dyar), was recorded from eastern Canada by Atwood (1943). These three species are quite distinct, and usually there is no difficulty in distinguishing them.

West of the 95th meridian, however, the situation is entirely different, for many species, subspecies, forms, etc., were recognized when this study was begun. Most of these were described from one or, at most, a few specimens from a single locality, with little or no idea of the populations that occurred in areas between the type localities. Of course, this is to be expected, since, in the period between 1850 and 1900 when most of the species were described, the West still was being settled and many areas were virtually inaccessible or inhospitable.

During this period and up to the present, it had been recognized widely that the adults were highly variable in color and pattern, and that it was hazardous to describe a species in this genus without knowledge of the larvae (which were believed to be relatively constant in color and pattern). Stretch (1881), the describer of several species of *Malacosoma*, comments: "In studying the genus, we must depend chiefly on the transformations for the separation of species, and where these are unknown, not so much on color as on the structure and proportion of the markings, as the species are very variable and approach each other in the imagines." Henry Edwards (1882) in describing *M. incurvum* says: "It is rather a hazardous experiment to describe a species of this genus, without a knowledge of the preparatory stages . . ." More recently, Langston (1957) makes the following statement concerning the identification of *Malacosoma:* "Many species of *Malacosoma* are so highly variable in the adult stage that it is almost impossible to separate them taxonomically. The larvae are quite distinct for most species, however, and are used as the basis for separation."

The literature, however, contains a few statements which indicate that the larvae are not as constant or as different as generally supposed. Langston (1957) says the larvae are quite distinct for *most* species, implying that some larvae may be difficult to identify. And Clark (1956, 1958) in his studies on the ecology of polyhedrosis of tent caterpillars has commented on variations in both larvae and adults that he observed in California and New Mexico. Even in the older literature, statements indicate that considerable variation was present in the larvae. For example, Dyar (1893) in the original description of *M. pluviale* says of the larva: "Body black, a pale blue dorsal line, divided between the segments, obsolete at the extremities, and forming 9 rather narrow, elongate, blue spots, tapering at their ends, exactly as in *C. fragilis*." (*C. fragilis* is the so-called Great Basin tent caterpillar.) Dyar (1895b) made the following additional remarks in comparing the larvae of *pluviale* with *fragile:*

> The fully marked larvae look strikingly different from *fragilis*, yet the two are exactly alike in pattern, and whereas in *pluvialis* the orange marks are greatly developed and the blue reduced, in *fragilis* the orange is reduced almost to obliteration and the blue greatly extended. Mr. Stretch has noted a considerable range of variation in the Astoria larvae. He says that they varied by the expansion or contraction of the dorsal orange markings, and in the latter case the blue became strikingly visible. This is a greater range of variation than I have happened to observe in any one locality, but the specimens sent me by Mr. Piper have the orange considerably reduced. I suspect that as we go East the orange marks will tend to be supplanted by the blue, and this species will grade into *fragilis*. However, I have yet to see larvae which are not definitely one or the other, and the moths seem not to pass into each other, though the Idaho region is still to be explored.

Dyar was correct in suspecting that *pluviale* would grade into *fragile*, and a similar situation has been found for several other "species" of *Malacosoma* described from western North America.

In short, ever since the species of *Malacosoma* first were described (and up to the present), identification of adult *Malacosoma* has been difficult or impossible. Larval characters have been supposed to be more reliable, but doubts have been expressed about them, too. This is particularly true of the *Malacosoma* which occur in the western part of North America.

A systematic study of *Malacosoma* based largely on adult morphology was completed by the senior author in 1958 (Stehr, unpublished M.S. thesis). It resulted in four species clearly being recognized in the United States and Canada, plus a fifth group of described species which could not be separated from one another by any known adult morphological characters, but which were supposed to be quite distinct as larvae. As only limited numbers of larvae were available, and most of them were not positively associated with adults, it was impossible to determine how closely the supposedly constant larval differences were correlated with adult differences.

Because of the lack of any specimens from many areas, the limited numbers of larvae, the even more limited numbers of larvae associated with adults, and the scarcity of reliable information about egg masses, tents, host plants, distribution, etc., it was decided that the only way to obtain a better understanding of these western North American groups was to study them in the field. The results of this field work, carried out in 1960, 1961, and 1962, form a large part of the information contained herein.

Summary of Results

The classification for the North American *Malacosoma* presented below is a result of this study. Based on available information, it is believed that this classification best represents the evolutionary stage attained by these populations, and it is given here in brief outline form, along with an indication of the status change of the names.

The most important changes are the reduction of *M. ambisimile*, *M. pluviale*, *M. lutescens*, and *M. fragile* to subspecies of *M. californicum* (Packard), the name which has priority, and the elevation of *M. incurvum* (Henry Edwards) to a species again. Actually, Packard was correct when he stated on several occasions his belief that several of the described species were only varieties of *californicum*. For example, in 1890 he commented:

> The caterpillar of a species of *Clisiocampa*, which I have now little doubt is that of *C. californica*, which I have bred from eggs received from Miss Emily L. Morton, to whom they were sent from Colorado by Mr. Nash, was abundant at Virginia City and Helena, Mont., on the leaves of the wild rose so common near those towns . . . a blown specimen received from Prof. J. J. Rivers 'from the mountains of Nevada that may be *fragilis*', is unquestionably a very distinctly marked larva of *C. californica* . . . In fact, this caterpillar is exposed to much variation, and it would be easy to make several species out of this widely diffused one, which in Colorado feeds on the aspen . . .

Grote (1895) made similar comments concerning the status of *M. ambisimilis*, *M. californica*, and *M. pluvialis*. He said, "In all these cases the names can only be applied with certainty to the larvae and bred moths. To consider them distinct species, as species are now understood, is clearly an impossibility . . ." It is difficult to know exactly what Grote understood a species to be, but his opinions on the status of these three "species" agree with the classification presented here. Unfortunately, the views of Dyar and others predominated, since Packard's and Grote's suggestions received no further attention.

The distribution maps for each species and subspecies in the following list should also be examined at this time (figs. 1, 2, 3, and 4). Other names used in the past are listed in the appropriate synonymy.

Malacosoma disstria Hübner—status unchanged
Malacosoma constrictum constrictum (Henry Edwards)—status unchanged
Malacosoma constrictum austrinum Stehr—new subspecies
Malacosoma tigris (Dyar)—status unchanged
Malacosoma americanum (Fabricius)—status unchanged
Malacosoma californicum (Packard)—*californicum* has priority over all other names that have been applied to this species throughout western North America
Malacosoma californicum californicum (Packard)—nominate subspecies
Malacosoma californicum ambisimile (Dyar)—reduced to subspecies
Malacosoma californicum recenseo Dyar—status unchanged.
Malacosoma californicum pluviale (Dyar)—reduced to subspecies
Malacosoma californicum lutescens (Neumoegen and Dyar)—reduced to subspecies
Malacosoma californicum fragile (Stretch)—reduced to subspecies

Malacosoma incurvum incurvum (Henry Edwards)—raised to species
Malacosoma incurvum discoloratum (Neumoegen)—raised to subspecies
Malacosoma incurvum aztecum (Neumoegen)—regarded as a subspecies

In figure 2 note that the six subspecies of *M. californicum* occur at the edges of the distributional range. In the center between the subspecies a large area is occupied by populations that are highly variable. None of the subpopulations within this area are regarded as being sufficiently distinct to warrant formal recognition, so they are referred to as *M. californicum.* The following terminology has been adopted, however, to distinguish between these central populations and the species as a whole, including the subspecies. The name "*M. californicum*" is used to refer to the species when it is not necessary to distinguish between subspecies and other populations. The name "*M. californicum* (central populations)" is used when referring to all populations except the subspecies.

Unless specifically stated otherwise, it can be assumed that intermediate and intergrading populations are present wherever the distributions of subspecies adjoin.

Economic Importance of the Genus *Malacosoma*

In North America tent caterpillars have been known as pests of various shrubs and trees since the earliest colonial times. Britton (1935) gives a brief history of outbreaks in New England of *M. americanum*, the eastern tent caterpillar, and states that "at least in 1646, the pest was exceedingly abundant, as it has been in certain other seasons." Epidemic populations of *Malacosoma disstria*, the forest tent caterpillar, are recorded in eastern North America as early as 1791 (Baird, 1918). Sippell (1962) mentions an outbreak described by Paul Kane in 1834 which may be the earliest record of an outbreak in Canada of *Malacosoma disstria*, the forest tent caterpillar, although it is not definitely established that *M. disstria* was the insect responsible.

All species of North American tent caterpillars either have been recorded in the literature as occurring in outbreak numbers or personally have been observed to do so during the field seasons that were spent studying them in the western United States and Canada. Some recent outbreaks have occurred in areas that are relatively undisturbed by man. Examples of such outbreaks are those of *M. disstria* and *M. tigris* in the scrubby oak forests of central Texas, *M. constrictum* in the oak stands of some of the mountains of central and southern California, and *M. californicum* in some of the aspen forests of the Rocky Mountains. Because of these outbreaks and because of the old records of outbreaks there can be little doubt that tent caterpillars occurred in outbreak numbers long before any settlers arrived in North America.

In many parts of North America the original vegetation has been drastically altered by man's activities, and replacement often has been by species that are the preferred hosts of tent caterpillars. The best example of this is the aspen forests of the northern United States and southern Canada, which came in after the conifers had been logged or burned off in many areas. Other favored hosts, such as most species of *Prunus* and introduced fruit trees, would be rare in mature hardwood forests, but they grow abundantly along fencerows, roadsides, and other sites that have been opened up by man's activities. No direct evidence indicates that the mere presence of vast new acreages of suitable hosts has caused outbreaks of tent caterpillars, but the larger the suitable area the more likely it is that conditions favoring an outbreak would be found somewhere within the area. It seems likely, therefore, that we have more outbreaks than formerly, and more extensive ones, too, since suitable hosts are abundant over larger areas.

Numerous authors have suggested that tent caterpillars may occur in outbreaks at about 10-year intervals, but outbreaks do not appear to be cyclic, since the length of time between reported outbreaks in a given locality varies considerably, being as short as 3 to 5 years, or as long 15 to 20 years or more. For example, Hildahl and Reeks (1960) have reported the recorded outbreaks of *M. disstria* in Manitoba and Saskatchewan. For 10 selected localities they reported the interval between the first severe infestation at a given locality and the next severe infestation at the same locality to vary from about 6 to 16 years. They also point out that 4 of the 10 localities experienced only one outbreak in a 35-year period. One of these localities had an outbreak in 1938, but had not had another one up to 1959, and others had not had an outbreak for almost as long.

Outbreaks in a given locality usually persist for 1 to 4 years before being brought under control by various factors such as disease, parasites, starvation, and weather, or a combination of several factors. Often an outbreak may be collapsing in one area while gaining momentum in another area that may not be any great distance away. Hildahl and Reeks (1960) report that *M. disstria* occurred in outbreak numbers at some place in Saskatchewan or Manitoba each year from 1923 to 1953. Records before 1923 were incomplete, and after 1953 outbreaks declined to the point where no defoliation was noted in either province in 1955 or 1956. Beginning in 1957, however, and continuing to the present time (1964), outbreaks again have been present (personal observation and various reports). This record shows that outbreaks have occurred almost continously since 1923, and it takes into account only one species and covers only two Canadian provinces. It would be safe to say that *Malacosoma* could be found in outbreak numbers somewhere in North America every year, and in most years numerous outbreaks could be located.

Many observers have reported on the factors which end tent caterpillar outbreaks, but little study has been done on the factors which permit an outbreak to build up. Hodson (1962) has presented data indicating that two outbreaks of *M. disstria* in Minnesota were preceded by an interval of 2 to 3 years in which temperatures after hatching were moderate, with no prolonged cold periods below 59° F. (when little or no feeding occurs), and with no temperatures cold enough to severely damage the aspen foliage and result in starvation. In addition, he reported that in both outbreaks there was an uninterrupted series of 6 years prior to and during the course of the outbreaks when moderate temperature after hatching was the rule. This and other unpublished data have led him to conclude that a series of years in which late springs are followed by moderate temperatures are most favorable for an outbreak of *M. disstria.*

Wellington (1952) states that the physical requirements of *M. disstria* include warm, humid, cloudy weather during much of the larval stage, and he has presented evidence suggesting that two outbreaks of *M. disstria* north of Lake Superior and Lake Huron (these outbreaks occurred at the same time as those reported by Hodson) were preceded by increases in the annual numbers of cyclonic passages. This agrees, in a general way, with the evidence presented by Hodson since cyclonic systems would tend to be warmer and more moderate than anticyclonic systems. The movement through an area, however, of a single anticyclonic system cold enough to freeze the aspen foliage could be disastrous to the caterpillars, but it would not stand out as important if only the relative frequencies of cyclonic or anticyclonic systems were compared without considering their individual characteristics.

The principal damage is caused, of course, by the tremendous numbers of caterpillars that may completely defoliate anything from the backyard apple tree to thousands of square miles of woodland (fig. 330). Trees that have been completely defoliated will put out a new set of leaves, but growth is greatly reduced, and weakening or even the death of the tree may result. As early as 1904, Foster reported a great reduction in the size of annual rings produced by a sugar maple in New Hampshire following heavy defoliation by *M.*

disstria in the years 1897–1899. More recently, Duncan and Hodson (1958), Ghent (1958), Rose (1958), Hildahl and Reeks (1960), and Barter and Cameron (1955) have reported that basal area growth of aspen is greatly reduced by defoliation by *M. disstria*. Duncan and Hodson reported that a reduction of basal area growth of up to 90 percent may occur in the year following heavy defoliation. Churchill *et al.* (1964) conclude that recovery of normal basal area growth after the cessation of defoliation appears to take one growing season in the most severe cases. Thus, several years of heavy defoliation would cause a delay of several years until the time a tree is large enough to be of commercial value, regardless of whether the defoliation target is an aspen used for pulpwood in the North or a black cherry used for furniture in the eastern United States. No doubt other host species would be affected similarly by several years of heavy defoliation.

In a given locality, heavy or complete defoliation usually does not occur for more than 2 to 3 years in succession. Churchill *et al.* (1964) reported on the long-term effects of defoliation of aspen in Minnesota. Their study has shown increasing mortality with increasing defoliation in the combined intermediate, codominant, and dominant vigor class, but not with the suppressed class. They conclude, therefore, that circumstantial evidence of mortality caused at least indirectly by forest tent caterpillar feeding is provided. Reports such as those of Caudell (1902b) attributing death of oak brush in Colorado entirely to repeated defoliation by *M. tigris* are rare, and usually are not supported by any evidence other than casual observation. Even if hosts are not killed, however, several successive years of heavy defoliation may weaken them enough to permit other factors such as poor site (Churchill *et al.*, 1964), drought (Duncan and Hodson, 1958), overgrazing (Clark, 1956a), or bark beetles and borers (Barter and Cameron, 1955) to cause higher mortality rates.

In the western states tent caterpillars often feed on various shrubs and bushes that are valuable browse species for both domestic stock and big game. Clark (1956a) reported that defoliation by tent caterpillars in combination with other factors has resulted in serious damage or death to large areas of bitterbrush browse, *Purshia tridentata*, in parts of northern California.

In some resort areas of the United States and Canada tent caterpillars may adversely affect business, since many vacationers are reluctant to fight the swarms of "worms," and are repelled by the bare, "mid-winter" appearance of the forests in late June and early July before a second set of leaves is produced.

The forest tent caterpillar, *M. disstria*, often has been so abundant that reportedly it has stopped trains, although this hardly can be regarded as causing a great economic loss. Swain (1918) gives the following account:

> It was not uncommon last summer for the trains on the Gatineau River line of the Canadian Pacific Railway in Quebec to be stopped by myriads of these caterpillars swarming on the rails, which were effectively greased by their crushed bodies. The engine men were kept busy in many places sanding the rails and sweeping away the crawling masses of caterpillars in front of the engine; while the latter was often covered with hundreds of the creatures after passing through infested districts.

Similar instances have been reported from other areas.

Many species of tent caterpillars will feed on fruit trees throughout North America, but they are of no concern to the professional fruitgrower since the normal spray program used for more serious pests also will control them effectively. The backyard fruit tree often is attacked, but the caterpillars usually are dispatched promptly by means of clippers, torch, broom, or similar home remedy.

One type of damage caused primarily by those species which build conspicuous tents is the "injury" to peoples' aesthetic sense caused by a nearly naked tree crawling with "worms" and bearing numerous unsightly masses of webbing. These "worms" and unsightly tents have in the past stirred up many a campaign to "eliminate tent caterpillars from the face of the earth" by collecting egg masses and by destroying caterpillars and tents. Harris (1841) gives the following exhortation:

> Let every able-bodied citizen, who is the owner of an apple or cherry tree, cultivated or wild, within our borders, appear on duty, and open the campaign on the first washing day in May, armed and equipped with brush and pail, as above directed, and give battle to the common enemy; and let every housewife be careful to reserve for use a plentiful supply of ammunition, strong waste soap-suds, after every weekly wash, till the liveried host shall have decamped from their quarters, and retreated for the season. If every man is prompt to do his duty I venture to predict that the enemy will be completely conquered in less time than it will take to exterminate the Indians in Florida.

Britton (1935) gives an interesting account of some egg mass and tent campaigns that were carried out against the eastern tent caterpillar. These usually consisted of attempts to persuade people to destroy all the tents that could be found and included contests for school children, Boy Scouts, etc., in which prizes were offered for the largest number of egg masses collected. Needless to say, such campaigns often were beneficial to selected trees, but as population-control programs they were failures.

In summary, it can be said that tent caterpillars are a nuisance problem in most parts of North America, but they can cause economic losses to forests, rangeland, and associated activities in areas where high populations persist for several succeeding years.

Life Cycle

The life cycles of all species of *Malacosoma* are very similar. Snodgrass (1938) gives a general description of *M. americanum* from egg through adult that is better and more detailed than others of a popular nature.

The eggs (usually 150–200, but ranging from a few to as many as 600) are laid as a mass encircling, or partially encircling, small twigs of the host plant, or as a relatively flat mass on larger branches, or even near the ground as a flat mass on the trunks of small trees or shrubs. As the eggs are deposited they are held in place by a frothy substance from the accessory glands which has been named "spumaline" by Hodson and Weinman (1945). Most species also cover the eggs with a layer of spumaline as they are laid. Embryological development begins immediately and the young caterpillars are fully formed within the eggs 2 to 3 weeks later. They then enter a period of diapause for a few months, followed by dormancy which lasts until the next spring.

Hatching takes place about the time the first new leaves appear in spring. This may range anywhere from late January in Florida to June at high elevations in the western mountains. The caterpillars' first meal necessarily consists of chorion and spumaline, since they must chew their way out, but they soon begin attacking buds or leaves and constructing their tent on a branch or in a nearby crotch if they happen to be a tentbuilding species. They do not feed within their tents; instead they crawl out to neighboring branches, spinning a strand of silk wherever they go and usually following it back to their tent after feeding. Those species which do not build tents cluster on branches or trunks between feeding periods. Tent caterpillars feed on a wide variety of hosts, but most commonly they are found on species belonging to the families Rosaceae, Fagaceae, and Salicaceae.

The number of instars is not constant, but the caterpillars usually pass through five or six instars in from 4 to 8 weeks, depending on weather conditions. Molting customarily takes place inside or on the tents of those species that build tents, or on a mat of silk spun on branches or trunks by the species that do not build tents. Most of the damage is caused by the last two instars, which consume many times as much food as all of the earlier instars combined. By the time the last instar has been reached, caterpillars are about 2 inches long, have lost their gregarious habit, and travel extensively searching for food. They are rather indiscriminate about what they eat at this stage, and this has resulted in many species of plants being listed as hosts even though egg masses may never be laid on them.

Toward the end of the last instar they become quite restless and often are seen wandering about in an apparently aimless way. Eventually they select an appropriate site in which to spin their cocoons, such as within the old tent, inside logs, beneath loose bark, between folded leaves, etc. The cocoons are about 1 inch long, fairly loosely constructed, and colored white or yellow by a powdery material dispersed between the strands of silk. The prepupal stage takes about 2 days and the pupal stage up to 2 weeks, depending on temperatures.

The adults emerge in late afternoon or early evening. Mating may take place the first day, and the female soon lays her eggs on a suitable host. Both males and females die in a few days since functional mouthparts are absent and no food can be taken.

Methods

The major part of the field work was carried out during the springs and summers of 1960 and 1961, with some additional work done in the spring of 1962. The general plan was to collect larvae and rear them to adults, starting in the south at low elevations and working north as the season progressed.

It is apparent that an area as large as western North America cannot be studied both intensively and extensively in two field seasons, and that only relatively widely scattered samples can be taken except in areas believed to be of particular importance for one reason or another. Possibly the most important reason for covering a large area is to determine what forms are present in areas that have never been collected and to determine the distributional limits of known populations. All available information pointed to much greater variations from area to area rather than from valley to alpine areas. Therefore, priority was given to covering as much area as possible. Consequently, in many areas it was not possible to study the alpine populations before it was necessary to move north to study more northern populations occurring at lower elevations.

All of the field collecting was based on the fact that those "species" of tent caterpillars whose status was doubtful and most in need of study build a rather conspicuous tent which can be spotted with little difficulty from the road while driving from 20 to 50 m.p.h. This permitted large areas to be covered relatively rapidly, and obviated the necessity of stopping every few miles to look for caterpillars. The difficulty in locating larvae which do not construct tents can be illustrated by the fact that of the nearly 500 collections made in 1960 and 1961, only 7 were made of *M. disstria*, which does not build a tent—6 of the 7 were made incidental to collecting tentbuilders and the other 1 was collected as a result of very conspicuous defoliation.

Equipment

The major piece of equipment was a mobile insectary-trailer (fig. 336) containing 45 built-in rearing cages, a workbench, and sufficient storage space for all necessary collecting and preservation materials. The exterior of the trailer was fitted with plywood flaps that protected the cages when the trailer was being moved; they could be propped open for shade in warm localities, or removed for direct sun in cool areas. The roof was constructed with a dead-air space, vented, insulated with fiberglass and covered with aluminum sheeting. This combination, plus a white exterior and cross ventilation, kept the temperature inside the trailer at or below the outside air temperature. This was quite satisfactory for rearing *Malacosoma*.

The cages (18 inches high, 18 inches wide, 24 inches deep) opened to the inside aisle of the trailer. All sides were screened with 50 × 50 mesh bronze screen to confine small larvae and prevent rusting. The floor of a cage was made of plywood which also served as the ceiling of the cage below. The cages were built-in; they should have been removable so they could be cleaned more easily, or disinfected if necessary.

Freshly cut foliage was provided as often as necessary, and was held in 1-quart mason jars filled with water. The space in the mouth of the jar not filled by branches was plugged with a wad of paper towels to prevent larvae from crawling or falling into the water. To prevent the jars from tipping over when the trailer was moved and also to conserve space, two holes, the size of the inside diameter of the jar ring, were drilled in one side of the floor of each cage, alternating sides with tiers of cages. Jar rings were screwed to the ceiling and to the floor around the holes. Mason jars were then screwed into the rings from below, permitting the base of the branches from the cage above to project into the cage below. This resulted in a saving of about 7 inches of vertical space per cage, in addition to providing firm anchorage for the jars. The jar rings on the floor of the cage were used to hold jar caps in place over the holes if the cage was to be used for some other purpose. Of course, with this arrangement, when jars of water are changed, it is possible for larvae from one cage to get into the cage below or above, but the chance of this happening is practically nonexistent if any larvae near the opening are moved away and the fresh jar of water is screwed into the ring as soon as the old one is removed. Usually it is not necessary to do this, since water can be added by pouring it into the jar from the cage above.

After the larvae had spun up, the cocoons were removed from the cages and placed individually in small paper drinking cups which were covered with a polyethylene square held in place by a rubber band. The cups were placed in cardboard trays and examined each night. The use of individual emergence cups accomplished two things: it separated males from females for use in breeding experiments, and it prevented active moths from disturbing newly emerged ones or inactive ones, thereby resulting in better specimens.

In addition to the insectary-trailer, the other major piece of equipment was a pickup truck with a camper attached. The insectary-trailer was parked in a central location in the area being studied, and the pickup-camper was used to make collecting trips of from 1 to 4 days into the surrounding territory. The pickup-camper was ideal for this kind of field work since it was possible to stop overnight just about any place without wasting time pitching a tent or looking for a room.

Larvae collected in the field were held in large .004-polyethylene bags until they could be transferred to cages in the insectary-trailer or preserved. This was very satisfactory, and healthy larvae showed no ill effects when held in bags as long as a week, provided they were not left in the sun. If left in the sun both the temperature and the condensation of moisture on the inside of the bags became excessively high.

Field Collecting

The number of larvae collected, preserved, reared, etc., varied considerably from collection to collection. Only 45 cages were available for rearing, so it was not possible to rear all collections, nor was it necessary, since some collections were similar to others. In addition to the collections which were made, numerous other colonies were examined in the intervening areas, and notes were taken on them. Whenever possible, each collection consisted of the larvae believed to have hatched from a single egg mass, but, as will be pointed out, it is virtually impossible to be absolutely certain that all larvae in a tent hatched from a single egg mass unless the egg mass is collected and hatched.

The general procedure followed in collecting was to examine several colonies in an area, checking for variation in larvae, egg masses, tents, and hosts. If all colonies in the area were similar, a colony usually was selected from the most common host, and the other hosts in the area were recorded. If some colonies appeared to be different in some respect, they were more carefully studied and appropriate ones were selected for rearing.

In some areas colonies were so numerous that any sample was bound to include larvae from several egg masses, while in other areas colonies were miles apart or impossible to find. An example of an area where colonies were difficult to find is the west side of the Sierra Nevada range south of Lake Tahoe. Not a single colony was located here despite 2 days of driving through the area. Undoubtedly some were present since they had occurred in outbreak numbers a few years earlier (Clark, 1955, and Langston, 1957), but they evidently were at a very low level in 1960 and we were not fortunate enough to find any. This was the exception rather than the rule, however, and no difficulty was encountered in locating at least a few tents in the vast majority of the areas visited.

Originally, it was planned to collect the larvae as soon after hatching as possible and rear them to adults. Single colonies were to be collected and reared to obtain some idea of the range of variation that could be expected in both larvae and adults which presumably came from a single egg mass. This plan, however, had to be abandoned for several reasons, the most important of which was the introduction into the insectary-trailer of a disease, tentatively identified as a non-inclusion virus by Steinhaus (Steinhaus and Marsh, 1962), which made it practically impossible to rear larvae from the earlier instars to adults.

This disease affected all instars of all species and subspecies reared in the trailer, but little or no mortality was observed after pupation, even though there can be little doubt that many of the larvae which successfully pupated were infected to some degree. Collecting, therefore, had to be planned so as to obtain last instar larvae in order that pupation would occur before the disease could progress to a fatal level.

Although the collection of last instar larvae is advantageous in some ways, it also has disadvantages. One advantage lies in easier collecting, since the large tents of late instar larvae are readily spotted. Another advantage is the shorter period of required feeding resulting in a more rapid turnover of cage space and less work in feeding the larvae. Also, larvae collected as last instars have been feeding on natural, living hosts for the greater part of their larval life, while caged larvae have been eating cut foliage that cannot be maintained in as good condition as the living host. In addition, there were times when the native host was not available within a reasonable distance of the trailer, so some related plant had to be substituted. These host transfers were accomplished without difficulty in nearly every case, but there was always the possibility of the larvae being affected in some way that was not readily apparent. The last advantage in collecting nearly mature larvae is the presence of a fully developed color pattern in contrast with the reduced color pattern present in the earlier instars—especially the first and second. Many of the western "species" were described originally because of differences in the larval color patterns. It was extremely important therefore, to be able to recognize these populations in the field in order to study them in the areas where their distributions meet, and to look for other differences or similarities that may be impossible to observe after they have been collected.

An obvious disadvantage of collecting nearly mature larvae is that one does not have any early instar larvae for preservation. Another is the possibility of miscalculating larval development and arriving at a potential collection site after all the larvae have pupated. The other major disadvantage is the steadily increasing chance that older larvae will become mixed with those from different egg masses, because older larvae range farther in feeding and lose their gregarious habits as they mature, especially during the later part of the last instar. Even if larvae are collected in the first instar, however, it is not certain that only a single egg mass is involved since larvae from two or more egg masses often combine into a single colony. To be absolutely sure that all larvae are from a single egg mass, one must collect the egg mass and hatch the larvae. This, of course, is next to impossible, since egg masses are difficult to find except in areas where populations are extremely high.

Disease

In any study such as this which covers a large area, it is inevitable that some diseased specimens will be collected, even though they may appear to be healthy when collected.

Once a disease has been introduced into the insectary, often it is impossible to get rid of it completely. Tent caterpillars are quite susceptible to diseases of various kinds. One of the most commonly encountered is nuclear polyhedrosis. This disease has caused widespread mortality on many occasions under field conditions, but during this study it was of no importance in the insectary, and caused only an occasional loss of a few caterpillars. The disease already mentioned, however, and tentatively identified by Steinhaus (Steinhaus and Marsh,

1962) as a noninclusion virus, was extremely troublesome. Apparently it was picked up somewhere in northern California while the insectary-trailer was located at Albany on San Francisco Bay—a relatively cool area. No diseased larvae were noticed while the trailer was located there, and none were noticed after the trailer was moved to Hat Creek in Lassen County, California, until about a week after the temperatures began climbing into the 90s every day. At that time many larvae began to show disease symptoms and died several days later.

Presumably many of the caterpillars had become infected when the trailer was at San Francisco Bay, where temperatures were too low to permit a general outbreak. Thus, the disease was well established before its presence was suspected and there was little that could be done to disinfect effectively the entire trailer once the disease reached epidemic proportions.

Larvae from most of the collections made while the trailer was at San Francisco Bay had pupated, were pupating, or were in the late last instar when the disease reached an epidemic level. As previously noted, once the larvae have pupated, little mortality occurs, so it was possible to obtain adults from most of these collections. Collections in which all the larvae died before pupation were either similar to other successfully reared collections, or they were replaced with more mature larvae obtained on a second trip to the original localities. Most collections made after the disease became a problem contained late instar larvae, so they were successfully reared.

From the economic viewpoint this disease was highly effective in controlling tent caterpillars under insectary conditions, where the cages were protected from the weather, and it was easy for the wind to blow dry, contaminated dust throughout the trailer. Under field conditions, however, the effectiveness of the disease undoubtedly would be considerably reduced.

The following symptoms characterize this disease. Infected larvae cease to feed, but continue to wander about very actively until they begin to shrivel and shorten. At this stage the anal prolegs begin to become useless and a piece of moist, soggy frass usually protrudes from the anus. As the disease progresses the body shortens even more and the anal prolegs become completely useless and upturned. Infected larvae regurgitate large amounts of a reddish-brown fluid when they are touched or disturbed. This regurgitation, combined with the loss of fluids through the soggy piece of frass and the lack of replacement by feeding undoubtedly accounts for the rapid shrivelling and shortening of the body as the disease progresses. In the final stages the larva is unable to crawl or cling to any support, and eventually falls to the ground. Mature larvae that normally would be nearly 2 inches long become so desiccated and shrivelled that they are usually only ½ to ¾ of an inch long at death. Complete desiccation and death usually occur at a temperature of about 30° C. in from 3 to 5 days after the first symptoms are noticed.

Parasites

All indications in the literature (Langston, 1957, etc.) are that the parasites of *Malacosoma* are not host specific and consequently could not be expected to provide any information which would be of systematic value. All egg and larval parasites reared during this study were saved and are listed in Appendix IV (page 291).

Egg Masses

After mating, females immediately begin searching for a suitable oviposition site, and under caged conditions they often crawl around with wings vibrating for some time before selecting a spot. Each female normally deposits her eggs as a single mass on a suitable host plant and in a way that may be characteristic for the species. The number of eggs per mass varies considerably, ranging from less than 100 to more than 400, and as many as 600, but most often ranging from 150 to 250. Virgin females may lay a few eggs, but these are always infertile and laid in a highly irregular way.

All North American species except *M. tigris* cover the eggs with a frothy material secreted by the accessory glands and termed spumaline by Hodson and Weinman (1945). Bubbles of spumaline are released just before each egg is placed in position. The egg is placed with the long axis perpendicular to the stem and with the micropyle toward the outside.

The spumaline varies considerably in color, texture, and toughness from species to species, and in the case of *M. californicum* and *M. incurvum* from population to population. The color ranges from nearly pure white in some populations to a very dark brown in others. Rarely the spumaline on different egg masses of the same local population may be different colors. Immediately after the eggs are laid, the spumaline is lightest, but may become considerably darker with age. The toughness of the spumaline depends to some extent on the humidity, being more brittle when dryer. Resistance of the spumaline to weathering varies, apparently because of individual differences in the females (Wellington, 1959).

The spumaline serves several functions. It is an adhesive which holds the eggs in place. It is not waterproof as has been erroneously supposed in the past, but is definitely hygroscopic (Hodson and Weinman, 1945), absorbing moisture from the air which helps to prevent the eggs from drying out. It also protects the eggs from parasites, which are successful only in attacking eggs exposed at the edges of the egg mass. It is worth noting that the eggs of *M. tigris* are not covered by spumaline, yet they do not dry out and parasitism was very low in those collected during this study. The lack of spumaline in this species, however, possibly is compensated for by the eggshell being somewhat thicker than that of those species which cover the eggs with spumaline. It is also interesting to note that the reservoirs of the accessory glands of female *tigris* contain as much spumaline as those of any other species, yet only enough spumaline is used to hold the eggs in place.

The spumaline of all species except *M. californicum* is homogeneous. In some, but not all, populations of *californicum*, the spumaline contains numerous minute, dark objects which appear to be scattered throughout, more or less at random; these are termed "specks" (fig. 118). They should not be confused with particles of dirt which collect on the outermost bubbles of spumaline and inside broken bubbles, but which are not present on the inner unbroken layers of bubbles. These specks are discussed in some detail since they are useful in separating certain populations of *M. californicum* from other populations of *californicum*, and from *M. incurvum*.

It is not difficult to observe the specks on fresh egg masses, since there are many unbroken bubbles which can be examined. On older egg masses, however, where the spumaline has been worn away by weathering or eaten away by the caterpillars as they hatched, the best way to observe the specks is to look for small unbroken bubbles between the eggs. The edge of the bubble where it adheres to the egg should be examined as the light-colored egg provides a contrasting background, and the specks are most concentrated in the thickened areas where the bubbles adhere to the eggs or to each other.

Tests with various organic, inorganic, and enzymatic reagents have established that the specks are an organic substance which is probably the same material as the rest of the spumaline and only distinguishable by its darker color. It is not known why the pigment should concentrate into specks like this and whether or not it has a function, but the specks are present in the spumaline while it is still in the reservoirs of the accessory glands before the eggs are laid, so they are not the result of some reaction which takes place after the spumaline has been deposited.

This means that the presence or absence of specks in a given population can be checked by one of two methods: either by examination of egg masses collected in the field, or by examination of the spumaline of unspent females, whether they are pinned or preserved. Preserved specimens are easiest to examine since the spumaline remains soft enough so that thin slices can be cut with a razor blade. In pinned specimens the spumaline is hard and brittle, but it also can be examined for specks by cutting thin slices which are more properly termed "chips." These chips must be made as thin as possible since the specks may be difficult to see in thick pieces of heavily pigmented spumaline. Many chips will be unsuitable for this reason, but some of them will be thin and unfractured, so that the more transparent edges can be examined for specks. If specks are numerous they are easily seen with the aid of a dissecting microscope, but if there are only a few, it is essential to have a good, thin, cleanly chipped fragment since they are easily missed.

The density of the specks is not constant for all egg masses from all localities, but populations of *M. californicum fragile* from the Mojave Desert probably have the most dense and most easily visible specks. Varying densities may be found in the same local population. In most of these cases the egg masses appear to be identical in every respect except the density of the specks, and these egg masses are believed to have been laid by moths belonging to the same species.

Whenever possible during this study several hatched egg masses were collected for each field collection that was made. Appendix I contains data on the number of egg masses collected at each locality, and whether or not the spumaline contained specks. In some cases no egg masses were collected, either because none could be found, or because it was not deemed worthwhile to spend time looking for them.

Most of the data suggest that the presence or absence of specks is not related to the host species which the larva fed on. For example, in at least eight different localities (Coll. Nos. 114, 115, 117, and 230 of *M. californicum fragile* and 254, 259, 294, and 316 of *M. californicum*) some of the egg masses contained specks and some did not, even though all of them were collected on the same host. Of course, there is no assurance that the females which laid these eggs came from larvae which fed on the same host the previous year, but it seems likely since no colonies were found on other hosts in these localities. Also, a check of the females reared from these collections showed essentially the same result; some of the females had specks in their spumaline and some did not, even though the larvae which had developed into these females had all fed on the same host in a given locality, and all had been reared under similar conditions.

In addition, seven different hosts belonging to four different families were fed upon at these eight localities. If the specks are caused by the larvae feeding on a certain host species or closely related group of hosts, such a diversity would not be expected. Furthermore, if the host were the *only* controlling factor in the production of specks, one would not expect to find specks in the spumaline of some populations feeding on a given host, and no specks in other populations feeding on the same host. Yet this is what is found when an examination is made of populations feeding on a widely distributed host, such as *Prunus virginiana.*

The biochemistry of these specks and of the diffuse color in the spumaline is not known. It is possible that the two are chemically similar, and are concentrated and diffuse pigment of the same type. The specks are most easily observed in populations of *M. californicum fragile* which occur in the Mojave Desert. The color of the spumaline of these populations is a light gray. Neighboring populations of *M. californicum* have spumaline which is brownish-gray or brown, and the specks are more difficult to see because of the more heavily pigmented spumaline. Specks, however, often appear to be as numerous in the brown spumaline as they are in the gray spumaline of the desert populations of *c. fragile*, so it cannot be assumed that the specks are simply due to a failure of the pigment to disperse evenly throughout the spumaline.

If the production of specks is either a normal stage of development of spumaline pigment or a concentration of some excess precursors, then one might expect to find an occasional egg mass of the other species in which specks were present. None have ever been found in the spumaline of species other than *M. californicum,* so it is reasonable to conclude that the production of specks is a peculiarity of some populations of *M. californicum.* Whether the specks are a stage in a process or the product of a process remains to be determined.

Specks have never been found in populations of *M. californicum* occurring along the Pacific Coast or in the northern United States and Canada. Figure 5 outlines the area within which populations have been found that have at least a few specks in the spumaline of some egg masses. Within this area there are populations that here are regarded as *M. californicum* which do not have specks. These are more fully discussed in the section on *M. californicum.*

The closely related species, *M. incurvum*, also occurs partly within this area, but as far as is presently known, all populations of *incurvum incurvum*, *incurvum discoloratum*, and *incurvum aztecum* have spumaline which does not contain any specks. If fact, the lack of specks is one of the best ways to separate *incurvum* egg masses from those of *californicum* when both species are found in the same locality.

Egg masses are of two basically different types: the "helical" egg mass, which is laid completely encircling small twigs; and the "clasping" egg mass, which is laid on small twigs or larger branches, or even on small trunks an inch or so in diameter, but is not laid as an encircling mass although, if the egg mass is laid on a very small twig, the last few eggs may overlap the first ones.

Helical egg masses are laid by *M. disstria* (figs. 108, 113), *M. constrictum* (fig. 107), and *M. tigris* (fig. 106). In laying this type of egg mass, the female positions herself at right angles to the twig and lays her eggs in a continuous band four to six eggs wide as she crawls around the twig (fig. 108). She usually circles the twig three or four times and aligns the eggs in a continuous helix so that it is difficult to distinguish one turn around the twig from the adjacent ones (fig. 106). Often the eggs are so perfectly laid that they appear to be in diagonal rows inclined about 45° to the axis of the twig. As she nears the end of the egg mass, she reduces the width of the band of eggs she is laying until the last eggs are laid by twos or singly, resulting in a fairly even edge which is carefully covered with spumaline (if the species is one that normally covers the eggs with spumaline). The female is quite persistent in trying to cover the eggs completely, and, on one occasion, a female *M. disstria* was observed to try for 45 minutes to cover the exposed edges of the last five eggs she had laid, although she had evidently exhausted her supply of spumaline.

Clasping egg masses are laid by *M. americanum* (figs. 109, 110, 111), *M. californicum* (figs. 105, 112, 115, 116), and *M. incurvum* (figs. 114, 117). In laying this kind of egg mass the female again positions herself at right angles to the axis of the twig or branch, but instead of laying a continuous helical band of four to six eggs, she lays them in individual, slightly curved rows by extending the tip of her abdomen to one side as far as she can reach, and then laying a row of 10 to 15 eggs until she cannot reach any farther to the opposite side. Before laying the next row of eggs she may move forward slightly. She repeats this procedure until nearly all of her eggs have been laid. As she nears the end of the normal egg mass she shortens the rows and finishes by covering all exposed edges with spumaline. This method of laying results in slightly curved rows of eggs. Occasionally, half-moon shaped egg masses are found with the concave edge of the egg mass not covered with spumaline. These result from the female being disturbed while laying.

It is evident that the final shape of the clasping type of egg mass depends on the diameter of the twig or branch on which it is laid. If the eggs are laid on a large branch or near the base of a small trunk, the egg mass will be nearly flat since the eggs can be laid on only one side (fig. 111). If they are laid around a very small twig, they may encircle the twig (fig. 109), or if they are laid around a somewhat larger twig, they may only partially encircle it (fig. 110). If the spumaline is removed, however, it is always easy to determine whether the eggs were laid as a basically flat clasping mass, since there will be a definite edge where the last eggs were laid that will not be aligned with the first eggs that were laid (fig. 109).

The eastern tent caterpillar, *M. americanum*, often has been reported as laying an egg mass which encircles the twig, when, in fact, the eggs usually only partially encircle it (the spumaline may encircle it) and may even be laid as a flat mass near the base of young trees an inch or so in diameter (fig. 111). This is commonly the case in Minnesota, western Wisconsin, and northern Michigan, but some or even most egg masses are still laid on twigs in some areas. Egg masses collected in eastern Wisconsin near Green Bay, in Indiana, Ohio, Virginia, Kentucky, Kansas, Oklahoma, Missouri, Louisiana, and Texas were all laid on small twigs or branches at varying heights above the ground, even if the host was a small tree with a trunk diameter of less than 1 inch. The true situation throughout the rest of eastern North America is not known, but all reports indicate that egg masses are laid on small twigs, and no reports of egg masses being laid at the base of small trees have been found. This is a point which should be checked, nevertheless, since it is unlikely that anybody has looked anyplace except on twigs. No reason is known for the laying of some egg masses near the base of small trees in Minnesota, Wisconsin, and Michigan, but it has been suggested that eggs laid near the ground would be covered by snow and thus protected from the rather cold midcontinental winter temperatures.

Tents

Not all species of tent caterpillars build tents, and of those species that do build tents not all build them the same way or make the same use of them. Those which build large, conspicuous tents (*M. americanum*, *M. incurvum*, and *M. californicum*) usually start constructing the tent soon after hatching, and they may build it right over the hatched egg mass if it happens to be located near a suitable fork or branch. At other times they may construct the first tent several feet away from the egg mass. Larvae from each egg mass usually start building their own tent, but sometimes larvae from several egg masses may form a single large tent, especially when populations are dense. Quite often the initial tent will be abandoned, and a second, third, or even more tents constructed. The shape of the tent varies from relatively compact and equidimensional, to long and narrow. It may be located near the center of a shrub, but most often it is located on the outer branches of the host in a fork or near the tip of a leafy branch (figs. 333, 335).

Several factors seem to influence the shape of the tent. The most important ones may be the life form of the host and, as reported by Wellington (1957, 1960),[3] individual differences in the behavior of the larvae making up a colony. His studies on *M.* [*californicum*] *pluviale* showed that colonies containing higher percentages of active (Type I) larvae tended to build the more elongate tents at or near the tips of branches, and colonies containing fewer active larvae and more sluggish (Type II) larvae constructed more compact and equidimensional tents farther back from the tips of branches or in crotches. He notes that although the opposite type of tent could have been built in many cases, it was not, and he concludes that the shape of the tent was not limited by the life form of the host.

In the populations of *M. californicum pluviale* with which Wellington worked there can be little doubt that the types of larvae were the dominant factor influencing the shape of the tent, but it remains to be seen if this holds true for the other species and subspecies. Sullivan and Wellington (1953) found the same different types of larvae for *M. americanum* and *M. disstria* as were found for *M. californicum pluviale*, so there is no reason to believe that these types of larvae would not be found in other species and subspecies. Observations made in the course of this study, however, indicate that the life form of certain hosts also may have a role in determining tent shape and location.

For example, in the area around San Francisco Bay *M. californicum californicum* frequently is found on the coast live oak, *Quercus agrifolia*. This species of oak possesses numerous short, stout twigs near the tips of the branches which, in turn, have many stiff leaves projecting in all directions near the ends of the twigs. Tent caterpillars will not eat the old, tough leaves (the preceding year's growth on live oaks), but they make good use of them by frequently constructing their tents over them. This often results in a compact type of tent that is located near the tip of the branch. The new growth is usually only a few inches long, and any of it that is located near the tent may be covered by the tent and/or severely damaged by feeding. There are, of course, some sites that will permit the construction of elongate tents, but these may be in the minority, and thus it is possible that a colony that normally would build an elongate tent may build a more compact one because of the life form of the available site.

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[3] Since this was written, Wellington has published additional work on individual differences. See W. G. Wellington, 1967, Can. Ent., 99: 249–263 for references to his papers on this topic.

A good example of the possible influence of the life form of the host on the shape of the tent was found at the site of Coll. No. 25, where *M. californicum californicum* was commonly found on *Quercus agrifolia* and on *Salix* sp. Tents were more common on *Q. agrifolia* than on *Salix*, but it seems reasonable to assume that all colonies were members of the same local population, and it seems unlikely that one host would have a greater number of active colonies than the other, although the possibility cannot be completely ruled out. In general, the tents near the tips of the branches on *Q. agrifolia* were more compact and equidimensional than were those near the tips of the branches of the willows. The willows provided only relatively flexible leaves for the support of tents near the tips of the branches, while the oaks provided stiffer leaves and numerous twigs for support near the tips. If the colonies on both hosts are assumed to be similar with respect to the types of larvae of which they are composed, then it seems probable that the life form of the host influenced the shape of the tent to some extent.

A similar, but not exactly identical situation is present in the Mojave Desert area where *M. californicum fragile* occurs on *Prunus fasciculata*, the desert almond. This shrub usually has many rather stiff, interlocking branches and twigs which form innumerable sites that would be suitable for tents. Many of the twigs are rather long and they may extend beyond the main part of the shrub for several inches. Such twigs appear to be suitable locations for the construction of elongate tents, but they are rarely used, possibly because the leaves of the desert almond are so small (about ¾ of an inch long by ¼ of an inch wide) that there would be practically no space inside a tent which was constructed over such a slim framework.

It is not known what types of larvae built the tents that were observed, but many of the tents were more or less equidimensional and were constructed over a framework of numerous intertwined twigs and branches, making it impossible to remove them without cutting through several twigs and branches. Other tents were built on individual branches, but these tents usually were constructed where several twigs left the main branch and were most often equidimensional (fig. 335). In this case, as in the case of *M. californicum californicum* on *Q. agrifolia*, it seems probable that the life form of the host may influence the shape of the tent, but only additional study of colonies containing known larval types will tell whether or not it does and to what extent.

M. disstria, the forest tent caterpillar, is the only species of *Malacosoma* which builds no tent at all. The larvae normally rest on leaves, branches, or trunks (fig. 332) when not feeding, moving to the shady or sunny side, depending on the temperature. When they molt, they attach themselves by their crochets to a flat mat of silk which has been spun on some support, but this is as close as they come to building a tent.

M. constrictum and *M. tigris* are two species having similar tent-building habits. Both build a new "tent" each time they molt, but after molting they abandon it and cluster on branches in a manner similar to *M. disstria.* These molting tents are quite small, the largest, last instar ones usually being not more than 2 or 3 inches in diameter (tents this large are rare), and spun quite closely to the branches or leaves so there is practically no space on the inside (fig. 334). The larvae never rest inside these small tents as do the species which build large tents. Larvae of *M. constrictum* have been found resting on the outside of tents of other species, such as *M. californicum* and its subspecies, but no *constrictum* larvae were ever found inside these tents. The tents of both *constrictum* and *tigris* usually are inconspicuous, and this, no doubt, is one of the major reasons for the belief that *constrictum* is not very abundant, and for the fact that *tigris* has not been recognized in the literature since it was originally described in 1902 (except for recent reports in the "Cooperative Economic Insect Report," 1963 and 1964, where it was referred to as "*Malacosoma* sp., probably *texanum*").

Variations in the behavior and reactions of different species are related to whether or not they construct tents and live in them. Studies made by Sullivan and Wellington (1953) have shown that all instars of *M. disstria* become photonegative when they are sufficiently heated. In contrast, they found the first three instars of *M. americanum* and *M.* [*californicum*] *pluviale* showed the same reactions when heated sufficiently, but the fourth, fifth, and sixth instars showed a photopositive reaction. They believe this photopositive reaction of the larger larvae of the tentbuilders to have survival value under ordinary conditions, since the larvae leave the tent when it becomes too hot and rest outside the tent where temperatures normally are cooler. *M. disstria*'s photonegative reaction also has survival value since larvae move to the shaded sides of branches when it becomes too hot.

In this respect there is an interesting difference between the behavior or reaction of *M. disstria* larvae and that of *M. tigris.* In 1962 near Inks Lake State Park, Burnet County, Texas, both species were common and causing heavy defoliation of the oaks. *M. disstria* builds no tent and *M. tigris* builds only small molting tents, and both rest on branches when not feeding. In this locality, however, mature *disstria* larvae invariably were found resting on the shady side of branches or trunks, but mature *tigris* larvae were found resting in many places with no apparent preference for sun or shade. This difference vior was noticed about noon on a rather warm day. The exact temperature is not known, but the maximum temperature recorded in the U.S. Weather Bureau's *Climatological Data* for 18 April 1962 for nearby localities was 84° F. at Burnet (10 miles east), 90° F. at Llano (20 miles west), and 86° F. at Lampassas (25 miles northeast).

Sullivan and Wellington (1953) found that last instar *disstria* larvae became overheated and photonegative at an air temperature of 34.5° C. to 35.5° C. (approximately 95° F.) under laboratory conditions. They also reported mean internal temperatures of 35.4° C. for mature, photonegative *disstria* larvae engaged in prepupational travel in the field. The air temperatures at Inks Lake State Park on 18 April 1962 probably did not reach 95° F., but the day was bright and clear, so larvae exposed to the sun could have been overheated. Since the *disstria* larvae were found resting in the shade, it is reasonable to assume that they were there because they had become overheated.

From these observations it seems evident that *tigris* larvae are able to tolerate warmer body temperatures than *disstria* larvae, or else they are somehow able to maintain a lower body temperature than *disstria* under similar conditions of exposure to the sun. It is possible that *tigris* larvae have a reinforced photopositive reaction similar to that reported for *M. americanum* and *M.* [*californicum*] *pluviale* by Sullivan and Wellington, but this seems unlikely since their habits are much more similar to *disstria's* in every respect.

Of what use is the tent, and is there any advantage in building a large tent, or in building no tent at all?

One use that all species make of their "tents," whether they be just a mat of silk, or large and spacious, is as a base for attachment when molting. They hook their crochets into the silk, and apparently are more securely anchored than they would be if they did not have the silk. Most individuals of a given colony molt at the same time. The bunches of exuviae which are left behind are often more conspicuous than the larvae, and have sometimes been mistaken for dead larvae. The tentbuilders usually retire inside their tents to molt where they appear to be better protected than their nontentbuilding relatives. Nevertheless, the nontentbuilders do very well, so any protection afforded by a tent during molting is not essential to all species, although it may be important to those which build large tents. This remains to be determined.

Certainly, those species which build conspicuous tents are at a definite disadvantage as far as predation by man is concerned, since humans notice the "ugly nests" and go out of their way to destroy them, while the nontentbuilders go unnoticed unless they are very abundant.

The argument can go both ways as far as other parasites and predators are concerned. Potential enemies may be attracted by the tent, but, on the other hand, caterpillars may escape by hiding in the tent. Wellington (1957) noted that tachinid flies were more attracted to clusters of larvae than to individuals, but pointed out that this may be an advantage to the population as a whole, since the less active, sluggish individuals which are less likely to become adults spend more time in clusters than the active larvae, and thus would tend to absorb a higher percentage of the parasite eggs.

Larvae often are found with several eggs attached on or near the head (figs. 339, 370). On several occasions during this study larvae which were being molested by tachinids have been observed to jerk violently the anterior part of their body from side to side, effectively preventing the deposition of eggs on themselves, and forcing the tachinids to approach less active larvae. (If the eggs are not laid near the head, the caterpillar can easily chew them off.) If the disturbance by tachinids or other means is severe enough, older larvae have been observed to drop to the ground, and in the case of younger larvae they may spin down on silk threads and hang suspended for a while before making their way back to the tent.

It is not known whether the larvae which show the jerking reaction are the "active" or "sluggish" types described by Wellington, but it is difficult to imagine how a tachinid could lay several eggs on an individual which reacted this way, and any larva with several eggs on it must certainly not have been very active. This same jerking movement has been observed when branches bearing larvae have been suddenly jarred, and Stretch (1881) and Ancona (1930) noticed a similar reaction when loud noises were made near tents. A loud shout is sufficient to set off the jerking response. Therefore, the jerking response appears to be a general type of response that is initiated in some individuals and/or colonies by unusual disturbances of various sorts.

It remains to be determined whether the tent provides more protection than attraction to potential enemies, but a tent certainly would not hamper a large predator such as a bird once it comes to realize there is a meal inside, and smaller enemies such as ants and spiders can wait for larvae to come out to feed, or even crawl inside the tent searching for them, although this may not always be done with safety from the predator's viewpoint. Sullivan and Green (1950) reported seeing pentatomid predators being entangled in silk spun by large larvae of *M. americanum*, and that this behavior did not appear to be entirely accidental in some instances.

As far as disease is concerned, a group of caterpillars which returns to the same tent time after time would seem likely to pick up any disease organisms that are present in the tent, since it contains much frass, and diseased caterpillars often die inside. Wellington (1960) has shown that sluggish colonies had a higher mortality from disease than the more active colonies, which constructed several new tents, leaving behind the sluggish, dying, and dead individuals, and thereby having less contact with diseased material. Other factors such as starvation contribute to the higher mortality rate of sluggish colonies, but it is apparent that an individual caterpillar's chances of becoming infected with disease are probably related to the amount of time that is spent in contact with dead or dying individuals. Thus, it seems reasonable to expect that species which construct and live in large tents (whether the colonies are active or sluggish) would be more likely to become diseased than those species which cluster on branches and, thereby, avoid contact with dead or diseased individuals and frass which fall to the ground. The species which do not live in tents, however, cluster tightly together on branches, so they still would stand a good chance of picking up any diseases that are present.

According to Sullivan and Wellington (1953), a possible function of the tent is the maintenance of a more humid microclimate which helps to reduce desiccation. If this is true, it may explain a quite noticeable difference in behavior between northern Pacific Coast populations and desert populations of *M. californicum.*

Along the Pacific Coast from San Francisco Bay northward where the weather is usually rather damp and cool during the time when tent caterpillars are present, they were often seen resting on the outside of their tents and basking in the sun when it was shining. In contrast, tent caterpillars found in the Mojave Desert rarely were seen resting on the outside of their tents, but there are very few days in the desert when the humidity is high.

If these behavioral differences are due indeed to a simple response to atmospheric humidity, then there may be other physiological differences between these populations which permit the desert forms to remain inside their tents even though the temperatures get quite warm. Sullivan and Wellington (1953) have shown that the temperature inside the compartments of fifth instar tents of *M.* [*californicum*] *pluviale* may vary widely, depending on the exposure to the sun and the position of the compartment within the tent. They note that caterpillars move to cooler compartments as the one they are in heats up, but they rapidly leave the tent and cluster on the outside as soon as the temperature of the coolest compartment gets too hot.

This same reaction may take place with the desert larvae, but casual observations made on caged larvae held near San Francisco Bay indicate that the desert larvae may be adapted to warmer temperatures than the northern Pacific Coast larvae, and therefore could be expected to tolerate higher temperatures inside their tents before being forced to leave. Nearly mature larvae which had been collected near Morongo Valley, San Bernardino County, California (Coll. No. 27) and reared in the insectary at Albany, California, at prevailing outdoor temperatures (quite cool) were inactive and fed very little before they were warmed with an infrared lamp. Larvae collected in the San Francisco Bay area and kept in the adjacent cage were more active than the desert larvae and grew faster, although development still was slower than it would have been if they had been under field conditions. The basic color of the larvae also seems to be correlated with the climate to the extent that the Pacific Coast populations are predominantly black and orange, which would tend to absorb the sun's rays, while the Mojave Desert populations are predominantly light blue and white, thus tending to reflect the sun's rays. It remains to be seen how important such differences are in affecting the behavior of various populations.

If the tent does play an important part in preventing the desiccation of tentbuilders, then there may be other physiological or structural differences between them and the nontentbuilders, since it seems unlikely that *disstria*, *constrictum*, or *tigris* could prevent harmful desiccation by merely clustering tightly together on branches, although water loss undoubtedly is reduced by clustering.

Another possible advantage that has been suggested for the tentbuiders is the protection from the weather that the tent may provide. A well-constructed tent sheds rain fairly well as long as it does not rain too hard or too long, but after a good soaking rain many of the caterpillars found inside tents will be just as wet as those without tents, and they may be worse off if they must crawl over and through a soggy mass of disease-laden debris to get outside to dry off. And who is to say that a healthy caterpillar is worse off after getting soaked? The protection afforded by a tent would doubtless prevent many caterpillars from being blown or knocked off the host plant during a severe downpour or windstorm, but most nontentbuilders that are knocked off the host are probably uninjured, and manage to find their way back to a suitable host unless they are very small. Thus, the protection from the weather that is provided by a tent is of questionable value.

If the number and extent of outbreaks is used as a criterion of success of all species of *Malacosoma*, it is apparent immediately that all species are quite successful from time to time whether or not they build tents. The most successful species undoubtedly is *M. disstria*, and it builds no tent at all. The next most successful species would be *M. americanum*, *M. californicum*, and *M. incurvum*, all of which build large tents. And the least successful species would be *M. constrictum* and *M. tigris*, which build practically nothing in the way of a tent, yet even they are capable of causing severe defoliation at times. In short, other factors probably are more important in determining the success of a species of *Malacosoma* than whether or not it builds a large tent. Nevertheless, it seems unlikely that the expenditure of energy involved in such complex behavior as tentbuilding serves no useful function in those species which construct large tents. It remains to be seen precisely what these function(s) are, and how important they are.

Cocoons

The cocoons of all species of *Malacosoma* are constructed somewhat loosely, if they are compared with cocoons such as those of the silkworm, *Bombyx mori* (L.). They always consist of a tighter, inner silken case which closely surrounds the pupa, and they sometimes have another outer, loose layer of silk (fig. 309). The presence or absence of this outer layer of silk seems to depend to some extent on the type of site that is chosen for spinning the cocoon. Cocoons spun in tight locations such as cracks and crevices have little or no outer layer, while those found in less protected locations may have leaves or other materials drawn about the cocoon and held in place by the outer layer. Some species, such as *M. disstria* which normally draws leaves together, almost invariably have an outer layer, while others such as *M. californicum fragile* usually have none (fig. 310).

The cocoons of all species are dusted with a yellowish or whitish crystalline powder reported to contain urates (Wigglesworth, 1953).[4] This powder is very irritating to some people and could possibly furnish a degree of protection from enemies. Essig (1926) reported a rather unusual effect of tent caterpillars, noting that "In California a number of hogs were killed on the ranges of Mendocino County because they ate the cocoons and pupae of this moth [*M. disstria*] which were very abundant in 1918." This sounds somewhat farfetched, but it could be true since the powder present on the cocoons may cause allergic reactions on some people (see below).

The powder is present in the malpighian tubules of mature larvae as a thick yellowish or whitish fluid, and is excreted through the anus by the larva after the cocoon is completed. After excreting it, the larva smears it around the inside of the cocoon with its head, forcing it into the spaces between the silk threads of the cocoon. There it dries into a whitish or yellowish caked material which is broken into a fine powder when the cocoon is disturbed. Partially starved or diseased larvae construct flimsy cocoons and often have little or none of the powder found on normal cocoons.

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[4] The crystals are reported to be calcium oxalate monohydrate by E. Ohnishi *et al.*, 1968. Crystals from cocoons of *Malacosoma neustria testacea*. Science 160, pp. 783–784.

It may be of interest from the medical point of view to note that some people have an allergic reaction to the powder found on the cocoons. The reaction results in a red welt appearing on the skin in areas contacted by the powder. The welts somewhat resemble those caused by nettles. The reaction is most severe where the skin is folded and moistened by perspiration, such as on the neck and around the eyes. Little or no reaction occurs when the skin is not moistened, so it may be necessary for the powder to get into open pores before any irritation takes place.

The reaction is accompanied by rather intense itching, but can be relieved by a good washing with soap and water. Apparently, this removes the irritating material, but the welts do not disappear for some time. This reaction has been observed on three persons who have other allergies. One is allergic to ragweed pollen, the second to ragweed and grass pollen, and the third to grass and tree pollen. No reaction has been observed in persons who do not have some other known pollen allergy. It is conceivable that, when *Malacosoma* populations are high, enough cocoons could be present in an area for the powder to affect allergy-suffering persons working in such an area.

Adults

Adult *Malacosoma* are sexually dimorphic. In addition to genitalic differences, normal males have smaller, differently proportioned wings, smaller bodies, longer antennal rami, and sometimes they are colored differently than females of the same species. These differences are strikingly demonstrated by two bilateral gynandromorphs (figs. 204, 207) that were reared during this study.

The *M. americanum* gynandromorph was reared from mature larvae collected near Fredericksburg, Gillespie County, Texas. The *M. californicum californicum* gynandromorph was reared from an egg mass used as a control during F_1 rearings. Both parents of this gynandromorph were reared from larvae collected at Belmont, San Mateo County, California. It is interesting to note that one gynandromorph is a left-side male, right-side female while the other one is the reverse. The percentage of gynandromorphs in natural populations is quite low, only 2 out of more than 9,000 reared adults in this study, but *Malacosoma* gynandromorphs are not extremely rare since quite a few have been reported in the European literature (see Collier, 1936, for a list of references to some of them).

If males and females are considered separately, adult *Malacosoma* of all species are remarkably uniform in structure. Both males and females have been examined for morphological differences between species, subspecies, and local populations and, with the exception of those structures discussed below, all species are essentially the same. Of course, this does not mean that differences do not exist which might be uncovered by a more intensive examination than was performed here. Even if differences of some kind are found, however, it still must be demonstrated whether they are indicators of species, subspecies, or even of local populations.

The chromosome number was checked for all species and subspecies except *M. tigris* and *M. incurvum* by making squashes of the testes of mature larvae. The haploid number was 31 in every case, and there is no reason to believe it would be different for *tigris* or *incurvum*, since the other American and both Palearctic species of *Malacosoma* (*castrensis* and *neustrium*) which have been examined to date have a haploid number of 31 (Makimo, 1951).

The only structures that have proved to be of value in separating species are the male and female terminalia, the epiphysis, and, to a limited extent, the color pattern. The terminalia are by far the most useful and reliable. The epiphysis has limited usefulness, but is quite reliable for one species (*M. disstria*) The color pattern is useful, but an experienced eye often is necessary, and this must be supplemented whenever possible by genitalic confirmation of doubtful cases.

In this revision the evidence gathered from the examination of the various populations in the field has been given overriding priority. Certainly this is as it should be since the presence of (or lack of) evidence indicating reproductive isolation under field conditions is the most important evidence that can be obtained. In many cases morphology is a very good indicator of relationships, but it often does not reveal the whole story. The results of this study have shown that morphology gives a good indication of some relationships in *Malacosoma*, but that a much better overall picture of relationships is obtained when field data are available. Since preserved specimens, however, rarely have any useful field data accompanying them, morphology must be resorted to for identification in most cases.

As is the case with many Lepidoptera, *Malacosoma* adults are most often identified to genus by their general appearance. Doubtful specimens can be confirmed as *Malacosoma* by examination of the wing venation or genitalia. The overall size and shape of the wings coupled with the two oblique lines (usually slightly bowed outward) on the upper surface of each forewing is quite characteristic for all species (see figs. 119–329). Rarely the lines may be faint or even absent as in figures 213 and 214.

Five major components make up the forewing pattern. They are the inner, median, and outer areas, and the inner and outer lines (fig. 10). The median area and the inner and outer lines together may form what can be called a median band if they are similarly colored as in figure 120.

Just proximal to the inner line and just distal to the outer line are narrow areas paralleling the inner and outer lines which may be distinctly lighter than the remainder of the inner and outer areas or the median area of the wing. Sometimes the median part of the median area is lighter than the edges of the area, resulting in the darker edges appearing as a pair of dark lines set off by the lighter median part and the narrow lighter areas paralleling the inner and outer lines as in figure 249. In contrast, when the median band is the same color as the outer and inner areas of the wing, the wing may appear to be crossed by a pair of light lines formed by the narrow lighter areas paralleling the inner and outer lines as in figure 250. All of these components of the color pattern may vary from light to dark, and different combinations may result in strikingly different appearances of individual moths from the same populations or even the same colonies.

In some species such as *M. americanum* (figs. 312–320), the lines are invariably lighter than the surrounding areas. In other species such as *M. disstria* (figs. 119–139) the lines are invariably darker, but they may be bordered by faint lighter areas as in figure 127. In other species such as *M. constrictum* the lines usually are dark, but strikingly different individuals may be found in the same locality (compare figs. 155–156). In some species, however, especially *M. californicum* and *M. incurvum*, the components of the wing pattern are even more highly variable and almost exact opposites in patterns may be found (compare fig. 225 with 227, 249 with 250, 256 with 258, 285 with 287, and 295 with 304). Because of these extreme variations and the many other variations found in adult *Malacosoma*, individuals showing many of these variations have been illustrated for all species and subspecies.

The outer margin of the forewings is usually fringed with alternating patches of light and dark scales as in figure 204, but some specimens may have a unicolorous fringe as in figure 214 or 285. Ventrally (fig. 311), the forewing has only a single line in approximately the same position as the outer line on the upper surface.

Dorsally, the hindwing is usually uniformly colored, but sometimes has a contrasting light or dark transverse area which approximately lines up with the outer line of the forewing on spread specimens as in figures 162, 179, 270, and 278. Ventrally, the hindwing (fig. 311) usually has a single line which may be more distinct than the dorsal one, and which often bends sharply inward near the anterior margin.

The wing venation (fig. 10) is constant for all species. Only slight individual variations in the point of branching of veins have been noticed except for veins R2 and R3. These veins may vary within the same species from complete fusion to almost complete separation.

Color is extremely variable, even within species, ranging from dark chocolate brown to light straw yellow, with all intermediate shades. The body is about the same color as the wings and lacks any distinctive markings. Females are more stout-bodied than males, and have a greater wingspread. The wingspread of females is 25 to 50 mm.; most specimens are 30 to 35 mm. The wingspread of males is 20 to 40 mm.; most specimens are 25 to 30 mm.

The head is densely covered with fine, hairlike scales, and the eyes sparsely so. Ocelli are absent. The antennae are bipectinate, males with rami of medium length, and females with shorter rami, about half as long as those of the males. Mouthparts are absent except for the three-segmented labial palpi.

The thorax is densely covered with fine, hairlike scales which obscure all structures. The tarsi of all legs bear numerous small spines ventrally on all five segments, and the last tarsal segment terminates in a pair of strongly curved claws. The meso- and meta-thoracic tibiae have a pair of short spurs at the tip. Each foreleg usually bears an epiphysis (figs. 75–78) which is more highly developed in males than in females. It is nearly always present in males, but frequently absent in females.

The abdomen is moderately densely covered with scales and hairlike scales; the tip of the male abdomen is rather blunt and tufted with long hairlike scales, while the abdomen of the females is much heavier, more evenly rounded at the tip, and without tufts of scales. The first segment of the abdomen is somewhat reduced, segments 2–6 are "normal," and the terminal segments are modified to form the genitalia and accessory structures. Spiracles are present on segments 1–7. The tergites and sternites are moderately sclerotized, and tergites 2–7 of females have a median unsclerotized area which is most pronounced on segments 3–6.

Male Terminalia

The male terminalia of *Malacosoma* (fig. 30) have been highly modified, yet they retain the fundamental plan of male lepidopterous structure.

The structures which cover and protect the genitalia proper are the seventh sternite and the eighth tergites. The seventh sternite (figs. 57–74) is usually widened at the base, and the posterior margin may be toothed or scalloped in some fashion. It has limited systematic value. Protecting the genitalia dorsally and laterally are two curved sclerites, one on each side, each terminating ventroposteriorly in a pair of distinct prongs (figs. 12–29). These are called the accessory claspers for lack of a better term, since the term "clasper" as used in the Lepidoptera usually refers to the valvae (=harpae=parameres). The accessory claspers are loosely connected dorsally by a membrane, and they are believed to be the modified eighth tergum. The accessory claspers are relatively constant in general size and shape, and have some systematic value. They apparently serve for holding the female since they are capable of opposable movements.

The terminology used in describing the genitalia proper is basically that of Snodgrass (1957) with the substitution of more specific terms for some structures. The ventral portion of the genitalia is the modified eighth sternite (figs. 37–54). It is "U"-shaped, with the "arms" of the U tapering backward into sharp points. The overall shape and size of the eighth sternite is characteristic for most species, and the lateral arc of curvature of the points near the tip (fig. 40) is helpful in separating some species. Attached to the dorsal surface of the eighth sternite is the pouchlike, modified ninth sternite known as the saccus. Extending posteriorly and fused with the posterior part of the saccus is a pair of fingerlike structures that make an abrupt, nearly right-angle turn downward, projecting between and past the arms of the eighth sternite. These are known as the parameres (valvae or harpae) and they are connected by an interparameral bridge. They have some systematic value. The vesica bears no cornuti and has no systematic value. Posteriorly, the ninth tergum is modified to form a sclerotized area known as the tegumen. The alimentary canal passes between the base of the aedeagus and the dorsal parts of the accessory claspers, terminating in a central membranous area partially surrounded by the tegumen. The anus is centered in this membranous area and lies between two small "hairy" projections on the tegumen known as the socii. The tegumen and socii have little systematic value. Several parts of the terminalia bear numerous small setae, bristles, scales, etc., but none of these have been found to be of systematic value, and they are not included in the illustrations.

Female Terminalia

As in the males, the terminalia are covered by numerous scales and setae which usually must be removed before the diagnostic structures can be clearly seen. The external terminalia of female *Malacosoma* are basically the same as the terminalia of other higher Lepidoptera, consisting of an external copulatory opening to the bursa copulatrix on the eighth sternite (the ostium), and of the ovipositor. The ostium is surrounded by an area which may be heavily sclerotized, only partially sclerotized, or nonsclerotized. The term "genital plate" is applied to this area (figs. 83, 90, 95, and 102). The degree of sclerotization, the shape, and the position of the ostium in the genital plate have some systematic value. The internal genital structures are nonpigmented and membranous, and they have no known systematic value. See Snodgrass (1938) for an illustration and description of the internal reproductive system.

The ovipositor lobes (figs. 81–104 except 83, 90, 95, and 102) are blunt, each with dorsal and ventral sublobes (fig. 100) that have considerable systematic value. The anterior-lateral area of each lobe is lightly sclerotized. Extending anteriorly from this area is a long apodeme on each side that has little systematic usefulness. Posteriorly, the ovipositor lobes are somewhat wrinkled and covered with numerous setae. The conformation of the lobes around the egg pore and anus (figs. 82, 85, 87, 89, 92, and 94) is sometimes helpful in identification.

Larvae

Chaetotaxy

Although Dyar (1895b) numbered and noted the arrangement of the "warts" which bear the primary setae on the first instar larva, as far as is known, no attempt has been made to separate the larvae of *Malacosoma* by characters other than color and color pattern. This is understandable for two reasons. First, the color pattern is quite sufficient to distinguish some species in the later instars, and second, the large numbers of secondary setae superficially obscure the primary groups of setae.

Examination of first instar larvae has revealed groups of setae unobscured by the numerous secondary setae present in the later instars.

All of these groups have been interpreted as primary setae. Primary setal groups can be distinguished from secondary setae in later instars by their relatively longer length, more heavily sclerotized bases, and by their occurrence on pinaculumlike areas. Figure 7 illustrates the primary setal groups found on abdominal segments 3–6.

In addition to these primary setae, there are some smaller setae on first instar larvae which are here interpreted as secondary. Since many of them are difficult to see and they appear to have no systematic value, they have not been included in figure 7.

The terminology proposed by Hinton (1946) has been used. Terms have been applied to each setal group on the basis of what seems to be the most logical application of Hinton's system to *Malacosoma*. No study of other lasiocampid larvae and related groups has been made, so homologies are not positively established.

The usefulness of chaetotaxy in separating the species of *Malacosoma* is roughly proportional to the distinctiveness of the species in other respects. In other words, the most distinct North American species, *M. disstria*, is also the species most easily identified by setal differences. No reliable setal differences have been found for identifying the other species, but some setal characters are helpful when used in conjunction with other characters. It is unfortunate that reliable setal characters have not been found for the other species, since the color pattern is poorly developed in the early instars, and setal characters would be very useful. Numerous other larval structures have been examined in searching for larval characters to separate the species, but none have been found which are as good as certain features of the color pattern.

The setal groups present in the first instar larva do not correspond exactly to those present in the later instars. The most notable change is the reduction of D2 as a distinct group on abdominal segments 1–8 in the last instar of some populations. The setal groups on abdominal segments 3–6 are the most useful ones. The number of setae per setal group is not absolutely constant, but the mean number of setae per group is as follows: D1–(4 or 5); D2–(3); SD–(2); L1–(2 or 3); L2–(3); SV1–(4); and SV2–(2). Other groups named by Hinton either are absent or indistinguishable from the secondary setae. The most useful groups systematically are abdominal groups D1 and L1. The most stable group seems to be abdominal group SD which is always composed of two setae—one long seta (SD1) and one short seta (SD2).

The naming of setal groups by some system is, of course, a necessity if one is to talk about them with any degree of convenience, but a more important reason for naming them in this study is to use the terms in referring to definite areas of the caterpillar when speaking of the color pattern. For example, one could say the subdorsal area is blue except for a black spot surrounding setal group SD. This is more precise than merely saying that the lateral area is blue with a black spot.

Secondary setae are very numerous and usually superficially obscure most of the primary setae except the D1 group, even though the primary setae may be differently colored. Quite often the secondary setae will be one color on one part of the body and a different color on another part. If they are different colors, those setae above the subdorsal line (fig. 7) will be one color (almost invariably some shade of orange), and those below the subdorsal line (fig. 7) will be another color (usually a shade of white, but sometimes orange). Therefore, all secondary setae ventral to the subdorsal line are called "lateral setae," and all secondary setae dorsal to the subdorsal line are called "dorsal setae." See figure 7. There are relatively few secondary setae on the subdorsal area, so these dorsal and lateral groups of secondary setae are quite well defined and easily observed. Many of the older descriptions of *Malacosoma* larvae which refer to "dorsal" or "lateral" setae undoubtedly are referring to the setae which occur on these areas.

Color Pattern

As has already been noted, the color pattern is quite useful in distinguishing some species. The color pattern is most stable in those species which are most easily separated by other means. Possibly this results from the fact that these species (*americanum*, *disstria*, *constrictum*, and *tigris*) are completely isolated and probably have been for a long time in the past, while the other two species (*californicum* and *incurvum*) are species which have reached a stage in evolution where some populations are on the border between good species and subspecies, resulting in highly variable populations between the more homogeneous ones.

It is now known that the color pattern of *californicum* and *incurvum* is highly variable, but in the past it was believed to be more constant. Because it was believed to be more constant, it and setal color have been used almost exclusively to distinguish between the "species" of *Malacosoma* found in western North America ever since they were described originally. For example, the color of setae is often mentioned in larval descriptions, and in the case of *ambisimile*, one of the most important ways of distinguishing *ambisimile* from *californicum* was the color of the lateral setae (*ambisimile* had white lateral setae and *californicum* had orange lateral setae). Extensive collecting of *Malacosoma* larvae, however, has revealed that the color of the lateral setae is not constant for any species. It varies from white to orange in all species and certainly is not a good *specific* character, although it is useful in separating subspecies.

In some respects the color pattern is more constant than setal color, since certain color patterns may be restricted to definite geographic areas, while setal color varies more randomly. Four basic colors make up the color pattern of *Malacosoma* larvae. They are black, blue, white, yellow, and various shades of each. The localization and relationships of these colors in making up the color pattern (fig. 11) are described since so much reliance has been placed on them in the past (and still is) in determining the species.

Blacks are due to pigmented microtrichia. The most intense blacks are the result of heavily pigmented, tightly packed microtrichia. In areas where the black is less intense, the microtrichia are either less heavily pigmented or more widely spaced, often both. Microtrichia are present over nearly the whole body, even in some areas that appear white or yellow. In these areas they may be colorless or sometimes lightly pigmented, but relatively widely spaced, permitting the yellow or white to show through from beneath. Small amounts of pigments, especially yellow and orange, may be present in the cuticle, but most yellows and whites are due to pigments located in the peripheral fat body immediately beneath the basement membrane. Some white also is due to the white visceral fat body. External whites (sometimes with a bluish tinge) are produced in ways similar to those described below for the bluish colors.

The intensity of the pigments in the fat body varies considerably, but as a general rule the most intensely pigmented areas occur beneath the most transparent cuticle, and the less strongly pigmented areas occur beneath the more opaque cuticle. This is not a simple effect of the more opaque cuticle filtering out more of the color. Removal of the more opaque cuticle shows the fat body beneath it to be less intensely pigmented than the fat body of neighboring areas located beneath more transparent cuticle. This suggests the possibility of a direct relationship between the amount of light that penetrates the cuticle and the intensity of the pigment that is formed.

The blue, blue-green, blue-gray, and blue-tinged white areas are produced by an amorphous layer of material deposited externally to the microtrichia. When these areas are viewed with an "ultrapak" vertical illuminator, the color of the material is white, in contrast to the bluish color seen in diffuse light. It follows that the bluish color must be due to a Tyndall effect rather than a pigment. Nearly all of the blue also disappears if the integument is wetted, while the other colors are unaffected. This layer is possibly equivalent to the "cement layer" of Wigglesworth (1947) or the "tectocuticle" of Richards (1951).

For lack of a better term it is called the "cement layer" here, since this term currently is widely used.

Much of the cement layer can be removed by careful scraping. This greatly reduces the intensity of the blue. The intensity is affected also by the microtrichia, with the most intense blues occurring in those areas where the microtrichia are most heavily pigmented and most tightly packed (resulting in a blacker background). Less heavily pigmented and/or more widely spaced microtrichia in combination with the colored fat body result in lighter blues, blue-grays, off-whites, etc.

On larvae of *M. americanum* (fig. 350), the white dorsal stripe is the result of a white fat body and nearly colorless microtrichia which are covered with a white cement layer. The properties of this layer which make it appear white rather than blue are unknown, but it appears to be somewhat thicker than the blue layers, and it is deposited on a white background instead of black. There could also be differences in the composition or deposition of it which could influence the color. Black microtrichia surround the bases of numerous secondary setae located on the dorsal stripe, but the cement layer does not cover these areas, so they are seen as black. The small orange sinuous areas beside the dorsal white stripe appear to be covered with colorless microtrichia and a colorless cement layer, but the orange fat body showing through from below seems to dominate completely all other colors.

From this brief description of the major components of the color pattern and their location in *Malacosoma*, it can be seen that the larval color pattern is the result of many variable factors interacting in a complex way, and that the color pattern could be greatly altered by relatively minor changes in the components. For example, if the cement layer were deposited over greater areas of black microtrichia, the amount of blue would be increased and the black decreased. Nothing is known about the factors which influence the development of color pattern in *Malacosoma* larvae.

To describe the color patterns of all species and their variations, the following terminology has been adopted for the different areas and for certain distinctive marks. The body is divided into six longitudinal areas as indicated in figure 7. These are the middorsal, addorsal, subdorsal, supraspiracular, subspiracular, and ventral areas. These areas are not exactly the same as those used by Crumb (1929) and others in describing the color patterns of lepidopterous larvae, but the color patterns of *Malacosoma* are not exactly the same, so a modified system had to be used.

In addition to the six basic areas, the "dorsal stripe" is referred to at various times. This stripe is always white or bluish-white, straddles the midline of the body, and often covers much of the middorsal area. It may be continuous from one segment to the next (fig. 350), broken between segments (figs. 340, 375, and others), only faintly visible (figs. 360, 381), or absent (figs. 342, 352, 382, 392, and others). If absent, the dorsal area where it normally is found may appear as a black stripe as in figure 358. The "subdorsal line" is a narrow area at the junction of the subdorsal and supraspiracular areas which may be absent, but if visible, usually consists of an irregular longitudinal yellowish line that is often broken between segments as in figures 341 and 347.

Some setal groups have distinctively colored areas around them or distinctive groups of secondary setae surrounding them. Setal group D1 usually is indicated conspicuously by the presence of a black area surrounding it, and often appears as a pair of round black spots near the dorsum of the larva (figs. 345 and 388 are good examples), with one spot on each side of the middorsal area. More often the addorsal area is black and obscures the black D1 spot (compare figs. 380–383). Setal group D2, although difficult to distinguish on most larvae, may be surrounded by a small black spot (fig. 388), and sometimes is marked by a small black area which projects downward from the addorsal area on specimens which have black addorsal areas and blue subdorsal areas (figs. 380–383). Setal group SD is also marked on some larvae by a black mark of varying size and shape (fig. 374). Setal group L2 quite often is surrounded by numerous secondary setae which may be conspicuously tufted as in figure 345 and 391.

Variability in Larvae of *M. Californicum*

If larvae of *M. californicum* from many different localities in the West are examined, it soon becomes apparent that they are more variable than larvae of the other species. In order to discuss and describe this variation, the following special terminology has been adopted for what seems to be a basic color pattern that has been modified in various ways to produce the distinctive larval forms that are found.

This basic pattern is made up of the following components. The middorsal area usually is blackish, but may be largely obscured by a series of bluish-white dashes, one per segment. The dashes, if present, range from large, almond-shaped marks (fig. 365) to small, thin lines (fig. 381). The color of the addorsal area varies considerably from one geographic region to another, but all specimens have a black spot surrounding setal group D1. This spot may be inconspicuous if the adjacent areas are black. Often the black around D1 may extend ventrally to just below setal group SD, resulting in a mark that is referred to as the "vertical black bar" (figs. 7 and 376). The dorsal end of the bar usually is inclined slightly anteriorly. This vertical black bar may be quite conspicuous, only partially formed, or absent. It is seen most strikingly in populations of *M. californicum lutescens* which occur in the southern Great Plains (fig. 376), but it may be found in many other populations in a somewhat modified or obscured form (figs. 358–361, 363–365, 367, 370–372, 374–379, 383, 384, and 387).

In some populations additional black areas may blend with the vertical black bar to form distinctive marks. One of these marks commonly encountered in some areas is termed the "torso" mark (figs. 9 and 7). It is formed by the addition of anterior and posterior "arms" to the vertical black bar just below the black D1 setal group which forms the "head" of the torso (fig. 9). The posterior arm usually extends back to include setal group D2. A further modification of this mark by the addition of one or more black areas on the lower posterior edge is termed the "tailed torso" (fig. 9). Both the torso and tailed torso marks are most common in populations of *M. californicum pluviale* (figs. 370–372) and *M. californicum recenseo* (fig. 364), but all kinds of intermediate marks between these and the vertical black bar can be found in neighboring populations (see figs. 358, 360, 365, and 378). In some larvae the black may be so extensive that the entire larva appears black with practically no, or only very few, distinctive marks (figs. 359, 361, 372, 377, and 384).

Just anterior and just posterior to the vertical black bar approximately midway between the dorsal and ventral boundaries of the subdorsal area are two spots termed the "anterior" and "posterior subdorsal spots" (fig. 7). These spots are bluish-white and range from being nearly absent (figs. 352–354) to being conspicuous spots or blotches (figs. 356, 370, 384), or to being large areas that completely merge with the bluish subdorsal area so that no spot is apparent (fig. 376, and others).

The supraspiracular, subspiracular, and ventral areas do not have any distinctive markings such as those just described for the more dorsal areas. The color of these areas is usually a mixture of several colors that blend together to give a color pattern (see fig. 371) that may be characteristic for a given geographic region.

The larva of *M. californicum ambisimile* (fig. 354) can be taken as an example of how the basic pattern may be modified (or in this case largely obscured). Typical *c. ambisimile* larvae are largely black, usually lack a dorsal stripe, have small or no anterior and posterior subdorsal spots, and have the supraspiracular and subspiracular areas bluish or bluish-white. The absence of a dorsal stripe is probably due to a lack of any cement layer being deposited, since most specimens have no stripe, but a few specimens may show a weak dorsal stripe. The orange color, so prominent in forms such as *M. californicum pluviale*, is only slightly developed and shows merely as a few irregular longitudinal orange lines. The anterior and posterior subdorsal spots are greatly reduced or even absent. The vertical black bar is obscured by the predominance of black in the surrounding areas, but a few lighter individuals clearly show the vertical black bar as a distinct area. These lighter individuals also have a more distinct dorsal stripe, more conspicuous orange areas, and larger anterior and posterior subdorsal spots. All of these characteristics are tending toward those of some populations of *californicum* found north of San Francisco Bay, and help confirm *c. ambisimile*'s status as a subspecies.

Sexing Larvae

Larvae of *Malacosoma* are easily sexed by characters found on the venter of the ninth abdominal segment of males and on the eighth and ninth abdominal segments of females. Males have a very small pit or depression midventrally near the anterior edge of the ninth segment (fig. 79). This pit marks the location of an internal histoblast which is connected by the vas deferens to the testes which are located on either side of the fifth segment.

Females have two pairs of slightly larger and more conspicuous pits, one pair on the eighth and one pair on the ninth segments (fig. 80). These pits mark the location of internal histoblasts which no doubt represent part of the genital system. The lateral oviducts, which leave the ovaries in the fifth segment, converge and join together ventrally about midway through the seventh segment without making any obvious connection with either pair of histoblasts, or with the integument of the seventh segment. If there is a connection between the histoblasts and the oviducts at this stage of development, it is very delicate and could not be dissected out in the specimens at hand.

These pits are present in all instars of both males and females, but the smaller the larva, the more difficult the pits are to see, especially if the ground color of the integument is light. The most positive way of sexing them is to look for the presence or absence of the four pits of females since the pit on the males is quite small and easily overlooked on some specimens. Last instar specimens can usually be easily sexed without magnification, but younger ones can be difficult even with the aid of a microscope.

The same characters were found to be useful in sexing the larvae of some species belonging to other families of Lepidoptera, but additional species in the same families could not be sexed by this method.

Experimental Crosses

Introduction

One method to determine whether interbreeding between two populations takes place under field conditions is to search for intermediate populations in the area where the two populations in question meet. A problem that occurs with this method is the difficulty of knowing how an intermediate should look. Should it be midway between both populations or will some characters tend more toward one population than the other? One way to determine this is to try to cross the populations in the laboratory and observe the variation that shows up in the progeny (if any). The observed variation can then be compared with what is found in the field. Of course, it is desirable to rear such crosses through the F_2 in order to obtain a more complete picture of the possible variations and evidence of any hybrid breakdown if it exists, but this is not always possible owing to such factors as disease, length of life cycle, difficulty of holding certain life stages, etc. Such crossbreeding was attempted for many of the populations of *Malacosoma* in question, but it was only partially successful because of a combination of difficulties, the most important of which was disease.

The data presented in the following section are incomplete in many respects, but they are the best that could be obtained under the prevailing conditions, and they are presented for some of the possibilities that they suggest.

Methods

Crosses between the described species, forms, etc., were attempted whenever it was possible to synchronize the emergence of the adults. Some of the crosses attempted can never take place in the field under present conditions since the populations do not meet, yet such crosses may indicate the possible origin of populations that occur in the intervening areas.

Of course, successful interbreeding under laboratory conditions does not prove that interbreeding takes place in the field, but it does prove that it is possible for it to take place. Whether it does or not, and to what extent, must be determined by examining the populations in the field. Conversely, a lack of interbreeding under laboratory conditions does not prove reproductive isolation in the field. However, if interbreeding is successful *within* each test population in the laboratory, but unsuccessful *between* the test populations, reproductive isolation due either to a lack of attractiveness of one or both sexes (sexual, psychological, or ethological isolation), or because of physical noncorrespondence (mechanical isolation) is indicated. In *Malacosoma* physical noncorrespondence does not appear to be important, since the terminalia of all species are not greatly different in size and shape. Sexual isolation under laboratory conditions seems to be quite pronounced in some species, but weak or virtually absent in others.

No attempt was made to observe mating or attempted mating. Unmated females either lay no eggs or a few abnormally deposited ones. This fact has been demonstrated by Williams (1939), and was corroborated by this study. In every case where virgin females were placed in a cage without males, no more than 30 eggs were laid (usually 10 or less), and they were laid in an abnormal way. These eggs were held under the same temperature and humidity conditions as the normal ones, but none of them ever hatched, and subsequent examination of them revealed that embryological development had not taken place.

Cocoons were held in individual emergence cups, so there was no possibility of any mating taking place. Males from one population were placed with females of another population in the built-in cages in the insectary-trailer, or in screened, 1-gallon liquid food containers when other cages were not available (most of the time). The reciprocal cross was also attempted, as well as intrapopulational matings to serve as controls. The number of males or females per cross varied from one to ten or more, depending on how many were available on a given evening. It was found, however, that the optimum number of moths for obtaining the highest percent of normal egg masses was two to four of each population for the 1-gallon liquid food container cages. If larger numbers of moths were used, they created such a disturbance by flying about that the females were prevented from laying egg masses or were forced to lay abnormal ones. Branches for oviposition were provided, using the native host of the female whenever possible.

Mating and oviposition usually took place the first night. Both males and females appear to be sexually mature at the time of emergence from the cocoon, since many of them mate soon after their wings are dry, and the females lay egg masses the first night which are normal and viable in every respect. Males may mate more than once. This is supported by the observation on several occasions that more normal egg masses were obtained than the number of males in the cage. If the males mate only once, there should never be more normal egg masses than there are males, since females do not lay normal egg masses unless they have mated. Williams (1939) states that the females of *M. americanum* only mate once. This probably is true also for females of the other species of *Malacosoma*, but was not confirmed during this study.

Even though most of the oviposition took place the first night, the moths were left in the cage until all of the females had laid egg masses, or until all had died. Whenever possible two or more egg masses were obtained. After oviposition was completed the egg masses were held at 80 percent R. H. under the temperature conditions prevailing in the insectary-trailer. In October they were placed in a 10° C. temperature cabinet for a month, and then moved to 5° C. for the rest of the winter. Before hatching the following spring, the spumaline was brushed off and the eggs were surface-disinfected for 2 minutes in 1-percent sodium hypochlorite to reduce the possibility of having disease problems such as were encountered in the field rearing. No serious disease problems were encountered, although a few of the larvae died showing the typical symptoms caused by the noninclusion virus that caused serious trouble in the insectary-trailer.

Hatching was accomplished by holding the egg masses at 100 percent R. H. at room temperature. The caterpillars were reared in cages using the same methods already described, with the exception that all of them were fed apple foliage, which they accepted readily with no noticeable adverse effects.

Only one egg mass from each cross or control was reared, because of the amount of labor involved in rearing them. It would have been desirable to rear several egg masses from each cross and the controls, but it was impossible because of limitations of space and manpower.

Results

All attempts at crossing *M. disstria*, *M. constrictum*, and *M. tigris* with each other or with other species were completely unsuccessful. This does not mean that such hybrids cannot be produced, but no field-collected specimens have ever been seen which could be interpreted as being hybrids between these three species or between these and any other species, so it is safe to say that they are completely isolated in the field. *M. tigris* and *M. constrictum* are widely separated geographically, too. No difficulties were encountered in obtaining control egg masses of *M. tigris* or *M. constrictum* under caged conditions, but the success with *M. disstria* was quite variable. Nearly 100 percent of the females from Texas populations laid normal egg masses under caged conditions, but only about 20 percent of those from Alberta and Manitoba populations laid normal egg masses. No reason is known for this difference.

Only a limited number of attempts at crossing *M. americanum* with the western populations of other species could be attempted, but these were partially successful in one direction. No eggs were obtained from several attempted crosses totaling 13 female *americanum* from Texas which were caged with a total of 19 males from various western populations. However, eight normal egg masses and one abnormal egg mass were obtained from crosses totaling 39 females from various western populations which were caged with a total of 36 male *americanum* from Texas. Unfortunately, owing to the difficulties in holding the eggs, it was not possible to rear these eggs, but a check of the eggs showed that some of them had gone through embryological development. However, no field-collected specimens have ever been seen which could be interpreted as being hybrids between *americanum* and any other species, so it must be concluded that reproductive isolation is complete under field conditions, but breaks down partially under laboratory conditions. This is not unusual in *Malacosoma*, as is shown by numerous reports in the European literature concerning the production of hybrids under caged conditions between the European species *M. neustrium*, *M. castrensis*, and *M. franconicum*, three apparently distinct species which are probably well isolated under field conditions. See Collier, 1936, for a partial list of references to these.

Excluding *M. disstria*, *M. tigris*, *M. constrictum*, and *M. americanum*, the rest of this section on experimental crosses deals with those "species," subspecies, forms, etc., which have been described from western United States and Canada. Attempts at crossing these were made whenever possible. Table 1 shows the combined results for controls and "hybrids,"[5] comparing the numbers of normal and abnormal egg masses laid for the 1960 and 1961 field seasons. A normal egg mass is defined as one in which the eggs are deposited in the way that is typical for the species, and which is fully covered with spumaline if spumaline is normally present. (See the section on egg masses, figs. 105–118, and the description of the egg mass for each species.) Abnormal egg masses are those which differ in some respect from a typical one. Most commonly abnormal egg masses were laid irregularly (fig. 108) or they were covered only partially with spumaline.

The lower percent of normal egg masses and the higher percent of abnormal egg masses laid in 1960 compared with 1961 by both control and hybridized females most likely is due to larger numbers of

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[5] The term "hybrid" is used here in the sense that it is an organism which is the result of a mating between individuals from two different populations, whether or not these populations are regarded as different species.

TABLE 1.—*Normal and abnormal egg masses obtained from experimental crosses and controls in 1960 and 1961*

Experimental crosses and controls	Number caged females	Normal egg masses	Abnormal egg masses	Percent laying abnormal egg masses	Percent laying normal egg masses
1960 controls	61	20	4	6. 5	32. 8
1960 hybrids	214	82	21	9. 8	38. 3
1961 controls	110	70	1	0. 9	63. 6
1961 hybrids	236	155	15	6. 4	65. 7

disease-weakened moths reared in 1960, and to the excessive disturbance produced by the higher numbers of moths confined together in 1960. As previously mentioned, when too many moths were confined together they created such a disturbance by flying about that the ovipositing females often were disturbed and prevented from laying egg masses or forced to lay abnormal ones. There are no other differences between the controls and hybrids or between years that appear to be of any importance.

The following terms are used in discussing the results:

1960 F_1	Egg masses obtained during 1960 from crosses of field-collected specimens and reared during the spring of 1961.
1960 F_2	Egg masses obtained from the 1960 F_1.
1961 F_1	Egg masses obtained during 1961 from crosses of field-collected specimens.

Originally it was planned to rear selected F_1 egg masses to adults, obtain F_2 egg masses and rear them to adults in order to obtain estimates of hybrid viability, sterility, or inferiority, or the lack of these. No major difficulties were encountered in holding the 1960 F_1 eggs through the winter or in rearing them the following spring, but difficulties in assigning causes of mortality, and in holding the 1960 F_2 and the 1961 F_1 egg masses through the winter necessitated abandonment of the plan to rear them through the F_2. The difficulty in holding the egg masses over the winter affected all of the egg masses regardless of whether they were 1960 F_2s, 1961 F_1s, or controls, so the holding technique was probably at fault, although it had worked satisfactorily on the 1960 F_1s. The exact cause of the difficulty is not known, but it resulted in little or no hatch the following spring.

Presentation of all the data concerning all of these crosses that were attempted in 1960 and 1961 is not deemed necessary since essentially what is shown is that any isolating mechanisms between some of these populations which may be present under field conditions break down under laboratory conditions. However, some of the data for the 1960 F_1 rearings are presented in Table 2 because they are of interest in other respects.

Table 2.—*Partial rearing data for 1960 F_1 egg masses*

The specific names applied to each population are those which were in use when this study was begun. Those marked with a "?" are populations east of the Cascades that were called *M. pluviale* by some authors, and *M. fragile* by others. Those marked "MT" are populations occurring mainly in the Coast Range of California north of the San Francisco Bay area. Various names have been applied to these populations in the past, including *M. californicum*, *M. pluviale*, and *Malacosoma* sp. These populations are called the Mendocino-Trinity populations of *M. californicum* (Packard) here.

	Rearing number	"Species" female parent	Locality	Collection number		Collection number	Locality	"Species" male parent
Crosses with Reciprocals	R1	*fragile*	Tom's Place, Calif.	114	x	99	Geyserville, Calif.	MT
	R2	MT	Geyserville, Calif.	99	x	114	Tom's Place, Calif.	*fragile*
	R5	*ambisimile*	Morgan Hill, Calif.	40	x	114	Tom's Place, Calif.	*fragile*
	R6	*fragile*	Tom's Place, Calif	114	x	40	Morgan Hill, Calif.	*ambisimile*
	R8	*ambisimile*	Los Altos, Calif.	30B	x	8	Belmont, Calif.	*californicum*
	R9	*californicum*	Belmont, Calif.	8	x	30B	Los Altos, Calif.	*ambisimile*
	R11	*californicum*	Belmont, Calif.	8	x	99	Geyserville, Calif.	MT
	R12	MT	Geyserville, Calif.	99	x	8	Belmont, Calif.	*californicum*
	R14	*pluviale*	Eugene, Ore.	122	x	128	Dufur, Ore.	?
	R15	?	Dufur, Ore.	128	x	122	Eugene, Ore.	*pluviale*
	R23	?	Redmond, Ore.	130	x	139	Hayfork Summit, Calif.	MT
	R24	MT	Hayfork Summit, Calif.	139	x	130	Redmond, Ore.	?
	R25	?	Dufur, Ore.	128	x	22	Morgan Hill, Calif.	*ambisimile*
	R26	*ambisimile*	Morgan Hill, Calif.	22	x	128	Dufur, Ore.	?
	R27	*pluviale*	N. W. Calgary, Alta.	180	x	179	Derwent, Alta.	*lutescens*
	R28	*lutescens*	Derwent, Alta.	179	x	180	N. W. Calgary, Alta.	*pluviale*
	R35	*lutescens*	Beauvallon, Alta.	173	x	180	N. W. Calgary, Alta.	*pluviale*
	R36	*pluviale*	N. W. Calgary, Alta.	180	x	173	Beauvallon, Alta.	*lutescens*

	Rearing number	Total eggs in egg mass	Hatching date	Percent hatching	Percent mortality of hatched caterpillars	Percent total mortality	Infertile yolk eggs	Unhatched dead caterpillars	Other unhatched eggs	Mean days: hatching to emergence	Emerged males	Emerged females
Crosses with Reciprocals	R1	151	30 Apr.	97	67	68	0	4	0	37.2	24	25
	R2	141	1 May	44	57	79	0	72	0	38.5	19	11
	R5	140	1 May	91	64	67	3	8	1	37.5	28	18
	R6	154	6 May	96	49	51	4	2	0	35.8	46	30
	R8	102	6 May	73	59	71	6	20	2	35.6	16	14
	R9	129	1 May	94	42	46	2	5	1	35.1	34	36
	R11	218	1 May	94	44	47	3	5	5	35.5	65	50
	R12	176	1 May	74	44	59	1	45	0	36.6	38	35
	R14	55	4 May	49	48	75	2	26	0	35.6	11	3
	R15	154	30 Apr.	99	54	54	0	1	0	39.5	37	34
	R23	231	1 May	97	51	52	0	5	2	37.6	78	32
	R24	143	30 Apr.	97	65	66	0	4	0	38.5	23	26
	R25	87	1 May	97	37	39	0	3	0	40.7	34	19
	R26	120	3 May	83	43	53	7	8	5	38.8	25	32
	R27	197	30 Apr.	69	42	60	53	2	7	37.1	41	38
	R28	252	30 Apr.	98	51	52	0	4	0	37.7	51	71
	R35	238	2 May	99	51	52	2	0	1	35.3	58	57
	R36	237	30 Apr.	68	55	69	51	15	9	36.1	43	30

TABLE 2.—*Partial rearing data for 1960 F_1 egg masses*—Continued

	Rearing number	"Species" female parent	Locality	Collection number	Collection number	Locality	"Species" male parent
Without Reciprocals	R13	?	Dufur, Ore.	128 x	99	Geyserville, Calif.	MT
	R16	*pluviale*	Port Angeles, Wash.	125 x	40	Morgan Hill, Calif.	*ambisimile*
	R17	*pluviale*	Port Angeles, Wash.	125 x	121A	Grants Pass, Oregon	*pluviale*
	R19	*pluviale*	Grants Pass, Ore.	121A x	146	Susanville, Calif.	*recenseo*
	R21	*fragile*	Tom's Place, Calif.	144 x	122	Eugene, Ore..	*pluviale*
	R22	*ambisimile*	Hollister, Calif.	43 x	122	Eugene, Ore.	*pluviale*
	R39*	*ambisimile*	Hollister, Calif.	43 x	122	Eugene, Ore.	*pluviale*
	R31	*pluviale*	N. W. Calgary, Alta.	180 x	122c	Eugene, Ore.	*pluviale*
	R32	*lutescens*	Derwent, Alta.	179 x	120a	Mt. Shasta, Calif.	*recenseo*
Controls	R3	MT	Geyserville, Calif.	99 control			
	R4	*fragile*	Tom's Place, Calif.	114 control			
	R7	*ambisimile*	Morgan Hill, Calif.	40 control			
	R38*	*ambisimile*	Morgan Hill, Calif.	40 control			
	R10	*californicum*	Belmont, Calif.	8 control			
	R18	*pluviale*	Port Angeles, Wash.	125 control			
	R29	*pluviale*	N. W. Calgary, Alta.	180 control			
	R30	*lutescens*	Derwent, Alta.	179 control			
	R34	?	Redmond, Ore.	130 control			

	Rearing number	Total eggs in egg mass	Hatching date	Percent hatching	Percent mortality of hatched caterpillars	Percent total mortality	Infertile yolk eggs	Unhatched dead caterpillars	Other unhatched eggs	Mean days: hatching to emergence	Emerged males	Emerged females
Without Reciprocals	R13	228	30 Apr.	97	60	62	0	8	0	35.6	52	35
	R16	145	3 May	99	53	54	0	1	0	37.5	38	30
	R17	167	1 May	96	75	76	0	6	1	39.9	34	6
	R19	138	1 May	84	24	36	0	22	0	37.1	46	42
	R21	92	30 Apr.	98	32	34	0	1	1	37.6	32	29
	R22	152	1 May	91	100	100	9	5	0	(1)	(1)	(1)
	R39*	156	19 May*	76	82	87	25	13	0	33.4	15	6
	R31	221	30 Apr.	95	30	34	4	5	2	36.5	64	82
	R32	150	4 May	86	78	81	11	9	1	40.5	19	9
Controls	R3	186	5 May	96	71	72	0	7	0	38.8	35	17
	R4	162	4 May	04	100	100	2	153	0	(1)	(1)	(1)
	R7	145	4 May	04	100	100	2	136	1	(1)	(1)	(1)
	R38*	86	21 May*	52	76	87	17	3	21	31.4	9	2
	R10	91	1 May	69	41	59	20	5	3	33.3	21	16
	R18	107	2 May	88	74	78	0	13	0	38.9	17	7
	R29	198	30 Apr.	89	56	61	14	6	1	34.5	45	33
	R30	239	3 May	93	74	76	10	6	1	39.2	34	24
	R34	189	1 May	75	85	89	2	39	6	37.4	9	12

[1] All died before emergence.

* Indicates a replacement egg mass that was hatched after the original colony had died.

The parents of all the 1960 F_1 populations discussed here were collected in California, Oregon, Washington, British Columbia, Alberta, and portions of states or provinces bordering them. All of them lay the flat, clasping type of egg mass, build large, conspicuous tents, occur on a wide variety of trees and shrubs, and are indistinguishable from each other by any known structural characters of either the larvae or adults. Some of the adults may be recognized by the color pattern, but the populations which have been described as species in the past have been separated mainly by differences in the larval color pattern.

The reared 1960 F_1 consisted of 36 egg masses (including controls), totaling 5777 eggs, of which 4789 hatched, and 2042 were either preserved as larvae or reared to adults. The larvae which were preserved are counted as adults in the mortality figures, although some of them would not have survived to be adults. The full collection data for the parents of each egg mass are given in Appendix 1 (page 253). The specific names applied to each population are the names that were in use when this study was begun.

The 2,747 larvae which died of undetermined causes at any stage from the first instar to the pupa make up 57 percent of those which hatched. Desirable as it would have been to determine the cause of death for every caterpillar which hatched, it simply was not possible. No doubt many of them died of starvation in the early instars after falling off the foliage, since they are easily overlooked at this stage, and many do not find their way back to the foliage. Others may have refused to eat apple or may have succumbed to diseases, although only a few obviously were diseased. No doubt at least a few were genetic misfits, but they could not be distinguished from the others.

One thing, however, is apparent when the percent mortality of hatched caterpillars is examined. It is quite high in most cases, with many of the controls showing a higher mortality than the hybrids. No reason for the higher mortality of the controls is known, but inbreeding could have reduced the viability of the controls or hybrid vigor could have increased the viability of the hybrids, or it may be due purely to chance since only a single egg mass of each was reared, with two exceptions.

These two exceptions (indicated by *) were replacement egg masses that were hatched after a poor hatch of the first egg mass or an early dieoff of the caterpillars that did hatch. In one case R39 replaced R22 after all but two caterpillars had died in the second instar (possibly it got too hot in the area of the greenhouse where they were). In the replacement egg mass the hatch was poorer (76% instead of 91%), but the mortality after hatching was less (82% instead of 100%). In the second case R38 replaced R7, and both the hatch (52% instead of 4%) and the mortality after hatching (76% instead of 100%) were better, although still not good. Nevertheless, these two cases indicate that considerable variability in hatching and mortality could have been expected if it had been possible to rear more egg masses.

The egg masses are grouped into three sections: those crosses with reciprocals, those without reciprocals, and controls. Considering the fact that only a single egg mass was hatched, the data are fairly uniform for all egg masses, with few exceptions. In general the controls show greater variability than either of the other groups.

The total number of eggs per mass ranged from 55 to 252, with a mean size of 160. The mean size of the controls was 156 and of the hybrids 162. All egg masses were removed from the temperature cabinet on April 27th. Date of hatching was taken as that day when most of the caterpillars had hatched. Usually most of them hatched the same day, but occasionally a few hatched a day earlier, or if the hatch was poor, those that were successful in hatching sometimes straggled out for several days. This may account for the apparently later hatch of the controls (approximately 1 day later on the average) than the hybrids, since the hatch of the controls was poorer in most cases.

The number of eggs hatching was quite high for most egg masses. The two outstanding exceptions are R4 and R7 (both controls) in which the hatch was very low. Nearly all of these eggs had gone through their embryological development successfully, but for some reason they failed to hatch. No reason is known for this failure, but the caterpillars in R7 had eaten away about half as much of the chorion as would have been necessary for them to escape from the eggs, indicating that the eggs were fertile, but the chorion was too tough, or the viability was reduced for some reason. The hatch of the replacement egg mass for R7 (R38) was about 50 percent, which is considerably better, but still much below that of most other egg masses.

Among the other egg masses R2 showed only about 50 percent hatching. The male parent of this egg mass was the same as the parents of R4 (which had a very low hatch, 4%), but four other egg masses with one R4 parent (R1, R5, R6, R21) showed very good hatching, indicating that these variations in hatching were probably due to chance and of no significance.

The mean time for development from hatching to emergence as adults (both sexes) varied from 33.3 to 39.2 days for the controls, and from 35.1 to 40.7 days for the hybrids under greenhouse conditions at prevailing temperatures in May and June. This is a spread of 5.9 days for the controls and 5.6 days for the hybrids, but the mean time of development for nearly all of the controls and hybrids is somewhere between 35 and 39 days. These differences could be due to factors such as random variation, location in the greenhouse, food quality, and disease. The differences between the controls do not appear to be correlated with any other known differences between these populations. The hybrids are more uniform than the controls, but this is what one would expect since any differences between the parents would tend to be moderated in the F_1.

The developmental period for the two replacement egg masses (R38 and R39) was 31.4 days and 33.4 days respectively. This shorter developmental period was caused, no doubt, by warmer temperatures, since hatching took place approximately 3 weeks later in the spring than for the others.

In the past there have been suggestions made that developmental times may be useful in separating some of the closely related species of *Malacosoma* (Langston, 1957). It is certainly true that there are differences in developmental times between contrasting localities such as alpine and valley, but much of this variation can be attributed to temperature differences (especially night temperatures). This does not mean that differences in developmental rates do not exist between some populations, but such observed variations cannot be considered to be reliable unless the two populations in question occur at the same locality, and therefore have been subjected to the same basic weather conditions. (See the introductory discussion to *M. californicum* and *M. incurvum* on page 118 for an example of a meaningful difference.) If the populations in question do not occur in the same locality (as will usually be the case) then they must be reared from disease-free eggs under very carefully controlled conditions before any valid comparisons can be made concerning developmental rates. This has not been done, and was not done in this study because of a lack of disease-free stock and no temperature control in the insectary-trailer.

In any rearings that are undertaken consideration also must be given to such factors as individual variation, host preferences, and adaptive differences between populations occurring in different climatic areas. Under laboratory conditions Wellington (1957) found differences as great as 7 days between the developmental rates of active (Type I) larvae and sluggish (Type II) larvae of *M.* [*californicum*] *pluviale.* These differences were even greater under field conditions where colonies of sluggish larvae didn't move to their food as often as active colonies, and resulted in some active colonies completing development as much as 3 weeks before sluggish colonies. Obviously, if valid comparisons are to be made, the larvae must be segregated by activity types as soon as possible after hatching.

The larvae of all species and populations feed on a wide variety of hosts, but this does not mean they develop equally well on all hosts. Therefore, it would probably be necessary to rear them on several different hosts to get reliable results.

Each population probably is better adapted to the climatic conditions in its native area than to conditions in other areas. Therefore, careful consideration must also be given to the environmental conditions that rearings are to be made under, or one population may be favored by the selection of conditions that are closer to its optimum. The use of controlled environment chambers that can be programmed to duplicate the changing conditions what would be encountered in the natural habitat is essential, and, ideally, each population should be reared under the conditions that other populations which are being compared occur under, as well as its own. Only when all of these variables have been satisfactorily controlled, will it be possible to obtain valid comparisons of developmental rates.

When the developmental data from all of the 1960 F_1 rearings are segregated by sex, there appear to be slight differences in developmental rates between males and females. The length of development from hatching to adult emergence averaged close to 37 days for 1651 males and females from all rearings (excluding R38 and R39 which were reared during warmer weather). It averaged 36.73 days for 959 males and 37.28 days for 692 females. Nearly always more males than females emerged the first few days, and more females than males emerged the last few days that emergence took place. These differences are in agreement with observations made on field-collected, reared adults, and indicate that the males tend to emerge slightly earlier than the females.

The sex ratios are interesting from the standpoint that in 29 of the 36 rearings (6 of 7 controls, and 23 of 29 hybrids) more males than females were obtained. The sex ratios include preserved larvae, since there was a definite tendency to select females for preservation in the last instar. In the samples of last instars taken, 126 females and 48 males were preserved. The samples were taken before it was known how to sex the caterpillars (see the section on larvae for the sexing technique, page 46), so there was no conscious selection of one sex in preference to the other. Mature larvae, however, were selected for preservation using the incorrect assumption that the largest larvae were the most mature, and since it is known now that mature female larvae are on the average slightly larger than mature male larvae, this undoubtedly accounts for the higher number of females preserved in the last instar.

The ratio of males to females, however, when all of the preserved larvae are included is still 1.25 males to 1 female (42 percent females).

Adults emerging from cocoons collected by Hodson (1941) showed a sex ratio for *M. disstria* in Minnesota of 47 percent females in 1936 and 48 percent females in 1937. Similar unpublished sex ratios taken by Hodson in 1952 showed 30 percent females at Lake George, Minnesota (7 mi. E. Itasca State Park), 38 percent females in 1953 at Lake George, and 43 percent females in 1953 just north of Itasca Park. All of these results consistently show fewer females than males, and if it is assumed that the samples were random and there are no other differences between males and females which result in greater numbers of one sex being collected than the other, it indicates one of two things: either the females had a higher mortality rate at some time during their development, or there were fewer females at the start. It is not known which of these alternatives (or both) is true.

The *pluviale-lutescens* Relationship

The number of unhatched, dead caterpillars, infertile eggs (those eggs which contain only yellow or orange yolk and show no signs of any embryological development), and other unhatched eggs (those eggs showing signs of some development, but which are not recognizable as caterpillars because they died at an early stage of development or because they were decayed) do not appear to be of any significance in any of the egg masses with the exception of rearings R27 and R36. When these are compared with their reciprocals (R28 and R35) and the controls (R29 and R30), the number of infertile eggs is strikingly greater in R27 and R36.

In both R27 and R36 the male parent came from populations about 100 miles east of Edmonton, Alberta, which have been known since 1949 as *M. lutescens* (Neumoegen and Dyar), the so-called prairie tent caterpillar (figs. 373–375, 221). Before 1949 it had been known as *M. fragile lutescens* (Neumoegen and Dyar). The female parents came from a population in the foothills of the Rocky Mountains about 60 miles northwest of Calgary, Alberta, that has been known in the past as a bog form of *M. pluviale* (Dyar), the so-called western tent caterpillar (figs. 372, 200). (See the section on *M. californicum pluviale* for a discussion of the bog form and crossing it one way with nonbog *pluviale*, page 158. It would have been better to use nonbog *pluviale* since they are more likely to occur in the same area as *lutescens*, but their emergence could not be synchronized with that of *lutescens*.)

Often infertile eggs which are found in egg masses of *Malacosoma* are grouped together, indicating that the sperm probably were prevented from reaching these eggs for one reason or another, rather than that a certain percent of the sperm were inviable. In both R27 and R36, however, the infertile eggs (27% in R27 and 22% in R36) were more or less evenly scattered throughout the egg mass, indicating that some of the eggs or sperm probably were inviable for some reason, since only 4 percent of the eggs of the *lutescens* control were infertile, and only 6 percent of the eggs of the *pluviale* control were infertile. In other respects, such as date of hatching, percent survival after hatching, average number of days from hatching to emergence of adults, and sex ratio, there are no striking differences between R27, R36, and their reciprocals.

The differences between the controls (R29 and R30) in regard to date of hatching and length of developmental period from hatching to emergence as adults are of interest and possibly of some significance. The egg mass of the bog *pluviale* hatched on April 30, while that of *lutescens* hatched on May 3d. The bog *pluviale* averaged 34.5 days from hatching to adult emergence under greenhouse conditions, while the *lutescens* averaged 39.2 days. There is a possibility that this difference of about 5 days could be due to temperature differences at various locations in the greenhouse, disease, and the other factors already discussed which could influence developmental rates, rather than to any real difference in developmental rates. It also could be due to chance, since nonbog *pluviale* from Port Angeles, Washington, (R18) hatched on May 2d, and averaged 38.9 days from hatching to emergence. It may be also that the hatching date is actually earlier, and the developmental rate of the bog *pluviale* under given conditions is faster than that of nonbog populations. If this is true, it could account for the observed differences in developmental rates between the bog population of *pluviale* (R29) and the nonbog population (R18) when reared at similar temperatures. If the bog and nonbog populations occurred in the same locality, however, and they are not known to do so at the present time, any seasonal isolation due to differences in adult emergence times would tend to be cancelled out by the faster developmental rate of the bog population. In other words, the bog population would keep pace with the nonbog population because their rate of development under cooler conditions in the bog would be about the same as the nonbog population under warmer conditions.

If the difference in developmental rates between bog *pluviale* and *lutescens* is real, when it is combined with the 3-day difference in hatching dates, it results in the adults of bog *pluviale* emerging approximately 1 week earlier on the average than those of *lutescens*. Since the nonbog populations of *pluviale*, however, are most likely to be the ones that occur in the same locality as *lutescens*, it does not appear that there would be any seasonal isolation between *pluviale* and *lutescens*. It was not possible to compare developmental rates under field conditions in 1960, since the closest populations that were located of these two forms were nearly 100 miles apart.

Figure 2 shows numerous localities for *lutescens* in Canada, and relatively few in the United States, but this is an indication of the intensity of collecting rather than abundance, since the Forest Biology Laboratories in Canada have been surveying Canada for many years, and practically nothing has been done in the United States. Even so, there is a notable lack of collections from the area near the black line separating the *lutescens* localities from the *pluviale* localities in Alberta, Saskatchewan, and Manitoba. This may be due to the lack of roads in much of the area, resulting in fewer collections, or possibly *lutescens* and *pluviale* are so well adapted to their respective areas that neither they nor their "hybrids" do well in the boundary area.

The caterpillars reared from egg masses R27, R36, and their reciprocals were intermediate between the parent populations in many aspects of the color pattern, but they showed greater variability than either of the parent populations, although *lutescens* normally is more variable than *pluviale*. Nearly all of the hybrids showed a distinct vertical black bar which always is present on *pluviale*, but frequently absent on *lutescens* from the northern prairies. The lateral blue area, so pronounced in *lutescens* but reduced to patches of blue at the anterior and posterior subdorsal spots in *pluviale*, was quite variable, but more often than not it was more extensive in the hybrids than in *pluviale*. The dorsal stripe was always bluish-white as in both parents, but its width was variable. In the parents the width of the dorsal stripe is nearly always greater in *pluviale*. The addorsal area, which is largely black in *lutescens*, and orange with some black in *pluviale*, was variable with most of the specimens falling between the parental extremes.

The great majority of the adult male hybrids were similar in color and pattern to those of *pluviale*, with an occasional one tending toward *lutescens*. Most of the females, on the contrary, were intermediate in color and pattern, with some specimens tending more toward *lutescens*.

Many (but not all) male *pluviale* can be separated from *lutescens* by a character of the prongs of the accessory claspers (compare figs. 22 and 23 with 24 and 25). Figures 23 and 24 represent the extremes, and most specimens are closer to figures 22 or 25. Many female *pluviale* can be separated from *lutescens* by the larger and more distinct dorsal lobe of the ovipositor (compare figs. 98 and 101). These figures are close to that which would be considered "normal." See the comments under *M. californicum* (Packard) for a more detailed discussion of these characters (page 128).

A sample of males from the F_1 rearings R27, R28, R35, and R36 showed the prongs of the accessory claspers to be more or less intermediate, but with more of them tending toward the *lutescens* type, and with much variability. A similar sample of females showed that most of them were between the range of figures 98 and 101, but as in the case of the males, they tended to be closer to the *lutescens* type. The genital plate of most female *lutescens* from collections 173 and 179 was more extensively sclerotized than the genital plate of most female *pluviale* from collection 180, in which it was almost totally unsclerotized. In the sample of F_1 females, nearly all of them had genital plates which were more extensively sclerotized than the parent *pluviale* females.

Some characters of the F_1 specimens show greater variability than either parent, some are more or less intermediate, and others tend to dominate. Similar results were obtained in the other F_1 rearings. These observations on only a few easily seen characters show that neither parent is dominant over the other. The best explanation for the distinctive combinations of characters shown by typical *lutescens* and *pluviale* is that they provide some selective advantage over other combinations in the areas where they are found.

The data presented above for *lutescens* and *pluviale* are not conclusive, but they suggest the possibility that some genetic isolation exists between the males of *lutescens* and females of *pluviale* in the Canadian part of their distribution. This does not appear to be present when the reciprocal mating takes place. Further investigation should be done on this subject, however, since these results could have been caused by peculiarities of the local populations which were used, rather than attributes of the entire populations of *lutescens* and *pluviale*. Despite this possibility and despite differences in some larval and adult characters, these two populations are regarded as subspecies of *M. californicum*, because, as far as is known, all of these differences break down and the populations intergrade completely with each other and with the central populations of *M. californicum* along the western edge of the Great Plains in the northern United States (see figs. 377–379 and compare with figs. 370–372, figs. 373–376, and figs. 383–387).

F_2 Egg Masses

F_2 egg masses were obtained from the 1960 F_1 whenever possible, but, as previously noted, survival was very poor, so they were not satisfactorily reared. A sample of 20 eggs was examined from each egg mass, however, and 85 to 95 percent of the eggs of both the F_2 and F_2 controls contained embryos which had developed at least to the point where they were recognizable as caterpillars. This is somewhat less than the approximately 95 percent of recognizable caterpillars present in the 1960 F_1 egg masses. It should be noted, however, that the F_2 egg masses were held under conditions which obviously were unfavorable at some time, since most of them were dead or dying when they were examined.

Summary of Experimental Crosses

If the presentation of these data has emphasized the complete lack of any absolute reproductive barriers between the various western populations which build large tents, it has served its purpose. But a comparison must be made between the results obtained in the laboratory and observations in the field. The best way to do this is to compare the larval variability that was observed in the field with that which was observed in the larvae reared from the crosses.

It was possible to cross male *M. americanum* with females of other western populations and obtain normal egg masses. Some of these eggs went through their embryological development, but could not be reared because of the difficulties already mentioned in holding the eggs. Such crosses, however, probably never occur in the field since no specimens have ever been seen which can be interpreted as hybrids between *americanum* and other species.

This is not the situation that was found in the field for the other populations that have been discussed in the latter part of this section (those occurring in California, Oregon, Washington, western Nevada, Alberta, British Columbia, and bordering areas). Populations in these areas have been described in the past as five different species (*ambisimile*, *californicum*, *pluviale*, *fragile*, and *lutescens*), but in every case the larval variations that were found in the "hybrids" which were reared in the laboratory were also found in field populations. The variability of the "hybrid" adults also fell within the range of variability that was found in adults reared from field-collected larvae or field-collected adults.

The populations of *Malacosoma* which occur in the Great Basin, the United States Rocky Mountains, and the Southwest were studied in 1961. Most of the populations occurring in these areas are less well defined geographically, and show greater variability than many of those studied in 1960. As is pointed out in Table 1, the success of various attempted crosses was better in 1961 than in 1960. It was not possible to rear any of the 1961 F_1 egg masses because of the difficulty in holding them over the winter. The eggs, however, went through their embryological development almost as well as the 1960 F_1 egg masses despite the fact that conditions may have been less favorable in 1961, and there is no reason to believe they could not have been as successfully reared. This is true of all populations studied in 1961, including those which are regarded as *M. incurvum*. *Incurvum*, however, is regarded as a good species for other reasons which are discussed in a later section (see page 118).

The areas showing great larval variability in the field were usually quite extensive and, in general, they must be regarded as zones of intergradation between populations of the same species. Some populations are sufficiently different in one or more life stages, and well enough defined geographically to warrant recognition as subspecies, but recognition of them as good species would completely obscure the relationships between them.

It seems possible that these populations, which are presently quite different in some respects (most often in larval color pattern) yet almost identical in many other respects, could have evolved these differences in the past when they were separated physically by a barrier of some kind. If this is true, the highly variable and extensive populations which presently occur between them must have been formed more recently when they came in contact as the barriers disappeared or were modified, and before reproductive isolation had become well developed. Any suggestions as to where or when these populations were separated and reunited would largely be pure speculation, so they have not been attempted.

Another possible explanation for the present differences between some populations and the relatively large zones of intergradation between most of them is that they are the visible expression of gene combinations that are most favorable under the prevailing conditions in each area, and, therefore, are preserved by natural selection. This would not require that they be physically separated in the past.

The most likely explanation, however, for the differences is one that involves at least partial physical separation at some time as well as the preservation of favorable gene combinations by natural selection, since both of them acting together would be more effective than either one alone.

Genus MALACOSOMA Hübner

Malacosoma Hübner, 1820, Verzeichniss Bekannter Schmettlinge [sic], p. 192. Type species: *Bombyx franconica* Esper; designated by Kirby, 1892, Catalogue of Lepidoptera Heterocera, vol. 1, Sphinges and Bombyces, p. 819.

Clisiocampa Curtis, 1828, British Entomology, vol. 5, Insect No. 229. Type species: *Phalaena neustria* Linnaeus, original designation.

[*non*] *Malacosoma* (Chevrolat, MS); Dejean, 1835, Catalogue des Coléoptères, 2d edition, p. 379 (*nomen nudum*), [*Fide* Neave, 1940, Nomenclatur Zoologicus, vol. 3, p. 31.] Falderman, 1837, Nouveaux Mémoires de la Société Impériale des Naturalistes de Moscou, vol. 5, pp. 335–336, pl. 12, fig. 5. (Coleoptera: Chrysomelidae).

[*non*] *Malacosoma* De Man, J. G., 1879, Notes from the Royal Zoological Museum of the Netherlands. 1: 67. (Crustacea:Pinnotheridae).

[*non*] *Malacosoma* Kopperi, A. J., 1935, Annales Zoologici Societatis Zoologicae-Botanicae Fennicae Vanamo, 3(2): 21. (Protozoa:Butschliidae).

A few early descriptions of tent caterpillars were made under the generic name *Bombyx*, but all work of any importance on North American species has been published under one of two generic names, either *Malacosoma* Hübner, 1820, or *Clisiocampa* Curtis, 1828. No other generic names have been proposed for tent caterpillars, although species (mostly European) have at one time or another been included in other genera. See Collier (1936) for a list of these references.

Francis Walker (1855, p. 1444) appears to be the first person to again use the name *Malacosoma* for tent caterpillars after Hübner described the genus in 1820. Walker listed the European species *franconicum* under *Malacosoma*, but listed the rest of the Old and New World species under *Clisiocampa*. Grote (1864) used Hübner's name *disstria* (1820) in place of Harris's name *sylvatica* (1841) for the forest tent caterpillar, but retained the generic name *Clisiocampa*. *Clisiocampa* remained in use until 1892 when Kirby listed four European species in the genus *Malacosoma*, one in *Lachneis*, and the rest (including all North American species) in *Clisiocampa*. Dyar (1898) was the first person to consistently use *Malacosoma* instead of *Clisiocampa*, but later he described *tigris* (1902), *luteimargo* (1907), and *onissa* (1911) under *Clisiocampa*. After 1900 *Clisiocampa* was rapidly replaced by *Malacosoma*, but *Clisiocampa* was still used occasionally, even as late as 1930 by Ancona. *Malacosoma* seems to be universally used at the present time.

Freeman (1949) pointed out that *Malacosoma fragilis* should properly be *Malacosoma fragile*, since the gender of *Malacosoma* is neuter, not feminine. *Clisiocampa*, the generic name under which most of the North American species were originally described, is feminine, so the error in endings is a natural one that came about when *Malacosoma* replaced *Clisiocampa* as the proper generic name.

The genus *Malacosoma* is a relatively homogeneous group which is sharply distinct from other lasiocampid genera found in North America. It has not been possible to examine representatives of all other genera which occur in North America, but those which have been examined (*Gloveria*, *Eutachyptera*, *Dicogaster*, *Quadrina*, *Epicnaptera*, *Artace*, *Tolype*, *Heteropacha*, *Hypopacha*, *Nesara*, and *Euglyphis*) differ from *Malacosoma* in several respects. The monotypic genus *Hypopacha* appears to be the nearest relative of *Malacosoma* in North America, and Dyar (1928) says it forms a transition between *Euglyphis* (a large Latin American genus) and *Malacosoma*. On the basis of adult morphology alone, however, *Hypopacha* cannot be considered a close relative of *Malacosoma*.

The easiest way to identify specimens as *Malacosoma* is simply to observe the overall shape and size in combination with the presence of the two oblique lines on the forewings and the virtual lack of any other distinctive markings (see figs. 119–329). Wing venation can be used (fig. 10), but in practice this is rarely used because of the presence of other, more easily visible characters.

Four of the above genera (*Gloveria*, *Eutachyptera*, *Dicogaster*, *Quadrina*) and also *Caloecia* (which has not been personally examined) can be most easily separated from *Malacosoma* by their large size, males having a wingspread of about 1½ to 2 inches, and females even larger. Male *Malacosoma* never have a wingspread of 1½ inches, and females rarely approach 2 inches. In addition, all species of these genera which have been examined have a small light-colored spot (sometimes faint) located just beyond the discal cell in the forewing. This spot is absent in *Malacosoma*.

Epicnaptera is separated most easily by the scalloped margin of the wings, especially the hindwing. The margin is relatively even in *Malacosoma*. The remaining genera (*Artace*, *Tolype*, *Heteropacha*, *Hypopacha*, *Nesara*, and *Euglyphis*) are more nearly the same size as *Malacosoma*, but they do not have the single pair of distinctive lines on the otherwise unmarked forewings, or the wings are shaped differently. In addition, vein R4 of the forewing arises at or beyond the apex of the discal cell in species of these genera which have been examined, but arises before the apex of the discal cell in *Malacosoma* (fig. 10).

If there is any doubt as to whether a given specimen is a *Malacosoma* or not, the genitalia should be checked (especially males). The male genitalia of all species of *Malacosoma* are similar in their basic structure (fig. 30) and differ greatly from those of any other lasiocampid genera that have been examined. Females are not so easily separated by genitalic characters, but the shape of the genital plate area which surrounds the ostium (figs. 83, 90, 95, 102), whether it is sclerotized or not, is different from females of the other genera which have been examined. In the vast majority of cases, however, both male and female *Malacosoma* should be readily recognized by the combination of easily visible wing characters given above.

KEY TO ADULT MALE NORTH AMERICAN MALACOSOMA

(The genitalic characters are by far the most reliable.)

1. Lines on forewing darker than background color 2

Lines on forewing lighter than background color 6

2(1). Epiphysis longer than first tarsal segment of foreleg, about ⅔ as long as tibia and sickle-shaped (fig. 75); genitalia as in figures 12, 33, 37, and 57 . . . . *disstria*, p. 84 (Also see *neustrium*, p. 187).

Epiphysis, if present, shorter than first tarsal segment of foreleg, not ⅔ as long as tibia and sickle-shaped 3

3(2). Outer line on forewing usually distinctly curved toward base of wing near costal margin and meeting it at nearly a right angle as in figure 140; genitalia as in figures 13, 34, 38, and 58; distribution—Washington, Oregon, California, and Baja California 4

Outer line on forewing usually turned toward tip of wing near costal margin or meeting it at an acute angle as in figure 178; genitalia not as in figures 13, 34, 38, and 58; distribution—all of western and northern North America . 5

4(3). Color usually brownish; lines on forewing sometimes faint or nearly absent (males in figs. 152–160); distribution—south of a line drawn from Indio, Riverside Co., Calif., along the southern base of the San Bernardino and San Gabriel Mountains (fig. 4) . . *constrictum austrinum*, p. 99

Color usually yellowish; lines on forewing more distinct, rarely faint (males in figs. 140–151); distribution—north of a line drawn from Indio, Riverside Co., Calif., along the southern base of the San Bernardino and San Gabriel Mountains (fig. 4) . . . . *constrictum constrictum*, p. 93

5(3). Lines on forewing not indented along veins, and not bordered by a narrow, pale area; inner, outer, and median areas of forewing almost invariably the same uniform color; color varying from yellow to yellow-brown (males in figs. 161–175); genitalia as in figures 14, 32, 39, and 59; distribution—Utah, Colorado, Arizona, New Mexico, Texas, Mexico, and possibly adjoining areas (fig. 1) . *tigris*, p. 102

Lines on forewing often indented along veins as in figure 249, and often bordered by a narrow, pale area as in figure 261; inner, outer, and median areas of forewing usually with some variation in color between the areas; color extremely variable, ranging from gray to brown to yellow to orange-brown and various intermediate shades (see males in figs. 176–308 except figs. 206–208); genitalia not as in figures 14, 32, 39, and 59; distribution—all of western and northern North America 6

6(1, 5). Lines on forewing white or yellowish-white; outer line often nearly straight as in figure 314, and without indentations along the veins; lines never appearing to be bordered by a darker line; genitalia as in figures 15, 30, 31, 40, and 60; total length of eighth sternite (fig. 40) almost always distinctly greater than length of fore tibia; distribution—east of the central Great Plains and south from southern Canada to the Gulf of Mexico (fig. 2).
americanum, p. 111

Lines on forewing dark or light, lines various shades of yellow, orange, white, brown and gray; outer line usually distinctly bowed outward as in figure 295, and often with indentations along the veins as in figure 297; lines sometimes appearing to be bordered by a darker line as in figure 264; genitalia not as in figures 15, 30, 31, 40, and 60; total length of eighth sternite (figs. 41–51) almost always distinctly less than length of fore tibia; distribution—west of the central Great Plains, the northern edge of the United States, and Canada 7

7(6)*. Both forewings and hindwings usually dark reddish-brown; dark lines (sometimes very faint) crossing forewings which usually are not bordered by a light narrow area (figs. 188 and 189); distribution—west side of the Sierra Nevada and parts of northern California (fig. 3).
californicum recenseo, p. 148

Forewings and hindwings variable in color, sometimes dark reddish-brown, but usually a dark orange-brown, gray-brown, yellow-brown, or variations thereof; lines on forewings appearing light or dark, but usually bordered by a contrasting, narrow area (males in figs. 176–308 except figs. 188, 189, and 206–208); distribution—western North America except the area listed above. 8

8(7). Color of wings usually mixed gray-white and chocolate-brown, sometimes with a yellowish tint, especially in specimens from

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*There are no known structural characters which will separate the two species and their subspecies which make up the rest of this key. In some cases the subspecies are recognized on the basis of larval differences, but no matter what characters are used, it is not possible to identify some specimens.

the edge of the distributional limits; lines on forewings usually with many indentations (figs. 270–277) which often meet between the lines to cut off "islands" as in figure 270; veins in forewings often outlined by whitish scales as in figures 270 and 277; distribution—Mojave Desert area of California, Arizona, Nevada, Utah, and the southern part of the Great Basin (fig. 2); specimens may be found farther south in California and in Mexico, too.
californicum fragile, p. 164

Color not as above, usually more orange-brown, yellow-brown or gray-brown; lines on forewings sometimes with indentations, but rarely cutting off more than one "island" between the lines; veins in forewings usually not outlined with scales; distribution—western and northern North America, but not from the Mojave Desert area outlined above, except along streams or irrigated areas 9

9(8). Color medium brown to dark blackish, chocolate-brown (figs. 286 and 287), except for a few pale yellowish specimens with brownish lines on forewings (fig. 285); distribution—the Mexican plateau area as presently known.
incurvum aztecum, p. 183

Color variable, yellow-brown, gray-brown, yellow-gray or chocolate-brown, but not occurring in the Mexican plateau area as presently known 10

10(9). Color varying from yellowish-gray to dark gray-brown; lines on forewings usually with small indentations along the veins between the lines, or none, rarely with deeper ones (males in figs. 291–308); distribution—mainly found along the Colorado and Gila Rivers and their tributaries in the Utah-Arizona area 11

Color orange-brown, yellow-brown, or other shades of brown, usually with little or no gray; lines on forewings with or without indentations, but often with conspicuous ones which may meet to cut off "islands" between the lines, especially in specimens from the Great Basin, southern Rocky Mountains, and the Southwest; distribution—western North America and northern Canada 12

11(10). Color various shades of medium yellowish-brown; lines on forewings usually brownish, and usually without indentations or only small ones (males in figs. 300–308); distribution—lower parts of the Colorado River and its tributaries above Hoover Dam (fig. 4) . . . . . *incurvum discoloratum*, p. 177

Color ranging from yellowish-brown to a blackish chocolate-brown; lines on forewings light or dark, depending on the

background color; lines usually with only small indentations, but sometimes meeting along Cu 2, and rarely cutting off an "island" (males in figs. 291–299); distribution—usually along watercourses or irrigated areas in central and southern Arizona as presently known (fig. 4).
incurvum incurvum, p. 173

12(10). Color ranging from nearly yellow to dark reddish-brown (males in figs. 209–223), but usually varying combinations of bright yellow-cream and deep reddish-brown; lines with no identations or very small ones, rarely deep enough to meet between the lines; the most frequent color pattern a yellowish forewing with a variable, dark, reddish-brown median band as in figures 209, 211, 218, and 221; distribution—the Canadian prairies and the western two-thirds of the Great Plains in the United States (fig. 2).
californicum lutescens, p. 160

Color pattern similar or very different from that described above; distribution—west and north of the area described above 13

13(12). Color pattern usually various shades of orange-brown, with lines on forewings usually yellowish as in figures 177, 178, 182–184, and 191–193, but other variations as in figures 176 and 194–196 may be found; lines usually with no indentations along the veins, or only with very small ones; distribution—northern and western California, Oregon, Washington, British Columbia, western and northern Alberta, northern Saskatchewan, northern Manitoba, Ontario, Quebec, and parts of neighboring states and provinces.
californicum californicum (fig. 3), p. 138
californicum ambisimile (fig. 3), p. 142
californicum pluviale (fig. 2), p. 152

Adult males of these subspecies are identifiable only with the aid of distributional data.

Color pattern highly variable from area to area; variations on nearly all of the color patterns described since couplet 7 can be found (excluding some of the *incurvum* patterns) (males in figs. 224–269); often many of these variations can be found in a single area (figs. 224–248); distribution—parts of California, Oregon, Washington, Idaho, Montana, Arizona, New Mexico, Utah, Nevada, Wyoming, Colorado, Texas, and possibly Mexico (fig. 2).
various populations of *californicum*, p. 123

KEY TO ADULT FEMALE NORTH AMERICAN MALACOSOMA

(The genitalic characters are the most reliable.)

1. Lines on forewings white or yellowish-white, nearly straight, almost always without indentations along veins (figs. 207, 208, 315, 318, and 320); genital plate heavily sclerotized with ostium located near the edge (fig. 90); distribution—east of the central Great Plains and south from southern Canada to the Gulf of Mexico (fig. 2) . . . . *americanum*, p. 111

   Lines on forewings light or dark, usually bowed outward, often with indentations along veins as in figure 281; genital plate unsclerotized or partially sclerotized or fully sclerotized, but if sclerotized the ostium is near the center (figs. 83, 95, and 102); distribution—all of North America 2

2(1). Epiphysis usually shaped as in figure 76, and usually longer than the second segment of foretarsus, rarely smaller or absent; color yellow-brown to orange-brown, forewings crossed by soft brown lines without a distinct lighter border; lines almost always without indentations along veins (females in figs. 119–139); genital plate sclerotized and with ostium in center (fig. 83); ovipositor lobes as in figures 81 and 82 with no distinct dorsal lobe . . . . *disstria*, p. 84

   Epiphysis absent or shorter than second segment of foretarsus; color usually not as above; lines on forewings with or without indentations along veins; genital plate variably sclerotized with ostium in center; ovipositor lobes (figs. 84–104) not as above 3

3(2). Color medium chocolate-brown, dusted with whitish-yellow scales which are quite apparent on most specimens; lines on forewings dark (on a few rare specimens the lines may be light as in figs. 157 and 160) and without indentations along veins; median area usually somewhat darker than inner and outer areas (females in figs. 140–160); genital plate usually unsclerotized; ovipositor lobes as in figures 86 and 87; distribution—California, Oregon, Washington, and Baja California 4

Color variable, but not medium chocolate-brown and dusted with whitish-yellow scales in the distributional area described above; lines on forewings light or dark, with or without indentations along the veins; median area variable; genital plate variably sclerotized; ovipositor lobes variable, but not as in figures 86 and 87; distribution—western and northern North America 5

4(3). Lines on forewings usually not sharply contrasting with ground color (figs. 154, 157, and 160); distribution—south of a line drawn from Indio, Riverside Co., Calif., along the southern base of the San Bernardino and San Gabriel Mountains (fig. 4) . . . . *constrictum austrinum*, p. 99

Lines on forewings usually more sharply contrasting with ground color (figs. 142, 145, 148, and 151); distribution—north of a line drawn from Indio, Riverside Co., Calif., along the southern base of the San Bernardino and San Gabriel Mountains (fig. 4) . . . . *constrictum constrictum*, p. 93

5(3). Color reddish-brown to orange-yellow-brown, dusted with yellowish scales; lines dark, only slightly bowed outward and without indentations along veins (females in figs. 161–175); ovipositor lobes as in figures 84 and 85 with the dorsal and ventral lobes about equal and with a distinct concavity between them as in fig. 84; distribution—Colorado, Utah, Arizona, New Mexico, Texas, Mexico, and possibly adjoining areas (fig. 1) . . . . *tigris*, p. 102

Color variable, but usually orange-brown, gray-brown, yellow-brown, or chocolate-brown; lines dark or light, usually definitely bowed outward (especially the outer line), often with conspicuous indentations as in figure 281; ovipositor lobes never like figure 84; distribution—western and northern North America including Mexico 6

6(5)*. Color usually gray-white and chocolate-brown, sometimes with a yellowish or orange tint in specimens from the edge of the distributional limits; lines on forewings usually with many indentations along the veins which often appear rather "jagged" as in figures 281, 283, and 284; distribution—Mojave Desert area of California, Arizona, Nevada, Utah, and the southern

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*As with the males, there are no known structural characters which will separate the two species and their subspecies which make up the rest of this key. In some cases the subspecies are recognized on the basis of larval differences, but no matter which characters are used, it is not possible to identify some specimens. This is especially true of females.

part of the Great Basin (fig. 2); specimens may be found farther south in California and in Mexico, too.
californicum fragile, p. 164

Color not as above, usually more orange-brown, yellow-brown or gray-brown; lines on forewings with or without indentations along veins; distribution—western and northern North America, but not from the Mojave Desert area outlined above except along streams or irrigated areas 7

7(6). Color usually medium brown to somewhat blackish-brown, often with median area of forewings somewhat darker than inner or outer areas; lines on forewings usually rather subdued and forming a border for the darker median area if one is present; indentations along veins, if present, usually small (figs. 289, 293, and 296).

Distribution—usually along watercourses in central and southern Arizona . . . . . . *incurvum incurvum*, p. 173

Distribution—the Mexican plateau area as presently known.
incurvum aztecum, p. 183

Color variable, but usually more yellow, orange-brown, or gray-brown; median area variable; lines on forewings dark or light, usually distinct; indentations along veins present or absent; distribution—most of western and northern North America, but not known from the Mexican plateau area yet, and rare along watercourses in central and southern Arizona 8

8(7). Color a soft yellowish or orange-gray-brown; lines on forewings usually rather evenly curved (figs. 302, 305, and 308), with only a few small indentations along veins, if any, and usually with lines not sharply contrasting with background color as in figure 305; distribution—lower parts of Colorado River and its tributaries above Hoover Dam (fig. 4).
incurvum discoloratum, p. 177

Color variable, but in the distributional area outlined above, usually more orange-brown with more sharply contrasting lines on forewings; indentations along veins varying from small to quite "jagged" . . . . *californicum* 9

9(8). Lines on forewings usually appearing dark on a yellowish or yellow-orange-brown background as in figure 180, but appearing light if the background is darker than normal as in figure 181; dorsal lobe of ovipositor usually somewhat reduced as in figure 98; distribution—California, Oregon, Washington, Idaho, western Montana, British Columbia, areas west and north of the Canadian prairies, Ontario, Quebec, and possibly adjoining areas; various populations of *californicum*, including—

californicum californicum, p. 138
californicum ambisimile, p. 142
californicum recenseo, p. 148
californicum pluviale, p. 152

Lines on forewings usually appearing light on an orange-brown or brownish background color as in figure 230, but sometimes appearing as a light border for a darker line as in figure 231; dorsal sublobe of the ovipositor usually not reduced as in figure 98, but more distinct as in figure 100; distribution—Great Basin, central and southern United States Rocky Mountains, prairies of Canada, western two-thirds of the Great Plains in the United States, the Southwest, and possibly adjoining areas; various other populations of *californicum*, page 123, including—

californicum lutescens, p. 160

KEY TO MATURE LARVAE OF NORTH AMERICAN MALACOSOMA

(Preserved larvae should be dried off to see the colors properly.)

1. Middorsal line whitish and apparently continuous, without any obvious constrictions at the intersegmental areas; head black (figs. 350–351) . . . . *americanum*, p. 111

Middorsal line absent, or interrupted at the intersegmental areas, or with definite constructions at the intersegmental areas (figs. 339–399, except 350 and 351); if the line is nearly continuous, it will be bluish-white and the head will be bluish (fig. 398) 2

2(1). Middorsal line consisting of a series of keyhole-shaped, whitish-cream marks, one per segment (figs. 339 and 340), sometimes divided to form a larger anterior spot and a smaller posterior spot; rarely only the larger anterior spot is present . . . . *disstria*, p. 84

Middorsal line present or absent, but without markings like those described above 3

3(2). Middorsal area without a blue-white stripe of any kind on the abdominal segments 4

Middorsal area with some kind of a blue-white or whitish stripe on the abdominal segments 11

4(3). Middorsal and addorsal areas marked with an hourglass-shaped orange mark on each segment (figs. 345 and 346); the "neck" of the hourglass with a round black spot at the anterior edge surrounding the base of setal group D1; at least some of the setae in D1 blackish; lateral setae distinctly tufted around setal group L2 (figs. 345–348); (on blackish-orange specimens all of these characters are more difficult to see than on bluish-white ones); distribution—California, Oregon, Washington, and Baja California 5

Middorsal and addorsal areas variously marked, but usually not with an hourglass-shaped mark; if the mark is somewhat hourglass-shaped (fig. 392), the black spot surrounding setal group D1 is not round, the setae in D1 are not black, and the locality falls outside the distributional limits given above 6

5(4). Subdorsal and supraspiracular areas largely bluish and bluish-white, speckled with black; lateral setae white, or rarely slightly yellowish (figs. 345 and 347); distribution—north of a line drawn from Indio, Riverside Co., Calif., along the southern base of the San Bernardino and San Gabriel Mountains (fig. 4) . . *constrictum constrictum*, p. 93

Subdorsal and supraspiracular areas largely black and orange with the blue reduced; lateral setae orange (figs. 346 and 348); distribution—south of a line drawn from Indio, Riverside Co., Calif., along the southern base of the San Bernardino and San Gabriel Mountains (fig. 4). *constrictum austrinum*, p. 99

6(4). Middorsal, addorsal, and subdorsal areas of abdominal segment *eight* largely black (figs. 342–344), with both primary and secondary setae on segment eight black, and strongly contrasting with the orange secondary setae occurring on segments seven and nine; each segment with the subdorsal and supraspiracular areas crossed by a distinct vertical blue line bordered by black (figs. 343 and 344); subdorsal area of mesothoracic and metathoracic segments with a half-moon shaped black mark (most clearly seen in fig. 344); distribution—Colorado, Utah, Arizona, New Mexico, Texas, Mexico, and possibly adjoining areas. *tigris*, p. 102

Middorsal, addorsal, and subdorsal areas of abdominal segment *eight* usually not distinctly blacker than segments seven or nine, but if so, then without the vertical blue line bordered by black on the subdorsal and supraspiracular areas of each segment, and without a half-moon shaped black mark on the subdorsal area of the mesothoracic and metathoracic segments; distribution—much of western North America 7

7(6). Middorsal, addorsal, and subdorsal areas black (figs. 352 and 354), except for small anterior and posterior blue-white subdorsal spots which may be present; occasionally some irregular orange marks may faintly set off a black middorsal area; distribution—west-central California near San Francisco Bay 8

Middorsal, addorsal, and subdorsal areas not entirely black, either with definite orange markings and subdorsal spots (figs. 358 and 359), or with a blue subdorsal area (fig. 382); distribution—north of San Francisco Bay in California, and many other western states, especially in the

Great Basin, southern Rocky Mountains, and Southwest 9

8(7). Supraspiracular and subspiracular areas bluish-white; lateral setae white (fig. 355); distribution—southwest end of San Francisco Bay (fig. 3) . . most *californicum ambisimile*, p. 142

Supraspiracular and subspiracular areas black, sometimes streaked with orange; lateral setae orange (fig. 353); distribution—around San Francisco Bay except the southwest end (fig. 3) . . . . most *californicum californicum*, p. 138

9(7). Color pattern largely made up of yellow or orange and black; blue usually reduced to anterior and posterior subdorsal spots on either side of the vertical black bar which is modified so it usually resembles the "torso" mark (figs. 7, 9, and 358); this torso mark is quite distinct except in very dark larvae (fig. 359); middorsal area outlined with orange so it looks like a black stripe (fig. 358); distribution—west of the Cascades in California, Oregon, and Washington, and northern North America (a few specimens from the northern coast ranges of California may be largely blue and black and without a dorsal stripe, but these should be found as a small percent of similarly colored specimens which have a distinct, broken blue-white middorsal stripe).

rare individuals of *californicum pluviale*, p. 152

and rare individuals of other populations of *californicum*, p. 123

Color pattern largely made up of blue and black; orange, if present, usually only in the addorsal area; vertical black bar usually absent, but if present the sides are blue; middorsal area sometimes outlined with orange so it looks like a black stripe (figs. 387, and 390–392); distribution—Great Basin, southern Rocky Mountains, Southwest, and Mexican plateau 10a, 10b, 10c, 10d

10a(9). Usually with fairly conspicuous orange dorsal markings that often look somewhat like a pair of exclamation marks (!!) (fig. 392); never with a vertical black bar; lateral setae white and conspicuously tufted around setal group L2 (figs. 390–392); lateral color varying from bluish-green to black and bluish-gray in some specimens (figs. 390–394); occurring mainly at lower elevations in central and southern Arizona, primarily along watercourses and irrigated areas, but also extending up canyons.

most *incurvum incurvum*, p. 173

10b(9). Sometimes with fairly conspicuous orange dorsal markings that may look somewhat like a pair of exclamation marks

(!!) as in *incurvum incurvum;* never with a vertical black bar; lateral setae white or golden orange and tufted; dorsal setae golden; lateral color usually black and bluish-gray (specimens which have been examined are most similar to figs. 391 and 394); occurring in the Mexican plateau area.

most *incurvum aztecum*, p. 183

10c(9). Lateral setae white and not conspicuously tufted; lateral areas bluish and never with a vertical black bar; setae SD1 and SD2 usually white, sometimes dark; addorsal area usually with some orange (fig. 399); occurring mainly at lower elevations along the Colorado River and its tributaries above Hoover Dam.

rare specimens of *incurvum discoloratum*, p. 177

10d(9). Middorsal and addorsal areas usually black (fig. 382) with the addorsal orange markings, if present, usually reduced; lateral color bluish, occasionally with a vertical black bar (fig. 387); lateral setae white, yellowish, or orange and not tufted or only slightly so; occurring primarily at higher elevations in northern and eastern Arizona, and in the Great Basin and southern Rocky Mountains, but occurring at lower elevations if suitable hosts are present; not known to occur in the central plateau around Mexico City, but possibly found in the area between Mexico City and United States border.

californicum (in part), p. 123

11(3). Lateral setae white and not conspicuously tufted; lateral area bluish and never with a vertical black bar; middorsal stripe bluish-white, often about the same color as the subdorsal area (figs. 395–397), but whiter on some specimens (fig. 398); setae SD1 and SD2 usually white; occurring mainly at lower elevations along the Colorado River and its tributaries above Hoover Dam.

most *incurvum discoloratum*, p. 177

Various combinations of characters; occurring throughout western North America, but if occurring at lower elevations along the Colorado River and its tributaries above Hoover Dam, setae SD1 and SD2 are usually black 12

12(11). Addorsal areas usually with some indistinct orange markings; subdorsal area blackish; supraspiracular area bluish-gray; subspiracular area bluish-gray and whitish; dorsal setae golden orange; lateral setae white or golden orange (like figs. 390–394, but with weak dorsal stripe); occurring mainly at lower elevations in central and southern Arizona, primarily along watercourses and irrigated areas, but extending up canyons; or occurring in the Mexican plateau:

. . . . . . occurring in the Mexican plateau area—some individuals of *incurvum aztecum*, p. 183

. . . . . . occurring in central and southern Arizona—rare individuals of *incurvum incurvum*, p. 173

Various combinations of characters, but not agreeing with those given above in every respect, occurring throughout most of western North America; various populations and subspecies of *californicum* 13

13(12). Middorsal, addorsal, and subdorsal areas black, except for anterior and posterior blue-white subdorsal spots which usually are present; often some irregular orange marks may faintly set off the middorsal area (similar to figs. 352 and 354, but with weak dorsal stripe); distribution—west central California near San Francisco Bay . . . 14

Middorsal, addorsal, and subdorsal areas not entirely black, either with distinct orange markings and subdorsal spots, or with a blue subdorsal area; distribution—north of San Francisco Bay in west central California, and many other western states 15

14(13). Supraspiracular and subspiracular areas bluish-white; lateral setae white; distribution—southwest end of San Francisco Bay (fig. 3; similar to fig. 354, but with a weak dorsal stripe) . . rare specimens of *californicum ambisimile*, p. 142

Supraspiracular and subspiracular areas black, sometimes streaked with orange; lateral setae orange; distribution—San Francisco Bay area except the southwest end (fig. 3; similar to fig. 352, but with a weak dorsal stripe).

rare specimens of *californicum californicum*, p. 138

15(13). Color pattern largely made up of orange or yellow and black; blue usually reduced to anterior and posterior subdorsal spots on either side of the vertical black bar; vertical black bar usually distinct, but modified to resemble the "torso" or "tailed torso" mark (figs. 7 and 9); supraspiracular and subspiracular areas mixed orange, black and gray, with little blue (figs. 370–372); distribution—Pacific Coast west of the Cascades and northern North America (fig. 2).

most *californicum pluviale*, p. 152

Color pattern usually not largely made up of yellow or orange and black, but with more blue and less orange or yellow (some specimens as in figs. 364 and 365 appear similar to *pluviale* in dorsal view, but they are more bluish laterally); vertical black bar present or absent; distribution—east and south of that given for *pluviale* in figure 2 16

16(15). Color pattern more or less an even blend of reddish-orange, black and blue so that no one color dominates the others; vertical black bar present and often "torso" shaped (fig. 364), but rarely like a "tailed torso" since the blue tends to obscure the "tail"; distribution—west side of the Sierra Nevada and parts of northern California (fig. 3).
californicum recenseo, p. 148

Color pattern similar to that described above in areas adjoining *recenseo*'s distribution (fig. 365), but with more blue in areas farther to the east and south; vertical black bar present or absent (figs. 365–369 and 373–389); distribution—outside the area described above 17

17(16). Color pattern consisting of black addorsal areas flanking the blue-white middorsal line: bluish subdorsal, supraspiracular, and subspiracular areas (figs. 366–369, 380, and 381); never with a vertical black bar except toward the edges of the distributional limits (fig. 367); setae SD1 and SD2 black; distribution—Mohave Desert area of California, Arizona, Nevada, Utah, and the southern part of the Great Basin (fig. 2); specimens may be found farther south in California and in Mexico, too.
californicum fragile, p. 164

Color pattern variable, with or without a vertical black bar; setae SD1 and SD2 black or white or yellowish; distribution outside the area given above 18

18(17). Color pattern consisting of bluish subdorsal, supraspiracular, and subspiracular areas: addorsal areas black, but often containing some irregular orange lines next to the whitish middorsal line which sometimes is prominent enough to dominate most of the black; vertical black bar nearly always present in southern populations (fig. 376), but less frequently present toward the north (figs. 373–375); distribution—the Canadian prairies and the western two-thirds of the Great Plains in the United States (fig. 2).
californicum lutescens, p. 160

Color pattern variable, consisting of many different arrangements of blue and black, sometimes with yellow or orange which is most prominent in the addorsal area; with or without a vertical black bar (figs. 360–363,365,383–386,388, and 389); distribution—much of the Great Basin, Rocky Mountains, northwestern California, eastern Washington and Oregon, southern Idaho, and other areas not included in the distribution of the other subspecies (fig. 2).
californicum, p. 123

KEY TO THE EGG MASSES OF NORTH AMERICAN MALACOSOMA

1. Egg mass laid as a *helical band* which completely encircles a small twig as in figure 108 2

Egg mass laid as a *clasping mass* which may *appear* to nearly encircle a twig as in figure 109, or which may be laid as a partially encircling mass (fig. 110), or which may be laid as a nearly flat mass on a larger branch or small trunk (fig. 111) 4

2(1). Egg mass not covered by spumaline (fig. 106) . *tigris*, p. 102

Egg mass covered by spumaline of some kind 3

3(2). Spumaline pale, transparent, yellow, and containing approximately one large bubble per egg (fig. 107); on oaks.
constrictum constrictum, p. 93
constrictum austrinum, p. 99

Spumaline dark brown and containing numerous small bubbles (fig 113); on many hosts. . . . . *disstria*, p. 84

4(1) Spumaline rich dark brown with many bubbles of various sizes; egg mass usually laid so it nearly encircles small twigs (fig 109), but sometimes laid only partially encircling a branch (fig. 110), or even laid as a nearly flat mass near the base of the trunk of a small tree (fig. 111); distribution—east of the central Great Plains and south from southern Canada to the Gulf of Mexico (fig. 2). . . *americanum*, p. 111

Spumaline medium brown, tan, gray, white, or rich dark brown; if rich dark brown, then the bubbles are all quite small and uniform in size, or the spumaline often appears to be somewhat collapsed and nearly without bubbles; distribution—west and north of the area outlined above, and only slightly overlapping 5

5(4). Spumaline rather tough, usually not easily scraped off the eggs unless it is very dry; full of small, rather uniform-sized bubbles; color usually white or cream (fig. 117), or dark brown (fig. 114) . . . . . *incurvum* and subspecies, p. 169

Spumaline weaker, rather easily scraped off the eggs in most cases; full of various sizes of bubbles or somewhat collapsed and nearly without bubbles as in figure 115; color gray (fig. 116), gray-brown, tan, medium brown (fig. 105) or dark brown (fig 112) . . . . *californicum* and subspecies, p. 123

Malacosoma disstria Hübner

FOREST TENT CATERPILLAR

Phalaena neustria Linnaeus *sensu* Smith and Abbot, 1797, p. 117, pl. 59. Misidentified.

Malacosoma disstria Hübner, 1820, p. 192.—Dyar, 1898, p. 6.—Dyar, 1903, p. 263.—Holland, 1903, p. 313, pl. 10, fig. 9.—Essig, 1926, pp. 695–696.—Dyar, 1928, pp. 622–623, pl. 86a.—Collier, 1936, p. 112.—McDunnough, 1938, p. 138.—Keen, 1952, pp. 94–95, fig. 38 (A,B,C,D only).—Langston, 1957, p. 10.

Clisiocampa sylvatica Harris, 1841, pp. 271–272.—Packard, 1864, p. 387.—Packard, 1881, pp. 112, 138. Types: Museum of Comparative Zoology, Harvard University (not examined).

Clisiocampa neustoria [*sic*] Linnaeus *sensu* Emmons, 1854, p. 240, pl. 37. Misidentified.

Clisiocampa disstria (Hübner), Grote, 1864, p. 537.—Packard, 1881, pp. 40–41.—Stretch, 1881, pp. 68–69.—Edwards, 1889, p. 78.—Packard, 1890, pp. 117–118.—Packard, 1893, p. 179.—Dyar, 1893, pp. 37–38.—Neumoegen and Dyar, 1893, p. 29.—Neumoegen and Dyar, 1894, p. 154.

Clisiocampa erosa Stretch, 1881, pp. 67–68.—Edwards, 1889, p. 78.—Dyar, 1892b, pp. 364–365.—Dyar, 1893, p. 38.—Neumoegen and Dyar, 1893, p. 30. Type: Lectotype, here designated, male, Portland, Oregon. American Museum of Natural History.

Clisiocampa thoracica Stretch *sensu* Rivers, 1888, p. 103. *sensu* Dyar, 1893, pp. 38–39. *sensu* Packard, 1893, pp. 175–177.

Clisiocampa disstria var. *sylvatica* Harris, Neumoegen and Dyar, 1893, p. 29.—Neumoegen and Dyar, 1894, p. 154.

Clisiocampa disstria var. *thoracicoides* Neumoegen and Dyar, 1893, p. 30.—Neumoegen and Dyar, 1894, p. 154. Type: Lectotype, here designated, male, Poughkeepsie, New York, 25 June 1889. United States National Museum Type No. 34891.

Clisiocampa erosa var. *perversa* Neumoegen and Dyar, 1893, p. 30. Type: Holotype, female, Portland, Oregon, 13 July 1892. United States National Museum Type No. 34892.

Clisiocampa erosa var. *sylvaticoides* Neumoegen and Dyar, 1893, p. 30. Type: Lectotype, here designated, male, Portland, Oregon, 19 July 1892. United States National Museum Type No. 34889.

Clisiocampa erosa var. *thoracica* Stretch, *sensu* Neumoegen and Dyar, 1893, p. 30 (in part, larva only).

Clisiocampa disstria race *erosa* Stretch, Neumoegen and Dyar, 1894, p. 155.

Clisiocampa disstria race *erosa* var. *perversa* Neumoegen and Dyar, Neumoegen and Dyar, 1894, p. 155.

Clisiocampa disstria race *erosa* var. *sylvaticoides* Neumoegen and Dyar, Neumoegen and Dyar, 1894, p. 155.

Clisiocampa disstria race *erosa* var. *thoracica* Stretch, *sensu* Neumoegen and Dyar, 1894, p. 155.

Malacosoma disstria erosa (Stretch), Dyar, 1903, p. 263.—McDunnough, 1938, p. 138.

Malacosoma disstria perversa (Neumoegen and Dyar), Dyar, 1903, p. 263.

Malacosoma disstria sylvatica (Harris), Dyar, 1903, p. 263.

Malacosoma disstria sylvaticoides (Neumoegen and Dyar), Dyar, 1903, p. 263.

Malacosoma disstria thoracica (Stretch), *sensu* Dyar, 1903, p. 263.

Malacosoma disstria thoracicoides (Neumoegen and Dyar), Dyar, 1903, p. 263.

Malacosoma disstria form *anita* Reiff, 1913, pp. 307–308. Type: Holotype, male, Concord, Massachusetts, 2 July 1912. United States National Museum Type No. 34895.

Malacosoma disstria form *astriata* Reiff, 1913, pp. 306–307. Type: Lectotype, here designated, male, Lincoln, Massachusetts, 13 July 1912. United States National Museum Type No. 34894.

Malacosoma disstria form *sylvatica* (Harris), McDunnough, 1938, p. 138.

Malacosoma disstria form *thoracicoides* (Neumoegen and Dyar), McDunnough, 1938, p. 138.

Malacosoma disstria aberration *anita* Reiff, McDunnough, 1938, p. 138.

Malacosoma disstria aberration *astriata* Reiff, McDunnough, 1938, p. 138.

Malacosoma disstria erosa form *perversa* (Neumoegen and Dyar), McDunnough, 1938, p. 138.

Malacosoma disstria erosa form *sylvaticoides* (Neumoegen and Dyar), McDunnough, 1938, p. 138.

Malacosoma disstria erosa form *thoracica* (Stretch), *sensu* McDunnough, 1938, p. 138.

?*Malacosoma nubilis* Guer., McDunnough, 1938, p. 138. (manuscript name?)

Malacosoma disstria erosum (Stretch), Langston, 1957, pp. 10–11.

Malacosoma disstria erosum form *thoracica* (Stretch), *sensu* Langston, 1957, pp. 11–12.

ADULT MALES (males in figs. 119–139).—Coloration highly variable, the ground color ranging from light yellow (fig. 129) to dark brown (fig. 134); lines on forewings distinct, faint, or rarely absent, or median area between the lines same color as lines, resulting in a band across the wing (figs. 120 and 126); lines or bands always darker than ground color. Hindwings same color as forewings or slightly darker, often crossed by a faint dark area as in figure 131. Lower surface of wings variable, but similar in color to upper surface; both forewings and hindwings often crossed by a darker line or darker inner area. Epiphysis very large, curved, about as long as tibia (fig. 75).

MALE TERMINALIA.—Posterior edge of seventh sternite usually with many distinct "teeth" (fig. 57), but sometimes with only a few or none. Genitalia small compared with other species (compare the relative size of the eighth sternite in figure 37 with figures 38–51 which are all drawn to the same scale, using specimens with a 25–27 mm. wingspread); the "arms" of the eighth sternite short (fig. 37), so that the total length of the eighth sternite approximately equals the maximum width. Accessory claspers as in figure 12.

ADULT FEMALES (females in figs. 119–139).—Coloration more constant than males, but varying from yellow to yellow-brown; wings usually light yellow-brown; forewings crossed with two brown lines (figs. 130, 138, and 139), the outer line often more distinct than inner. Lower surface of wings darker than upper, usually brownish with a single darker line running across both wings. Epiphysis usually longer than second segment of foretarsus and distinctly curved (fig. 76), rarely smaller or absent.

FEMALE TERMINALIA.—Genital plate entirely sclerotized, variable in shape, but wider than long; ostium near the center of genital plate (fig. 83) and flanked by a shallow depression on either side. Ovipositor lobes as in figures 81 and 82 with no pronounced dorsal lobe.

ADULT DIAGNOSIS.—The only two North American species likely to be confused with *disstria* are *M. constrictum* (figs. 140–160) and *M. tigris* (figs. 161–175), both of which have dark lines on a lighter ground color and whose distribution overlaps that of *disstria* in part. In the past these two species often have been confused with *disstria*.

Male *constrictum* usually have the outer line more sharply bent toward the base of the wing near the costal margin (fig. 140) than do male *disstria*, while male *tigris* usually have the outer line more sharply bent toward the tip of the wing (fig. 162). The best character, however, to separate male *disstria* from any other North American species is the shape and size of the epiphysis. It is about ⅔ as long as the tibia and distinctly curved (fig. 75). This character appears to be 100 percent reliable since no male *disstria* has ever been examined which did not have this distinctive epiphysis. All other males of North American species have an epiphysis which is less than ⅓ the length of the tibia, or if larger than ⅓ the length of the tibia, it is not distinctly curved like that of *disstria*. The male genitalia are also quite distinctive, with the "arms" of the eighth sternite short (fig. 37), so that the total length of the eighth sternite approximately equals the maximum width. In all other North American species the "arms" are longer, so that the total length of the eighth sternite exceeds the maximum width (figs. 38–51).

Adult female *disstria* are not as easily identified by color pattern as males, and they are more likely to be confused with *M. californicum* and its subspecies than with *constrictum* or *tigris*. Female *constrictum* (females in figs. 140–160) are fairly dark, somewhat dull reddish-brown, and have the forewings dusted with whitish-yellow scales which are usually apparent to the unaided eye. Female *tigris* (females in figs. 161–175) are a more intense reddish-brown than female *constrictum*, but also have the forewings dusted with yellowish scales which are even more apparent to the unaided eye. Also, the median area on the forewings of *constrictum* and *tigris* is often darker than the inner and outer areas. Female *disstria* are yellow-orange to orange-brown or brown, but the forewings are not obviously dusted with scales of a different color than the background color when viewed with the unaided eye. The median area of the forewings is almost invariably lighter than the lines and about the same color as the inner and outer areas.

The separation of female *disstria* from female *M. californicum* and *M. incurvum* is normally not difficult because the lines on the forewings of *californicum* and *incurvum* usually appear lighter than the ground color, both lines are usually more bowed outward, and frequently have indentations along the veins. Female *disstria* have the lines darker than the ground color, they are more nearly straight, and they very rarely have any indentations along the veins. There are some female *californicum* (especially *californicum ambisimile* (figs. 185–187), *californicum californicum* (figs. 179–181), *californicum pluviale* (figs. 197–202), and *californicum recenseo* (fig. 190), however, on which the lines of the forewings appear to be darker than the ground color. In these, the lines often will be bordered by a narrow line which is lighter than the ground color as in figure 186. This narrow line is never present in female *disstria*. If the narrow line is absent in *californicum*, the lines on the forewings (especially the inner one) are more sharply bowed outward than on *disstria*.

In cases where identification based on the color pattern is doubtful, female *disstria* can usually be identified by the sclerotized genital plate (fig. 83). Females of the other species which are likely to be confused with *disstria* have a nonsclerotized or only partially sclerotized genital plate.

The shape of the ovipositor of *disstria* is the most reliable means of identification. It is most similar to that of *constrictum*, *tigris*, and the west coast and northern populations of *californicum*. Female *tigris* are easily separated by the conspicuous indentation (in lateral view) between the lobes of the ovipositor (fig. 84) which is absent in *disstria* (fig. 81). Female *constrictum* are most easily separated by the distinct dorsal lobe (fig. 86), and by the distinctive convergence (in posterior view) of the ovipositor lobes below the anus (fig. 87). There is little or no such convergence of the lobes in *disstria* (fig. 82). Females of the west coast and northern populations of *californicum* can be separated by a similar convergence below the anus (fig. 92), and the different overall shape of the ovipositor (figs. 91 and 97–99).

As in the males, the epiphysis is of considerable help, since it is easily visible, is usually relatively large, and curved similarly to the male's (compare figs. 75 and 76), although rarely it may be reduced or absent. In the vast majority of specimens which have been examined it is large, however, while the epiphysis of females of the other species is either absent or quite small.

MATURE LARVAE (figs. 339–341).—Head light blue, mottled with black, sparsely covered with fine whitish-orange setae. Each abdominal segment marked dorsally with a yellowish-buff, keyhole-shaped spot which may be divided to form an anterior spot and a smaller posterior spot, or the posterior spot may be absent. (All of these variations can be found in populations of *disstria* from many parts of North America.) Constriction of keyhole spot marked by a vertical black dash or black spot on each side which includes setal group D1. Immediately below these marks at the dorsal edge of the subdorsal area is an irregular, longitudinal reddish-brown line which is broken at the intersegmental areas. Posterior to keyhole spot on each segment, three short, irregular reddish-brown lines are usually visible, the outer one sometimes connecting to the reddish-brown longitudinal line to form a loop. Remainder of subdorsal area varying in color from bluish to nearly black. If black, the vertical black dashes or black spots may be obscured. Ventral edge of subdorsal area with a small black spot surrounding setal group SD on each segment. Immediately below this black spot runs the irregular, yellowish subdorsal line which is often bordered dorsally with black. Supraspiracular and subspiracular areas blue-gray to dark gray. Ventral area blue-gray to dark gray, usually with a median black spot on each segment, and often with a dark gray area running the full length of the body between the bases of the legs. Dorsal setae black or orange; lateral setae whitish or orange. Setae sparse compared with other species.

LARVAL DIAGNOSIS.—Larvae of *disstria* always can be identified by the yellow-buff, distinctively shaped spots on each segment. No other North American larva is marked like this. In addition, the following setal counts are useful in identification, especially early instars. On abdominal segments 3–6 setal group D1 usually contains 4 setae, and setal group L1 usually contains 2 setae. Other North American species usually have 5 setae in D1 and 3 setae in L1. The number of setae in these groups should be checked on both sides of several segments to obtain a reliable count, since the number of setae in individual groups may vary on some specimens. A Palearctic species, *M. neustrium*, is the only other species that has been examined which has 4 setae in D1 and 2 setae in L1. See the discussion of the Palearctic species (page 187).

EGG MASS.—Typically it is laid as a helical ring (figs. 108 and 113) which completely encircles a small twig. The eggs are covered with dark brown spumaline containing many bubbles of various sizes. *M. tigris* and *M. constrictum* are the only other North American species which lay their egg masses as a helical ring completely encircling the twig. No spumaline covers the egg masses of *tigris* (fig. 106), and the egg mass of *constrictum* is covered with a light yellow spumaline containing approximately one large bubble per egg (fig. 107).

TENTS.—*M. disstria* is the only North American species which does not build some kind of a tent. Small larvae cluster together on leaves or twigs, and larger larvae cluster on branches or trunks of trees when not feeding (fig. 332). Before molting they spin a rather inconspicuous matting of silk on a branch or trunk which they use for attachment when molting. The skins left attached to the molting site often have been interpreted by casual observers as dead caterpillars.

COCOONS.—The cocoons are suffused with a lemon-yellow powder similar to that of some other species, but the cocoon-building habits of *disstria* differ in some respects from those of the other species. The cocoon itself (fig. 309) has a more conspicuous outer envelope of silk than do the cocoons of most other species, but the most striking difference lies in the normal habit of *disstria* larvae to spin their cocoons in one or more leaves which have been webbed together with the outer envelope of silk. At times of high populations the only leaves remaining on the trees may be those which have been used in spinning cocoons (fig. 331). Other species usually select cocooning sites in the litter or in more protected situations.

FOOD PLANTS.—*M. disstria* has the widest host range of any North American species, and will oviposit on a large number of different species of deciduous trees. It will feed on even more, possibly helping to account for its being the most widely distributed species in North America. In the North and West its preferred host is aspen, *Populus tremuloides*; in the South it has heavily defoliated tupelo gum, *Nyssa aquatica*, blackgum, *Nyssa sylvatica*, sweetgum, *Liquidambar styraciflua*, various species of oaks, and many other deciduous trees. In short, it oviposits and feeds on practically all species of deciduous trees, and has been reported to cause serious defoliation in most parts of its range. During outbreaks larvae will defoliate the underbrush after stripping their normal hosts, and even will eat herbs when no other food is available.

One species which *disstria* avoids is red maple, *Acer rubrum*, which will remain completely untouched in an area that has been completely stripped of all other leaves. The red maple, however, does not escape entirely, since the caterpillars use its leaves to wrap their cocoons.

Hardy (1943) reported a similar avoidance of buffaloberry, *Shepherdia canadensis*, and silverberry, *Eleagnus argenta* in British Columbia, but again the leaves were used as cocoon sites.

The pear appears to be the only fruit tree which has some immunity among those that *disstria* might be expected to attack. Treherne (1913) reported that in British Columbia *disstria* and [*californicum*] *pluviale* "feed upon almost everything in the orchard except the pear, which under normal conditions seems immune." Downing *et al.* (1956), however, list both of these species as being sporadically injurious to pear in British Columbia. In the present study it was not possible to get any species to feed on pear. Possibly some cultivated varieties of pear are immune, but others may be acceptable in varying degrees. There may be a few other species of trees or shrubs immune to attack by *disstria*, but a lack of acceptable hosts does not appear to be a factor limiting its distribution.

TYPE.—Apparently destroyed. Dr. F. Kasy of the Naturhistorisches Museum, Vienna, Austria, could not find it in their series of *Malacosoma disstria* Hübner, and states that it is highly unlikely that it could be found in any other collection.

TYPE LOCALITY.—Unknown, probably somewhere in eastern North America.

DISTRIBUTION (fig. 1).—*M. disstria* is the most widely distributed North American species, occurring throughout most of the United States and Canada wherever deciduous trees grow. No specimens from Mexico have been seen, but it seems likely that it occurs there, since its distribution extends into southern Texas and New Mexico.

ECONOMIC IMPORTANCE.—*M. disstria* is without doubt the most destructive North American tent caterpillar because of its wide distribution, wide host range, and the relatively frequent outbreaks which occur on economically important species such as aspen, gum, oak, and maple.

COMMENTS.—There have been numerous subspecies, varieties, aberrations, etc., proposed for *M. disstria*, but Dyar (1928) was correct when he said, "The various varietal names proposed are superfluous, referring to individual variations only." Extensive dissections of specimens from all over North America have shown that *disstria* can be distinguished from all other North American species by characters such as the epiphysis and genitalia. These characters are constant for all subspecies, varieties, etc., which have been described. The various described forms were based originally on differences in adult or larval coloration, but, as far as is known, none of these color variations are restricted to any geographic area, so there is no basis for any subspecific designations.

Adults from the Pacific populations often are somewhat darker (figs. 128 and 134) than adults from other areas, and have had the infraspecific name "*erosum*" applied to them in the past, but similar dark adults can be found in other populations (figs. 127, 133, and 135). In addition, there are more striking differences in the larvae from within the Pacific populations (compare figs. 339 and 340) than have been found elsewhere in North America. Therefore, recognition of the Pacific populations as a subspecies is not warranted by the information currently available.

There certainly must be variations in the physiological adaptations of the various populations of *disstria* which occur in such climatically different areas as northern Canada and southern Texas, but these differences are not documented, and the change from one population to another would no doubt be a gradual one anyway. Until much more additional information is obtained concerning the various populations that make up *disstria* it is sufficient to refer to them by geographic localities rather than the use of subspecific names.

SPECIMENS EXAMINED.—3405 (Museum specimens—1795 males, 564 females, 907 larvae; reared specimens—80 males, 59 females, plus larvae and egg masses). See Appendix I for data on collections made during this study. In figure 1 individual localities have not been plotted for the eastern states solidly covered with circles, but *disstria* should be found throughout all of these states. The following list includes only localities from states or provinces which lie outside this area.

UNITED STATES.—ARIZONA: Dewey. CALIFORNIA: Alameda; Berkeley; Bloomfield (Sonoma Co.); Calistoga; Carmichael; Chico; Crescent City; Eldridge (Sonoma Co.); Eureka; Folsom; Fortuna (Humboldt Co.); Freshwater (Humboldt Co.); Glen Ellen; Guerneville; Healdsburg; Lake Tahoe; 11 mi. N. Laytonville; Lebec; Lodi; Longvale; Los Gatos; Mad River at Maple Creek (Humboldt Co.); Martin's Ferry (Humboldt Co.); Modesto; Napa; Napa Co.; Palo Alto; near Pepperwood (Humboldt Co.); Petaluma; Ricks; San Antonio Creek (Sonoma Co.); St. Helena; 4 mi. N. St. Helena; Santa Cruz Mountains; Santa Rosa; Sonoma Co.; Trinity Co. COLORADO: Denver; Hayden Mountains (Ouray Co.); Maybell; Valley View Lodge, 10 mi. S. Steamboat Springs. FLORIDA: Gainesville; Lakemont; Leesburg; Orlando; Pensacola; Quincy; Siesta Key, 9 mi. S. Sarasota. IDAHO: Glen Ferry; Island Park (near W. Yellowstone); 4th of July Creek, N. of Salmon; Moscow; Rexburg; Rock Island; Sandpoint; Wallace. KANSAS: Onaga; Riley Co. MONTANA: Avalanche Creek, Glacier N.P.; Avon; Belton; Bozeman; Florence; Hot Springs; Livingston; Montana Experiment Station (Hill Co.); Poplar; Trout Valley. NEBRASKA: Florence. NEW MEXICO: Cedar Creek Camp, 2 mi. N. Ruidoso; High Rolls; Simpson's Ranch, 5 mi. E. La Jara. OKLAHOMA: Hinton. OREGON: Albany; near Baker; Coquille; Corvallis; 5 mi. N. Corvallis; 2 mi. S. Dayton; Gearhart; Gervais; Jennings Lodge (Clackamas Co.);

Joseph; McMinnville; Mission Bottom; Oregon City; Portland; Salem; Silver Creek, near Baker; Spring Creek (Baker Co.); Tillamook; Tygh Valley (Wasco Co.); Wallowa Lake; Wheatland; Woodburn. SOUTH DAKOTA: Spearfish. TEXAS: Brownsville; Corpus Christi; Cuero (Dewitt Co.); Kingsville; Livingston (Polk Co.); San Antonio; Victoria. UTAH: Bountiful; Buckboard Flat Camp, 7 mi. W. Monticello; Deer Creek, Provo Canyon; Eureka; Hyde Park (Cache Co.); Junction (Piute Co.); Logan; Mt. Pleasant; North Fork Provo Canyon; N. Logan; Oak Creek Canyon, near Mt. Pleasant; Pleasant Grove; Provo; River Heights (Cache Co.); Salt Lake City; Stockton; Vineyard (Utah Co.); Weber. WASHINGTON: Bellingham; Blaine; Hazeltine; Hesseltine; Longview; Mt. Vernon; Olympic Hot Springs; Pullman; Puyallup; Seattle; Spokane; Wenatchee; Whatcomb; Woodland; "W. Wash.". WYOMING: Cody; Mammoth, Yellowstone National Park; Moran; Wheatland.

CANADA.—ALBERTA: 2 mi. E. Beauvallon; Bentley; Bowden; Calgary; Carlos; 6 mi. E. Crooked Creek; 8½ mi. S. Donnelly; Drumheller; 4 mi. N. Elk Point; 5 mi. S. Elk Point; Fabyan; 10 mi. SW. Judah, Smokey River Valley; Lethbridge; McLennon; Manyberries; Medicine Hat; 12 mi. S. Nampa; Nobleford; 4 mi. N. Phillips; Red Deer; Rocky Mountain House; St. Albert; Sunnyvale, Lloydminster; Wetaskiwin; 10 mi. W. Whitecourt; Winfield. BRITISH COLUMBIA: Bear Lake; Duncan, Vancouver Island; Grand Forks; Jesmond; 8 mi. N. Lando; New Westminster; Oliver; Quesnel; Revelstoke; N. Peak, Jade Pass, Revelstoke National Park; Rollo; Royal Oak; Seton Lake, Lillooet; Vancouver; Victoria; Woodpecker. MANITOBA: Armit Road; Aweme; Beulah; Grandview; Lac Du Bonnet; McCreary; Melbourne; Miniota; Moar Lake; Morris; Red Rock Lake, Whiteshell Prov. Park; Rosenburg; Russell; Viking L.; Whiteshell Lake. NOVA SCOTIA: Annap. Co.; Auburn; Baddeck; Barrington Passage; Mt. Uniacke; Petite Riviere; Truro. ONTARIO: Blackburn; Black Rapids; Cedar L. Field Station, 20 mi. N. Vermillion Bay; Chatham Laboratory; Chippewa Park, near Ft. William; Geraldton; Hymers; Marmora; Merivale; Nipigon; North Bay; Ogoki; Ottawa; Paris; Point au Baril; Smokey Valley, Mattagami River; Toronto; Trenton. QUEBEC: Buridge; Forestville; Kipawa; Kirk's Ferry; Lac Mondor, Ste. Flore; Lake St. Francis; Laniel; Laurentides Park, Marie du Sault; 1 mi. S. entrance of Laurentides Park; Rupert House; St. Thomas de Joliette. SASKATCHEWAN: Airport Bog; Attons Lake, Cutknife; Balcarres; Booth; Bulyea; Carlyle; Carlton; Cecil; Christie Lake; Christopher Lake; Clayburn; Cypress Hills; Cypress Park; Duval; Emma Lake; Gerald; Grandview; Grenfell; Harlan; Holbein; Indian Head; Jasmin; Kennedy; Landing; Lepine; LeRoss; MacDowall; Marchant Grove; Melville; Molein; Nipawin; North Side; Percevil; Prince Albert; Qu'Appelle; Red Deer Hills; Red Wing; Red Rock Blk.; Rocanville; Ryerson; Saskatoon; Scott Experiment Station, Scott; Shellbrook; Sintaluta; Southey; Springside; Steep Creek; Sturgeon Valley, Trossaulks; Wapella; Waskesiu Lake; Wawota; White Star; Wild Rose; Willow Brook; Wood Mountain; Yellow Creek.

Malacosoma constrictum constrictum (Henry Edwards)

Suggested common name: PACIFIC TENT CATERPILLAR[6]

Clisiocampa constricta Henry Edwards, 1874, p. 368.

Clisiocampa constricta Stretch, 1881, pp. 65–66.—Packard, 1881, pp. 41–42.—Edwards, 1889, p. 78.—Packard, 1890, p. 121.—Dyar, 1892a, p. 326.—Dyar, 1893, pp. 39–40.—Packard, 1893, pp. 177–178.—Neumoegen and Dyar, 1894, p. 157. Type: Lectotype, male, here designated, Napa County, Calif., May. American Museum of Natural History.

Clisiocampa strigosa Stretch, 1881, p. 67. Type: Lectotype, male, here designated, Yosemite Valley, Calif., July. American Museum of Natural History.

Malacosoma constricta (Stretch), Dyar, 1898, p. 6.—Dyar, 1903, p. 262.—Essig, 1926, p. 697 (in part, California and Oregon populations).—Dyar, 1928, p. 623, pl. 86d.—Collier, 1936, p. 111.—McDunnough, 1938, p. 138.—Keen, 1952, p. 95 (in part, California and Oregon populations).

Malacosoma constricta strigosa (Stretch), Dyar, 1903, p. 262.—McDunnough, 1938, p. 138.

Malacosoma constrictum (Stretch), Langston, 1957, pp. 9–10 (in part, California and Oregon populations).

ADULT MALES (males in figs. 140–151).—Color usually light straw-yellow, occasionally somewhat brownish. Wings lightly dusted with brown scales; lines on forewings brown, varying from quite distinct to virtually absent, but usually distinct; outer line usually sharply curved toward base of wing at costal margin so it meets it at nearly a right angle as in figure 140; median area same color as inner and outer areas in most specimens. Hindwing same color as forewing, sometimes crossed with a faint brownish line. Lower surface of wings same color as upper, usually with a single brown line crossing forewing, and sometimes with a brown line crossing hindwing. Epiphysis small, usually about the length of second segment of foretarsus.

MALE TERMINALIA.—Posterior edge of seventh sternite straight to slightly concave, often with three points (fig. 58). Genitalia (fig. 34) intermediate in size compared with *M. americanum* (fig. 31) and *M. disstria* (fig. 33); shape of eighth sternite distinctive (fig. 38), with the "arms" extending to or slightly past the parameres and distinctly converging (the distance between the points of the "arms" is approximately half the basal width of the eighth sternite). Parameres longer and thinner than in other species, tending to converge or touch at the tips. Accessory claspers usually as in figure 13.

ADULT FEMALES (females in figs. 140–151).—Color fairly dark reddish-brown. Forewings dusted with whitish-yellow scales which are

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[6] See Appendix III (page 289).

apparent to the unaided eye. Lines on forewings darker than ground color and not turned toward base of wing as strongly as in males, if at all; median area same color or slightly darker than inner and outer areas. Hindwings about same color as forewings, often with a faint darkened area running across the wing. Lower surface of wings same color as upper, with the inner area darker than outer area. Epiphysis absent or very small.

FEMALE TERMINALIA.—Genital plate nonsclerotized or only very slightly so. Ovipositor as in figures 86 and 87. See the following diagnosis for a discussion of ovipositor characteristics.

ADULT DIAGNOSIS.—The only males likely to be confused with *c. constrictum* are those of *M. tigris* and *M. disstria* since both have dark lines on a light ground color. *M. disstria* is distinguished by the characters given in the adult diagnosis (page 86). Male *tigris* are not so easily separated, but one of the best ways to distinguish them is by distribution, since the ranges of *constrictum* (fig. 4) and *tigris* (fig. 1) do not overlap. In the event one of them should be introduced into the range of the other, however, there are other good characters which will permit separation.

Male *tigris* (males in figs. 161–175) often have the hindwing darker than the forewing, and the outer line of the forewing is usually bent toward the wingtip so that it meets the costal margin at an acute angle rather than at a right angle as in most *constrictum*. A few *constrictum* (figs. 146 and 150), however, may have an outer line similar to that of *tigris*, and a few *tigris* (fig. 173) may have an outer line similar to *constrictum*.

The terminalia of male *constrictum* are also different from those of *tigris*. The "arms" of the eighth sternite of *constrictum* (fig. 38) converge distinctly, and the distance between the points of the "arms" is approximately equal to half the basal width at its widest point. The "arms" of the eighth sternite of *tigris* (fig. 39) are nearly parallel or only slightly converging, and the distance between the points is greater than half the basal width. The posterior edge of the seventh sternite of *constrictum* (fig. 58) usually has three distinctive points, while that of *tigris* (fig. 59) usually has a few small, irregularly placed projections or none at all. The prongs of the accessory claspers of *constrictum* always are sharply pointed (fig. 13), while those of *tigris* are sometimes pointed, but more often jagged, appearing as if they had been broken off (fig. 14).

Female *constrictum* can be confused only with *tigris* since these two species are the sole ones in which the females are dark brown, and have the forewings dusted with whitish-yellow scales which are conspicuous to the unaided eye. The genital plate of *constrictum* nearly always is unsclerotized, but the genital plate of *tigris* may be unsclerotized, so positive identification cannot be made by this means. The shape of the ovipositor lobes is quite different, however, and positive identification can be made by them. When viewed laterally, the ovipositor of *tigris* (fig. 84) has evenly rounded dorsal and ventral lobes which are separated by a distinct indentation. In lateral view the ovipositor of *constrictum* (fig. 86) differs in having both dorsal and ventral lobes more pointed and in having at most, only a small, differently shaped indentation separating them. Also compare the posterior views of the ovipositors (figs. 85 and 87). There is a conspicuous convergence of the ovipositor lobes below the anus of *constrictum*, but there is little or no such convergence in *tigris* (or in *disstria*, either, fig. 82). In addition, the ovipositor apodemes of *constrictum* (fig. 86) are usually only slightly widened near the middle, while those of *tigris* (fig. 84) and *disstria* (fig. 81) usually are widened distinctly near the ovipositor. The apodemes of other species vary considerably, so this character should only be used as an aid in separating *constrictum* from *tigris* and *disstria*, and not in separating it from other species.

Differences in the color pattern are of limited value in distinguishing female *constrictum* and *tigris*. Generally, the median area on the forewings of *constrictum* is the same color or only slightly darker than the inner and outer areas, while the median area of *tigris* is usually definitely darker than the inner and outer areas. In *constrictum* the distance between the lines at the inner margin of the forewing is generally less than the distance between the inner line and the base of the wing at the inner margin, while in *tigris* the distance between the lines at the inner margin customarily is greater than the distance between the inner line and the base of the wing. Also, the outer line on *constrictum* is usually bent inward near the middle more than it is on *tigris* where it generally is nearly straight. These differences are admittedly slight and not entirely reliable, but positive identification can be made by the ovipositor lobes if there is any doubt.

MATURE LARVAE (figs. 345, 347).—Head mottled blue and black, sparsely covered with fine, black setae. Dorsum without a contrasting whitish stripe or other distinctive middorsal markings such as are present on some species. Dorsally each segment marked with irregular, orange, wavy lines intermixed with black and creating a more or less hourglass-shaped orange blotch which is bordered on both sides by a conspicuous round black spot surrounding setal group D1. Subdorsal area aquamarine to blue and speckled with black. Supraspiracular area mixed bluish and grayish with an irregular, longitudinal cream-colored splotch just ventral to setal group SD on each segment. Area surrounding setal group L2 whitish. Subspiracular area blue-gray to gray. Ventral area mottled gray-black and white, often with a median black spot on each segment. Primary dorsal setae long and black (rarely a few of them may be pale); secondary dorsal setae orange and conspicuously tufted anteriorly and posteriorly on each segment. Lateral setae usually white, but occasionally yellowish; conspicuously tufted around setal group L2. (A few larvae collected near Grants Pass, Oregon, Coll. No. 121B, and near Bingen, Washington, Coll. No. 127, had yellowish lateral secondary setae, but all other larvae collected north of the Los Angeles area had white lateral setae.)

LARVAL DIAGNOSIS.—No single character will identify *constrictum* larvae as easily as some other species, but the combination of no conspicuous middorsal markings, the hourglass-shaped, dorsal blotch bordered by black spots, and the conspicuous tufting of both dorsal and lateral secondary setae is sufficient to distinguish them from the larvae of other species occurring within their range.

EGG MASS.—The eggs are laid as a helical band which completely encircles a small twig (fig. 107). They are covered with bright yellow spumaline which contains large bubbles, approximately one per egg. The spumaline is quite transparent, and the eggs are clearly visible. Only *M. disstria* and *M. tigris* lay egg masses which are similar in being laid as a helical band which completely encircles a small twig. *Tigris* egg masses, however, are not covered with spumaline (fig. 106), and *disstria* egg masses (fig. 113) are covered with dark brown spumaline containing many different sizes of bubbles.

TENTS.—*M. constrictum* and *M. tigris* are two species which do not build large, conspicuous tents like those built by *americanum*, *incurvum*, or *californicum*. Neither are they completely like *disstria* which builds no tent at all. The term "tent" is used loosely in referring to *tigris* and *constrictum*, since it usually consists of only a few thin layers of silk spun between some twigs or a cluster of leaves, or of some silk spun on some branches, twigs, or leaves similar to the way of *disstria*. The tents differ from those of *americanum*, *incurvum*, and *californicum* by being constructed so that the outline of the tent closely follows the configuration of the twigs or leaves it is built on, rather than being constructed with the silk spun more or less straight across between twigs or branches. This results in a tent with little or no space inside. Figure 334 shows an unusually large *tigris* tent with attached exuviae left by caterpillars after completing their last molt. The largest tents found (those used for the last molt) were only about 3 to 4 inches wide at the widest point. Such large tents are rare. Tents are generally much smaller and tend to be more like the silken mats that *disstria* builds for molting.

Both *constrictum* and *tigris* build their tents just prior to molting and use them only as a base for attachment during molting. They never rest inside the tent as do those species which build large tents. A new tent is built before each molt, and after molting the tent is abandoned. Between molts, the caterpillars cluster on branches (fig. 338) as does *disstria* (fig. 332), or rarely on the *outside* of the old tent.

In the field small tents are inconspicuous, and colonies of caterpillars are located more often by noticing a defoliated branch tip than by spotting a tent. Even in times of high populations, defoliation is much more noticeable than the tents.

COCOONS.—Cocoons are fairly tightly constructed, have no outer envelope of silk, and are dusted with a white powder. They are very similar to those of *tigris*.

FOOD PLANTS.—As far as is known, oviposition is restricted to various species of oaks, but see the exception mentioned for *M. constrictum austrinum*. Reports in the literature of *constrictum* occurring on hosts other than oak are invariably larval feeding records, rather than egg mass records. During the last instar, and especially during high populations, larvae may of necessity feed on other hosts, but these cannot be regarded as their usual hosts since the eggs are normally laid on oak. In the following host list, only those species are listed on which egg masses were found during this study, although it probably occurs on all species of oaks which grow in the states bordering the Pacific Ocean. Egg masses were found on the following hosts: *Quercus agrifolia*, *Q. douglasii*, *Q. garryana*, *Q. wislizenii*, *Q. durata*, and *Q. kelloggii*.

TYPE.—None. See the discussion of types in Appendix II (page 283).

DISTRIBUTION (fig. 4).—*M. constrictum constrictum* inhabits the territory north of a line drawn from Indio, Riverside County, Calif., along the southern base of the San Bernardino and San Gabriel Mountains as far north as Washington. It is common on the west side of the Sierra Nevada and will probably be found wherever oaks grow along the Pacific Coast. Its eastward spread seems to be limited primarily by a lack of oaks in the western part of the Great Basin and in the Mojave Desert.

ECONOMIC IMPORTANCE.—*M. constrictum* (including the subspecies *austrinum*) ranges from the relatively cool, moist areas of western Oregon and Washington to the hotter and drier areas of southern California and Baja California, so it is possible that it would do well in the oak forests of the eastern United States if it should happen to be introduced there. In the drier areas of the Coast Range at Pacheco Pass, Santa Clara County (Coll. No. 42), and 4 miles east of Priest Valley, Monterey County (Coll. No. 110), and in the foothills of the Sierra Nevada, 18 miles north of Woodlake, Tulare County (Coll. No. 111) *M. constrictum constrictum* was causing nearly complete defoliation of *Q. douglasii*. In the cooler, more humid areas along the northern Pacific

Coast, however, where the climate is more similar to the eastern United States, it was not causing any damage. Therefore, it may be best adapted to drier regions, and consequently might not do well if introduced into many parts of eastern North America.

Specimens Examined.—645 (Museum specimens—301 males, 94 females, 57 larvae; reared specimens—84 males, 109 females, plus numerous larvae and egg masses). See Appendix I for collections made during this study (page 255).

United States.—california: Almaden (Santa Clara Co.); Mountains back of Alma (Santa Clara Co.); Alviso; Anderson Springs (Lake Co.); Antelope Valley; Arroyo Seco (Monterey Co.); Atascadero; Cajon Pass; California Hot Springs (Tulare Co.); Calistoga; Camp Baldy (near Mt. Baldy, San Bernardino Co.); Carmichael; Carville (Trinity Co.); Cayton (Shasta Co.); Cayton Valley, Shasta National Forest; Contra Costa Co.; Denny (Trinity Co.); Diablo Range (Santa Clara Co.); Eel River; Egan Ranch (Napa Co.); El Cielo Drive (Santa Barbara Co.); Eldridge (Sonoma Co.); Fair Oaks (Sacramento Co.); Forest Home (San Bernardino Co.); 5 mi. S. Geyserville; Guerneville; 3 mi. NE. Guerneville; Greenhorn Mountains; Healdsburg; Hopland; Kelseyville; Kerr River Canyon; Lake Arrowhead (San Bernardino Co.); Laytonville; 11 mi. N. Laytonville; Los Angeles Co.; Los Gatos; Lucas Valley (Marin Co.); Lytle Creek (San Bernardino Co.); Mad River at Maple Creek (Humboldt Co.); Mendocino Co.; Miami Ranger Station (Mariposa Co.); Mt. Diablo; Mt. Hamilton; Mt. Herman (Santa Cruz Co.); Mt. St. Helena (Napa Co.); Napa; Nevada City; Orinda; Oroville; Pacheco Pass; Palo Alto; Paradise Springs (San Bernardino Co.); Paso Robles; Pinnacles (San Benito Co.); 4 mi. W. Quincy; Riverton (El Dorado Co.); Salinas R.; San Jose State College; Santa Clara Co.; Santa Cruz; Santa Rosa; Shasta Co.; Shingle Springs (El Dorado Co.); Silver Creek Hills (Santa Clara Co.); Sonoma Co.; Summerland (Santa Barbara Co.); Trinity Co.; Upper Santa Ana R. (San Bernardino Co.); Uvas Canyon (Santa Clara Co.); Ventura; Ventura Co.; Walnut Creek; Wawona, Yosemite; Wheeler Ridge (Kern Co.); Yosemite; Yosemite Valley; Yermo; "Calif.". oregon: Corvallis; Galice on Rouge River (Josephine Co.); Hood River; Kirby (Josephine Co.); McMinnville; Murphy (Josephine Co.); Rogue River; Salem; Woodburne; "Oregon". washington: Goldendale; Rochester (Thurston Co.).

Probably Mislabeled.—montana: Avalanche Creek, Glacier National Park.

Intermediate Population.—Intermediates between *M. constrictum constrictum* and *M. constrictum austrinum*. All of the following localities are in Los Angeles Co., but similar populations will probably be found both east and west of these localities: Angeles Crest Highway; Bouquet Canyon; Charlton Flats; Crystal Lake, San Gabriel Canyon; San Dimas; San Gabriel Canyon; Sierra Madre; Tanbark Flat; Tujunga. In fact, some of the adults from San Bernardino Co. which were arbitrarily classified as *M. constrictum constrictum* because they were predominantly yellow may be from populations having intermediate larval characteristics.

Malacosoma constrictum austrinum Stehr, new subspecies

ADULTS (figs. 152–160).—The description and diagnosis for adults of *M. constrictum constrictum* (page 93) apply equally well to this subspecies, except that the males are usually more heavily dusted with brown scales, often being nearly as brown as the females. Some males, however, may be as light as specimens of *constrictum constrictum*. In addition, the lines on the forewings of both males and females are often poorly defined.

This subspecies is recognized on the basis of very striking and consistent differences in the larvae from southern California compared with those which occur farther north. The larvae of *constrictum austrinum* (figs. 346 and 348) are structurally the same as *constrictum constrictum*, but the color of the lateral setae is orange instead of white, the head is largely black instead of mottled blue and black, and the proportions of the colors making up the color pattern are considerably different.

MATURE LARVAE (figs. 346 and 348).—Head black, with little or no blue, sparsely covered with fine orange and black setae. Dorsum without a contrasting whitish stripe or other distinctive middorsal markings as are present on some species. Dorsally each segment marked with irregular orange, wavy lines intermixed with much black and creating a more or less hourglass-shaped blotch which is bordered on both sides by a round black spot surrounding setal group D1. Subdorsal area deep blue, but partially obscured by black which also tends to obscure the round black spots surrounding D1. Supraspiracular area mixed blackish, dark gray, blue-gray and orange, with a very conspicuous longitudinal, irregular, orange splotch just ventral to setal group SD on each segment. Area surrounding setal group L2 yellowish-orange. Subspiracular area dark gray to gray, sometimes faintly blue-gray. Ventral area mottled gray-black and white, usually with a median black spot on each segment. Primary dorsal setae long and black anteriorly, sometimes tending to be orange posteriorly; secondary dorsal setae orange and conspicuously tufted anteriorly and posteriorly on each segment. Lateral setae orange, and conspicuously tufted around setal group L2 on each segment.

LARVAL DIAGNOSIS.—Larvae of *M. constrictum austrinum* can easily be separated from those of *M. constrictum constrictum* by the orange lateral setae and the much greater amount of orange and black in the color pattern which tends to obscure the blue that is so striking in *constrictum constrictum* (compare figs. 346, 348 with 345, 347).

The larvae most likely to be confused with it are those of *M. californicum californicum* (figs. 352 and 353) and possibly other variants of *M. californicum*, such as figure 359. However, *M. californicum californicum* never has the hourglass-shaped blotches which are flanked by the round black spots, nor does it have the conspicuously tufted dorsal secondary setae, or the long, blackish primary dorsal setae. In the past *constrictum austrinum* has undoubtedly been confused with *californicum* or *californicum californicum* because of the superficial similarities in the larvae, and also because very dark adult males of *californicum* and *californicum californicum* are vaguely similar to some specimens of *constrictum austrinum.* They are easily separated, however, from all populations of *M. californicum* by the distinctive shape of the male genitalia, especially the shape of the eighth sternite (compare fig. 38 with figs. 44–51 and see the description of the terminalia of *M. constrictum*, page 93). This confusion of larvae and adults of *constrictum austrinum* with those of *californicum* and *californicum californicum* has resulted in *M. californicum* commonly being reported from southern California where the occurrence of any form except *M. californicum fragile* is questionable. See the "distribution" under *M. californicum* for a discussion of this (page 127).

EGG MASSES, TENTS, AND COCOONS.—The same as those of *M. constrictum constrictum* (page 89).

FOOD PLANTS.—With one exception, egg masses were not found on plants other than oaks in 1960 or 1961. In this case, a few egg masses were found on *Ceanothus* twigs, but these twigs were intertwined with those of *Quercus dumosa*, on which many egg masses were found. No egg masses were found on *Ceanothus* which was not growing with *Quercus dumosa.* Caterpillars will eat other plants, and some were reared from eggs through the third instar on *Rosa* before they succumbed to disease. Oviposition does not normally take place on plants other than oaks, however. Egg masses were found on *Q. dumosa*, *Q. agrifolia*, and *Q. engelmanii* in 1960 and 1961. It should occur on all other species of oaks which grow in southern California and Baja California.

TYPE.—Holotype, a not fully mature, female, last instar larva collected as an early instar larva and reared to the last instar. Color pattern the same as described above, but the grays and blacks appear more brownish when preserved in alcohol. Length, 45 mm., killed in KAA solution, and preserved in 95-percent ethyl alcohol. United States National Museum Type No. 67665.

TYPE LOCALITY.—One quarter mile E. of Santa Ysabel, San Diego Co., Calif., Elevation 3000 ft., collected 3 April 1960 by F. W. Stehr, Collection No. 26. Host: *Quercus dumosa.*

DISTRIBUTION.—*M. constrictum austrinum* has been collected in the larval stage only at Guatay and Santa Ysabel in San Diego County, and at Temecula in Riverside County, Calif. Larvae collected at

La Canada, Los Angeles Co., Calif., are evidently from the transition zone between *M. constrictum constrictum* and *M. constrictum austrinum* since about half of them had white lateral setae and the other half orange or yellowish lateral setae. The dorsal blue and black pattern was also more distinct than typical *constrictum austrinum* in which it is more obscured by black. Not enough larval collections have been made to plot the northern boundary accurately, but on the basis of the preserved larvae that are available it can arbitrarily be set along a line drawn from Indio, Riverside County, Calif. along the southern base of the San Bernardino and San Gabriel Mountains. A definite boundary can rarely be set for any continental subspecies, and this is no exception since there appears to be a transition zone on the south slopes of the San Bernardino and San Gabriel Mountains which may extend westward to Santa Barbara or even farther. Southward, the distribution probably extends as far into Baja California as oaks grow, but no specimens are recorded from there to date. The southernmost record is Jacumba, San Diego County, which is adjacent to the Mexican border.

ECONOMIC IMPORTANCE.—In 1960 it was causing virtually complete defoliation of *Q. dumosa* and other oaks in the vicinity of Guatay and Santa Ysabel, San Diego County, Calif.

SPECIMENS EXAMINED.—273 (Museum specimens—90 males, 21 females, 3 larvae; reared specimens—90 males, 69 females, plus numerous larvae and egg masses). See Appendix I for collections made during this study (page 257).

PARATYPES.—23 last instar larvae, 90 males, 69 females, 30 egg masses, one 1st instar molting tent, one 2d instar molting tent, and numerous 1st, 2d, 3d, and 4th instar larvae; all with the following data: ¼ mi. E. Santa Ysabel, San Diego Co., California, El. 3000 ft., Coll. No. 26, 2 April 1960, Host—*Quercus dumosa*, F. W. Stehr.

All paratypes are in the University of Minnesota Collection except the following ones. Receiving 1 adult male and 1 adult female: Calif. Dept. of Agric., Los Angeles Co. Mus., Ill. Nat. Hist. Sur., Univ. of Idaho, Cornell Univ., Ore. St. Univ., Carnegie Mus., and Charles Kimball. The Amer. Mus. Nat. Hist. has 2 adult males, 2 adult females, and 1 egg mass; Mich. St. Univ. has 3 adult males, 3 adult females, 3 last instar larvae, and 2 egg masses; Univ. Calif. Berkeley has 1 adult male, 1 adult female, and 1 last instar larva. Calif. Acad. Sci. and Can. Nat. Coll. have 2 adult males, 2 adult females, 1 egg mass, and 3 last instar larvae; U.S.N.M. has 4 adult males, 5 adult females, 3 egg masses, and 3 last instar larvae.

OTHER SPECIMENS.—CALIFORNIA: Avalon, Santa Catalina Island; Claremont; Chula Vista; Fallbrook; Guatay; Holtville; Idyllwild, San Jacinto Mountains; Jacumba; Julian; Live Oak Park (San Diego Co.); Los Angeles; Mt. Lowe; Mt. Palomar State Park; Palm Springs; Palomar Mt.; Perris; Rancho La Sierra, Arlington; Riverside; San Bernardino; San Diego; S. Felipe

Wash (San Diego Co.); Santa Ysabel Indian Reservation; Santa Catalina Island; The Gavilan (Riverside Co.); Tub. Can., Borrego; Upland; Warner's (San Diego Co.?); Witch Creek (San Diego Co.).

INTERMEDIATE POPULATIONS.—See "specimens examined" for *M. constrictum constrictum* (page 98).

Malacosoma tigris (Dyar)

Suggested common name: SONORAN TENT CATERPILLAR[7]

Clisiocampa disstria (Hübner), *sensu* Neumoegen and Dyar, 1894, p. 154. Misidentified; in part, "A form with irrorate wings and dark secondaries occurs in Texas."

Clisiocampa tigris Dyar, 1902, pp. 38–39.—Caudell, 1902b, pp. 36–37.

Malacosoma tigris (Dyar), Dyar, 1903, p. 263.—Dyar, 1928, p. 623, pl. 86b.—Collier, 1936, p. 140.—McDunnough, 1938, p. 138.

Malacosoma disstria form *erosa* (Stretch), *sensu* Holland, 1903, p. 313, pl. 10, fig. 10. Misidentified.

Malacosoma tigris inducta Dyar, 1906, p. 195.—Dyar, 1928, p. 623, pl. 86i.—Collier, 1936, p. 140.—McDunnough, 1938, p. 138. Type: Holotype, male, Palmerly (=Palmerlee), Cochise Co., Arizona. United States National Museum Type No. 33659.

Clisiocampa onissa Dyar, 1911, p. 255. NEW SYNONYMY. Type: Holotype, male, Zacualpan, Mexico, August 1909, R. Muller, collector, 2178. United States National Museum Type No. 13005.

Malacosoma onissa (Dyar), Dyar, 1928 p. 623, pl. 86b.—Collier, 1936, p. 140.

Malacosoma texana Beutenmuller (*nomen nudum*), Dyar, 1928, p. 623 (see below).—Collier, 1936, p. 140.—McDunnough, 1938, p. 138.

Malacosoma texana Dyar, 1928, p. 623, pl. 86a. NEW SYNONYMY. [The name "*texana*" must be credited to Dyar since there is no record that Beutenmuller ever published a description. *In* Draudt, 1928, *in* Seitz, 1940, pp. 624–626, *texana* is the only species of *Malacosoma* which is not listed in the alphabetical list of the original descriptions of the American Lasiocampidae. Collier, 1936, indicates that the name *texana* Beutenmuller is "*i. litt.*," and it has not been possible to find any reference to the original description in the Zoological Record or any other journal.] Type: Lectotype, here designated, male, Texas, Collection J. B. Smith. United States National Museum Type No. 34884.

Malacosoma sp. probably *texanum*, Cooperative Economic Insect Report, United States Department of Agriculture, 1963, vol. 13, Nos. 13–17; 1964, vol. 14, Nos. 12–14.

ADULT MALES (males in figs. 161–175).—Color varying from yellow to yellow-brown, heavily dusted with brownish scales. Lines on forewings brown, varying from quite distinct to faint or even absent; outer line usually angled toward tip of wing at costal margin as in

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[7] See Appendix III (page 289).

figure 162 so an acute angle is formed; median area same color as inner and outer areas. Hindwing often darker than forewing (especially those from Texas), but sometimes same color, and sometimes crossed by a brown band, as in figure 162, which may be distinct or faint. Lower surface of forewings usually darker than lower surface of hindwings, forewings usually with a brownish line crossing them, hindwings sometimes with a brownish line crossing them which is most noticeable in those specimens with conspicuous lines on the upper surface of the forewings. Rarely, specimens may be found which are pale straw-yellow and with very faint markings (see fig. 171 and "comments"). Epiphysis small, about the length of second tarsal segment of foretarsus.

MALE TERMINALIA.—Posterior edge of seventh sternite not distinctive (fig. 59), varying from heavily sclerotized and with small "teeth" to practically nonsclerotized and smooth. Genitalia (fig. 32) most similar to those of *M. constrictum* (fig. 34), but more "robust," the "arms" of the eighth sternite (fig. 39) parallel or only slightly converging; distance between points of the "arms" usually greater than half the basal width of eighth sternite at its widest point. Prongs of accessory claspers (fig. 14) usually very thick, unevenly tapered and blunt, jagged or toothed at apex as though they had been broken off. Some specimens (including the lectotype) have evenly pointed accessory claspers.

ADULT FEMALES (females in figs. 161–175).—Color usually fairly dark reddish-brown in reared specimens from Texas (figs. 169 and 175), but lighter specimens may be more common in other areas (figs. 163 and 166). Forewings heavily dusted with yellowish scales which are apparent to the unaided eye. Lines on forewings reddish-brown, outer one usually fairly straight, inner one more variable; median area nearly always darker than inner and outer areas. Hindwings about same color as darkest area of forewings. Lower surface of wings about same color as upper surface of hindwings, inner area on lower surface of both forewings and hindwings sometimes darker than outer area. As in the males, rare specimens may be found which are pale straw-yellow, and with only faint markings (see fig. 172 and "comments"). Epiphysis very small or absent.

FEMALE TERMINALIA.—Genital plate varying from partially sclerotized to nonsclerotized. Ovipositor as in figures 84 and 85. See the following section for a discussion of ovipositor characteristics.

ADULT DIAGNOSIS.—The only males likely to be confused with *tigris* are those of *M. disstria* and *M. constrictum* since both have dark lines on a light ground color. Male *disstria* are easily separated by the characters of the epiphysis and genitalia given in the diagnosis (page

86). Male *constrictum* are not so easily separated from *tigris*, but one of the best ways to distinguish them is by distribution, since the ranges do not overlap (compare fig. 1 with fig. 4). There are good morphological characters, however, which will separate them. These are given in the adult diagnosis for *constrictum constrictum* (page 94).

Female *tigris* are most likely to be confused with those of *constrictum* since females of both species are the only ones which are fairly dark brown, and have the forewings crossed by dark lines and dusted with whitish-yellow scales which are conspicuous to the unaided eye. Often *tigris* can be distinguished from *constrictum* by differences in the color pattern, but there are differences in the shape of the ovipositor which will always separate them. When viewed laterally, the ovipositor of *tigris* (fig. 84) has evenly rounded dorsal and ventral lobes which are separated by a distinct indentation. Female *constrictum* (fig. 86) have a differently shaped ovipositor. See the adult diagnosis for *constrictum constrictum* for a more complete description of these differences and for differences in the color pattern (page 94).

Female *disstria* also have dark lines on the forewings, but they can usually be separated by color pattern differences and other differences given in the adult diagnosis for *disstria* (page 86). Positive identification of *disstria* can be made by the ovipositor lobes which are differently shaped and have no distinct dorsal lobe (fig. 81).

Occasionally rubbed or faded specimens of other species will be encountered which are difficult to separate from *tigris* by color or color pattern, but *tigris* can always be separated by the characters of the ovipositor lobes given above. The ovipositor lobes of *M. incurvum*, *M. californicum*, and *M. americanum* are always considerably larger if specimens of the same wingspan are compared, and the lobes are differently shaped (compare fig. 84 with figs. 88–103).

MATURE LARVAE (figs. 342–344).—Head nearly black, sometimes mottled with blue, and sparsely covered with fine black or brownish setae. Dorsum of body without a contrasting whitish middorsal stripe or other distinctive middorsal markings such as are present on some species. Dorsally each segment marked with a longitudinal orange blotch which is narrowed in the middle, and somewhat wider posteriorly than anteriorly. This orange blotch usually bears a median blackish line, but in some specimens the entire blotch may be virtually obscured by black. Subdorsal area basically black, but divided into two longitudinal black stripes by a conspicuous, longitudinal, wavy, orange line. (If the dorsal orange blotch is obscured by black the more dorsal black stripe may blend into it.) Anterior section of the more ventral black stripe marked with a variable blue patch which may almost entirely obscure the black in some specimens. Both subdorsal black stripes crossed slightly posteriorly of the middle of each segment by a vertical blue line which may cross the wavy orange line between them unbroken, or which may be interrupted by it. Immediately posterior to the vertical blue line is a second, much fainter, vertical blue line which is nearly always broken by the wavy orange line. On some specimens (fig. 344) the vertical blue lines and the anterior blue patch may be greatly expanded so that the entire lateral region is blue, but the anterior vertical blue line is still prominent, since it is marked off by black borders anteriorly and posteriorly. Laterally the mesothorax and metathorax are marked by half-moon shaped black spots which are most conspicuous on those specimens having much lateral blue (fig. 344). Dorsal edge of supraspiracular area orange or yellowish, and setting off the subdorsal black stripe. Remainder of supraspiracular and subspiracular areas varying mixtures of black, blue, orange, and gray. Ventral area mottled black and gray-white, often with a darker median area on each segment. Primary dorsal setae black, often tipped with white or yellow-orange; secondary dorsal setae orange, except on the eighth abdominal segment which is almost entirely black dorsally and laterally, and bears black primary and secondary setae which contrast with the tufted orange setae on segments seven and nine (see figs. 342–344). Lateral setae orange or white or intermediate shades and conspicuously tufted anteriorly around setal group L2. (All larvae collected in Texas had orange lateral setae as in figures 342 and 343; those from Utah had white lateral setae as in figure 344, and those from New Mexico had either orange or white or intermediately colored setae. In Dyar's original description he notes that the larvae had white or orange setae on the sides, so Colorado and New Mexico appear to be a region of transition between these two larval types, although the inflated specimens of Dyar's from Colorado in the United States National Museum are much closer to the Texas form than the Utah form. Very few collections of *tigris* larvae, however, have been made in the United States, and none have been made in Mexico where *tigris* occurs as far south as Chiapas, so it is reasonable to expect that other variations will be found which will not agree with this description entirely. When more complete information is available it may be desirable to recognize some populations as subspecies.)

LARVAL DIAGNOSIS.—Many of the markings of *tigris* larvae are variable from one geographic area to the next, but some longitudinal orange and black lines are present and the prominent vertical blue line is always present on specimens which have been examined. Possibly one of the best characters to identify *tigris* larvae besides the overall color pattern is the eighth abdominal segment which is mostly black dorsally and laterally, and bears black setae which contrast with the orange setae on segments seven and nine. The half-moon shaped spots on the mesothorax and metathorax are also quite distinctive. No other North American species has markings like these.

EGG MASSES.—The eggs (fig. 106) are laid in a helical band the same way that *M. constrictum* and *M. disstria* deposit their eggs. They are not covered by spumaline, however, as the egg masses of both *constrictum* and *disstria* are. The egg masses of *tigris* are unusual in other ways. Female *tigris* always seem to lay their eggs around very small twigs which are rarely more than 3 mm. in diameter. Neither *constrictum* nor *disstria* consistently choose such slender twigs for oviposition.

Whenever egg masses of other species are not completely covered with spumaline the exposed eggs are often heavily parasitized. However, even though there is no spumaline on the eggs of *tigris*, very few of those which were collected during this study were parasitized. No reason is known for this apparent immunity to egg parasites, but the exposed end of the egg is thicker than those of other species, and it may be thick enough to prevent much of the parasitization.

Hatched egg masses of *tigris* also have been found on dead twigs of living trees on several occasions, which is a rare occurrence among the other North American species. It is impossible to know if the twigs were dead when the eggs were laid, but it seems quite possible for the following reasons. The egg masses of other North American species are covered with spumaline. Hodson and Weinman (1945) found the spumaline of *M. disstria* to be hygroscopic, and suggested its principal function seemed to be the prevention of rapid desiccation of the eggs in dry air and the conservation of moisture which had been absorbed. The function of the spumaline on the egg masses of the other species would probably be similar. Egg masses of all species except *tigris* are almost never found on dead twigs, presumably because the eggs would desiccate through the dry twig and never hatch. Thus, any tendency to oviposit on dead twigs would be selectively eliminated. In contrast, the eggs of *tigris* are not covered with spumaline, and it must be assumed that the structure of the chorion is such that desiccation is prevented without having a covering of spumaline. If it is assumed that the chorion is relatively homogeneous throughout, it would be possible for *tigris* eggs to be laid on dead twigs, and for them not to desiccate through the dry twigs. There is no experimental evidence to support this, but it could be relatively easily obtained by cutting down or girdling a tree soon after oviposition, and comparing the hatch with a nearby living tree the following spring. If this were done in an area such as central Texas where *M. disstria* is found abundantly on the same hosts as *tigris*, a comparison could also be made with a species that covers its eggs with spumaline.

TENTS (fig. 334).—*M. tigris* builds tents like those of *M. constrictum.* It constructs only relatively small tents near the end of each instar which are used as a base for attachment when molting. It never rests inside the tents. See the discussion of tents for *constrictum constrictum* for a more complete commentary (page 96).

COCOONS.—Cocoons are fairly tightly constructed, have no outer envelope of silk, and are dusted with a white powder. They are similar to those of *constrictum* (page 97).

FOOD PLANTS.—As far as is known, oviposition (but not necessarily feeding) is restricted to various species of oak, as is the case with *constrictum.* The larvae will probably feed on various other trees and shrubs (especially in the late instars) as will the larvae of all other species. There are no reports of food plants in the literature because *tigris* has been a nearly forgotten species since it was described in 1902. In the original description Dyar recorded the host as "dwarf oaks." In 1961 and 1962 egg masses were found at several localities in Texas, one in New Mexico, and one in Utah on the following species of oak: *Quercus virginiana*, *Q. undulata*, *Q. dumosa turbinella*, *Q. macrocarpa*, and *Q. marilandica.* It seems probable that *tigris* will be found on all species of oak which grow where other conditions are suitable for it.

TYPE.—Lectotype, here designated, a male in the United States National Museum. USNM Type No. 34887. Size: 28 mm. wingspread. Data: 16926; Dyar and Caudell; *Malacosoma tigris* Dyar, male; Lectotype, *Malacosoma tigris* (Dyar), male, F. W. Stehr 1963. The "16926" refers to Dyar's notebook which has the following entry: "16926–8 out from Colorado, June 20, 1901 (BB938)." The "BB938" refers to Dyar's brown notebook number 938 which contains his field notes. It contains miscellaneous partially illegible notes about the collection, but the most important information is legible and is extracted as follows (question marks indicate portions which are illegible): "*Clisiocampa* not *fragilis* on scrub white oak in Platte Canyon, Col., May 18, 1901; spin no regular nest, but several small webs . . ? . . Slightly more webbing than *disstria.*" Most of the rest of the page describes the various larval instars and gives their measurements, but the top of the page contains the following note: "Many at Sedalia, Col. Eggs on twigs at base of branch . . ? . . a live or dead twig. (See specimens) More from Oslar, Cheyenne Canyon, Colorado Springs in stage before last on young . . ? . . oak, June 8, 1901." The most interesting information in these notes is that Dyar found egg masses on dead twigs, indicating that this may be a rather common habit (see discussion of this above).

Genitalia of lectotype in microvial labeled: Lectotype, *Malacosoma tigris* (Dyar), male genitalia, F. W. Stehr 1963. The lectotype is paler than most *tigris*, but it may be faded. The accessory claspers of the lectotype differ from the majority of males in being evenly pointed instead of jagged as in figure 14.

TYPE LOCALITY.—It is impossible to say with certainty which locality of several mentioned in his notebook the specimens of the United States National Museum came from, but since the original description mentions the Platte Canyon, near Denver, Colorado, first, this is selected as the type locality.

PARALECTOTYPES.—Eight male and 7 female adults bearing "Dyar and Caudell" labels and labels with numbers ranging from 16927 to 17154, all of which are equal to 16926 according to Dyar's notebook. Also 3 egg masses (2 on 1 twig), 10 inflated larvae and 3 cocoons (on 1 pin) bearing "Dyar and Caudell" labels of which 1 egg mass, 1 larva, and the cocoons have a label saying "938," referring to Dyar's brown notebook No. 938. There are also additional larvae and possibly other life stages in the United States National Museum which were not labeled as paralectotypes.

DISTRIBUTION (fig. 1).—*M. tigris* occurs in the southern Great Plains, the southern Rocky Mountains, the Southwest, and Mexico. In Mexico it probably occurs wherever oaks grow and the climate is suitable for breaking its diapause.

The most southern record for any species of *Malacosoma* in North America is for 3 male *tigris* from San Cristobal las Casas, Chiapas, Mexico, by C. C. Hoffman, August 1940. There are mountains above 9,000 feet in Chiapas which apparently enable *tigris* to break diapause that far south (Chiapas records not plotted in fig. 1).

It should also be found in Guatemala where elevations exceed 10,000 feet in several places. However, there is little above 6,500 feet in Honduras and El Salvador, and little above 4,000 feet in Nicaragua, so its southward distribution may be stopped by the inability to break diapause in these areas. It could survive in Costa Rica since there are many mountains above 6,500 feet, with some volcanic peaks reaching 11,000 and 12,000 feet. Most of Panama is below 3,500 feet except in the west near Costa Rica, so it probably could not break diapause in Panama either. There are no authentic records of *Malacosoma* from South America, but they could certainly break diapause all along the Andes if they could get there.

M. tigris's westward distribution seems to be limited by the lack of oaks in the Mojave Desert and the Great Basin. It seems to be adapted to arid areas and should do quite well in many parts of California if it were able to get there, and compete successfully with *M. constrictum* which also prefers oaks. The limits of its eastward distribution are not definitely known, but specimens have not been seen from areas farther east than central Texas. It may occur farther east since many species of oaks are present throughout most of the eastern United States. If it does occur east of Texas, however, it is probably rare, and even more rarely collected owing to its lack of a conspicuous tent.

The factors which limit its eastward distribution are unknown, but it does not seem to be limited by a lack of suitable host plants. Most likely there are climatic factors which limit it since the eastern edge of its known distribution more or less coincides with the transition zone between the arid regions of western Texas and the more humid regions of eastern Texas. In the Rocky Mountains it extends northward into northern Colorado, but in the Great Plains it has not been collected north of Texas, although it seems likely that it should be found in Oklahoma or even farther north.

ECONOMIC IMPORTANCE.—*M. tigris* does not appear to be of any great economic importance, since it feeds on oaks, most of which are of little value in the areas where it is known to occur. With the help of *M. disstria*, however, it has caused heavy defoliation in south-central Texas (see Coop. Econ. Insect Report, USDA, in recent years). In fact, *tigris* was the more common species in many areas in Texas in 1961 and 1962, and was probably causing more damage than *disstria*. Past reports of *disstria* causing heavy defoliation in Texas should be regarded with caution, since *tigris* was probably also responsible in many cases.

COMMENTS.—The name "*onissa*" is listed as a synonym of *tigris* even though it differs from most *tigris* in some respects. In the holotype, the outer margin of the forewing is bowed out at vein R5 more than most *Malacosoma*, and the base of the eighth sternite is flared out somewhat, but in other respects, such as the jagged accessory claspers, it is like typical *tigris*. When more is known about the other life stages of the Mexican *Malacosoma* it should be confirmed that "*onissa*" is a Mexican population of *tigris* which is somewhat different from the more northern populations, but which intergrades with them.

When the larvae of *tigris* are reared, the sex ratio of the adults is approximately 1:1. But in collections of adults only, females are extremely rare, only 7 females being found in a total of 411 adult nonreared specimens examined in this study (7 females in the United States National Museum were reared by Dyar). In one collection made by Dr. Frederick H. Rindge of the American Museum of Natural History near Monticello, Utah, in 1960, 125 males and no females were collected at light. In another collection made 10 miles west of El Salto, Durango, Mexico, in 1964 by the Canadian National Collections expedition 48 males and no females were collected. None of the other North American species shows such an extreme difference between numbers of males and females collected as adults. No explanation for this difference in behavior of *tigris* females is known, but they may not be attracted to light as strongly as females of other species. In any event, it is a difference in behavior that must be taken into account, if, for example, population estimates were to be made from light trap counts.

Normally colored larvae collected in Real County, Texas, in 1961 (Coll. No. 226), and reared to adults produced a total of 43 moths, all normally colored (figs. 174 and 175) except for 3 males and 4 females which were pale, straw-yellow, and had only very faint markings (figs. 171, 172). These individuals are as large as the normally colored moths and appear to be normal in every other respect. (All adults from this collection were slightly smaller than normal moths, such as figure 169, owing to disease and poor quality of the foliage fed to them.) Some larvae from this collection died from disease, but larvae from many other collections of other species from many other areas also died from disease without resulting in the production of any pale moths among the survivors. Similarly colored individuals of *M. californicum* have been collected as adults, especially in the Great Basin and southern Rocky Mountains, but in all cases the number of such individuals is very small. Possibly they are the result of extreme conditions which prevent the development of the normal color pattern, or they could be caused by homozygous recessives or other rare gene combinations. A similar situation occurs in populations of *M. incurvum aztecum* which are found around Mexico City. See the comments on this subspecies for a discussion of this (page 185).

SPECIMENS EXAMINED.—579 (Museum specimens—397 males, 14 females, 70 larvae; reared specimens—45 males, 53 females, plus numerous larvae and egg masses). See Appendix I for collections made during this study (page 257).

UNITED STATES.—ARIZONA: Chiricahua Mountains; Christopher Creek, Mogollon Rim (Gila Co.); Dewey; Garden Canyon, Huachuca Mountains; Hereford; Hot Springs; Huachuca Mountains; Madera Canyon, Santa Rita Mountains; end of road, Madera Canyon, Santa Rita Mountains; Manzanita; Oak Creek Canyon; Oracle; Palmerlee; Paradise; Payson; Pinal Mountains; Pine Camp Ground, Pine (Gila Co.); Pine Crest, Graham Mountains; Prescott; Ramsey Canyon, Huachuca Mountains; Santa Catalina Mountains; Santa Rita Mountains; Schnebler? Hill, Sedona; Sedona; SW Research Station, A.M.N.H., 5 mi. W. Portal; Todd's Lodge, Oak Creek Canyon; Tonto Creek State Fish Hatchery (Gila Co.); Turkey Flat, Chirichaua Mountains; White

Mountains, Apache Indian Reservation; White Mountains; Yavapai Co.; "Ariz.". COLORADO: Breckenridge; Glenwood Springs; Maybell; Mesa Verde National Park; Platte Canyon, near Denver; Rock Creek Canyon (near Alamosa); Valley View Lodge, 10 mi. S. Steamboat Springs. NEW MEXICO: Calaveras Creek Camp, Jemez Mountains (Sandoval Co.); Cedar Creek Camp, 2 mi. N. Ruidoso; near Hot Springs, Las Vegas; Jemez Mountains; Ruidoso; Santa Cruz; Simpson's Ranch, 5 mi. E. La Jara. TEXAS: Boerne; Hondo; Rio Frio; "Texas." UTAH: Buckboard Flat Camp, 7 mi. W. Monticello.

MEXICO.—CHIHUAHUA: Matachic; San Jose Babicora. DURANGO: Otinapa; Palos Colorados; 5 mi. W. Durango; 10 mi. W. El Salto. HIDALGO: Guerrero Mill. MORELOS?: Zacualpan. DISTRITO FEDERAL: S. Angel; Zacualpam. CHIAPAS: San Cristobal las Casas.

Malacosoma americanum (Fabricius)

Common name: EASTERN TENT CATERPILLAR

Bombyx americana Fabricius, 1793, p. 433, species 81.

Phalaena castrensis Linnaeus *sensu* Smith and Abbot, 1797, p. 119, pl. 60. Misidentified.

Clisiocampa americana Harris, 1841, pp. 265–271.—Stretch, 1881, p 68.—Edwards, 1889, pp. 77–78.—Dyar, 1893, p. 39.—Packard, 1893, pp. 182–184. Types: Unknown, but possibly unlabeled in the Harris Collection, Museum of Comparative Zoology, Harvard.

Clisiocampa decipiens Walker, 1855, p. 1488.—Packard, 1864, p. 387. Type: Trenton Falls, New York, male, British Museum of Natural History.

Clisiocampa americana (Fabricius) Walker, 1855, p. 1488.—Neumoegen and Dyar, 1894, p. 155.

Bombyx frutetorum Boisduval, 1868–69, p. 82. Type: Lectotype, here designated, male, locality—probably eastern Canada. United States National Museum Type No. 34885.

Malacosoma americana (Fabricius), Dyar, 1898, p. 6.—Dyar, 1903, p. 262.—Holland, 1903, pp. 312–313, pl. 10, fig. 12.—Essig, 1926, pp. 696–697 (in part).—Collier, 1936, p. 98.—McDunnough, 1938, p. 138.—Keen, 1952, p. 95 (in part, eastern states).

Malacosoma americana (Harris), Dyar, 1928, p. 622, pl. 86a.

?*Malacosoma pensylvanica* [sic] Guer., McDunnough, 1938, p. 138. (manuscript name?)

Malacosoma americanum (Fabricius), Langston, 1957, p. 5.

ADULT MALES (males in figs. 312–320, 206, 311).—Color varying from light to dark chocolate-brown. Wings lightly dusted with white scales; forewings crossed by a pair of oblique white or yellowish-white lines, sometimes bowed toward outer margin, but often nearly straight; median area variable in width, frequently lighter than inner and outer areas. Hindwing uniform chocolate-brown, occasionally crossed with a faint white area. Lower surface of forewings and hindwings chocolate-brown (fig. 311), often flecked with white scales; both forewings and hindwings crossed beneath (sometimes faintly) by a single whitish line. Epiphysis small (fig. 78), usually about length of second segment of foretarsus, but rarely a little longer.

MALE TERMINALIA.—Posterior edge of seventh sternite slightly scalloped, usually with a definite median notch (fig. 60). Genitalia (fig. 31) large compared with other species of the genus (figs. 32–36). Eighth sternite (fig. 40) very large, the "arms" extending well past the parameres (fig. 31), and total length much greater than basal width. Accessory claspers as in figure 15.

ADULT FEMALES (females in figs. 312–320, 208).—Same color pattern as the males, but often somewhat lighter, and more easily confused with females of other species than males.

FEMALE TERMINALIA.—Genital plate (fig. 90) heavily sclerotized, variable in shape, but almost always longer than wide, and somewhat heart-shaped, with a deep depression on each side of a median ridge which bears the ostium near the anterior edge. Ovipositor lobes as in figures 88 and 89. They are quite similar to those of *M. californicum* and *M. incurvum* (figs. 91–103), but these two species never have a heavily sclerotized genital plate *with the ostium at the anterior edge.*

ADULT DIAGNOSIS.—Both males and females can be identified usually by the nearly white lines on a chocolate-brown ground color. In doubtful cases, positive identification of males can be made by the genitalia which are much larger in absolute size (compare fig. 31 with figs. 32–36, and fig. 40 with figs. 37–39 and 41–54). Positive identification of females can be made by the heavily sclerotized genital plate in combination with the anterior position of the ostium (fig. 90). No other North American species has the ostium at the anterior edge of the genital plate.

Distribution (fig. 2) is also helpful in identification. The only species or subspecies recorded from within the range of *americanum* which could be confused with it are *M. californicum pluviale* and *M. californicum lutescens*. The male genitalia of these two subspecies, however, are smaller and distinctly different in size. The total length of the eighth sternite (fig. 40) is almost always distinctly greater than the length of the foretibia in *americanum*, and it is almost always distinctly less than the length of the foretibia in *lutescens* (figs. 49 and 50) and *pluviale* (figs. 47 and 48). In addition, the arc of curvature of the "arms" of the eighth sternite near the points is greater for *lutescens* and *pluviale* (figs. 47–50) than it is for *americanum* (fig. 40) where there is practically no arc.

MATURE LARVAE (figs. 350 and 351).—Head black, covered with numerous fine, blackish setae. Body with an apparently *continuous*, even, middorsal stripe, bordered by an area of longitudinal reddish-brown and black wavy lines which cover the addorsal area. Setal group D1 usually surrounded by an irregular black spot. Subdorsal area with a central black area on each segment crossed by a vertical blue mark posteriorly, and a less striking, more variable blue patch anteriorly; setal group SD at ventral edge of central black area. Dorsal edge of supraspiracular area marked with an irregular, discontinuous, reddish-brown to yellowish, longitudinal, wavy line forming a ventral border for the central black area; remainder of supraspiracular area and subspiracular area variably mottled and finely streaked with black, reddish-brown, blue, blue-gray, yellow and white. Ventral area mottled gray and black, each segment with a median transverse black band. Primary and secondary dorsal setae reddish-brown to orange or yellow; lateral setae reddish-brown to orange or white.

LARVAL DIAGNOSIS.—Larvae of *americanum* can always be identified by the apparently *continuous*, even, yellow-white middorsal stripe. No other North American larva is marked like this. Within its distributional area the only larvae that could possibly be confused with *americanum* are some individuals of *M. californicum lutescens* which may have a narrow middorsal stripe that appears to be nearly continuous as in figure 376 (usually the middorsal stripe is definitely broken as in figures 373–375). Confusion between these two has probably taken place in the past and resulted in *americanum* being reported from the western Great Plains. However, *americanum* larvae have black heads, and *c. lutescens* larvae have predominantly blue heads mottled with black. In addition, the lateral areas of *c. lutescens* are largely blue, and there is no central black subdorsal area crossed by a posterior vertical blue line as in *americanum*, although *c. lutescens* may have a conspicuous vertical black bar as in figures 375 and 376. These characters are most distinct in late instar larvae, and it may be difficult to positively identify early instars by them.

Possibly the best characters for separating early instar *americanum* from *c. lutescens* are the distinctly undulating, longitudinal yellowish line just below setal group SD, and the central, black subdorsal area which includes setal group D1 and is divided by a longitudinal yellowish line on *americanum*. These characters are most clearly visible on preserved or wetted specimens where blue colors do not show. *Malacosoma c. lutescens* has a similar longitudinal line just below setal group SD, but it is usually less distinct and without strong undulations; the subdorsal area may have a central black area, but this usually takes the shape of the vertical black bar, and it is never divided longitudinally by a yellowish line.

EGG MASS.—The eggs are laid as a basically clasping mass on small twigs (fig. 109), branches (fig. 110), or even the trunks of small trees (fig. 111). Egg masses laid on small twigs may *appear* to encircle the twig, but careful examination will reveal an irregular "seam" where the last row of eggs meets the first. Sometimes the last row may even be laid on top of the first row if a large female has laid her eggs on a small twig. All reports in the literature indicate that the eggs are normally laid on small twigs. In Minnesota, western Wisconsin, and northern Michigan, however, egg masses are often laid about 6 inches above the ground on the trunk of small trees from ½ to 1½ inches in diameter (fig. 111). At the same localities some egg masses may also be laid in the usual fashion on small twigs or branches.

Egg masses collected in eastern Wisconsin near Green Bay, in Indiana, Ohio, Virginia, Kentucky, Kansas, Oklahoma, Missouri, Louisiana, and Texas were all laid on small twigs or branches at varying heights above the ground even if the host was a small tree with a trunk diameter of less than 1 inch. No reason is known for the laying of some egg masses near the base of small trees in Minnesota, Wisconsin, and Michigan but it has been suggested that eggs laid near the ground would be covered by snow and thus protected from the rather cold midcontinental winter temperatures.

The spumaline covering the eggs of *americanum* is very dark brown, which in most cases distinguishes them from those species laying similarly shaped egg masses (*M. californicum* and *M. incurvum*), but whose spumaline is usually lighter colored.

TENTS.—See page 25.

COCOONS.—Cocoons are fairly tightly constructed, usually lack a conspicuous outer envelope of silk such as *M. disstria* spins, and are suffused with a bright yellow powder.

FOOD PLANTS.—Preferred hosts for oviposition are members of the genera *Prunus*, *Malus*, *Crataegus*, and other related plants. Food preferences are not as restricted as oviposition preferences, and larvae will eat many deciduous trees and shrubs, especially in the last instar. This, no doubt, accounts for the extremely large number of host plants which have been reported in the literature.

A good example of the difference in oviposition and feeding preferences was found near Kerrville, Texas (Coll. No. 412). Several large tents were found in an isolated clump of young oak (*Quercus shumardii*?) about 15 feet tall. Oak is not commonly regarded as a host of *americanum*, so a careful search was made for egg masses. None were found on the oak, but eight egg masses were found on a small, completely defoliated wild plum growing beneath the oaks. This plum tree was less than 2 feet tall and could not possibly have supported the caterpillars which hatch from one egg mass, much less eight, so they were forced to eat oak or starve. They had done very well on oak, and it seems that *americanum* could be a pest of oaks and other trees, were it not for the fact that the females prefer to lay their eggs on other hosts.

TYPE.—Apparently destroyed. Dr. S. L. Tuxen of the Universitetets Zoologiske Museum in Copenhagen could not find it in either their collection, or in the Kiel collection (now in their museum) where he says it should be.

TYPE LOCALITY.—Boreal America.

DISTRIBUTION.—*M. americanum* is generally distributed throughout the eastern half of the United States and the southern part of eastern Canada (fig. 2). It meets, but only narrowly overlaps, the distribution of *M. californicum pluviale* to the north, and that of *M. californicum lutescens* to the west (fig. 2).

ECONOMIC IMPORTANCE.—It cannot be considered to be a pest which causes extensive economic losses, since most of its hosts have little value. On hosts such as *Prunus serotina*, the black cherry, whose wood is valued for furniture, it may be of some importance since growth is reduced by heavy defoliation, and control is impractical unless relatively pure stands are involved. Neglected fruit trees are often attacked, but commercial orchards are protected by the normal spray program that is used for more serious pests. It can be regarded as a nuisance throughout most of its range, but the large number of leaflets, pamphlets, circulars, and popular articles, which have been published in the past concerning its life history and control, attest to its status as a first-class public nuisance, especially in years of high populations.

COMMENTS.—*M. americanum* is completely isolated under field conditions from both *M. californicum lutescens* and *M. californicum pluviale*, two subspecies which overlap its distribution to the west and north respectively (fig. 2). No field-collected specimens have been seen which could be interpreted as intermediates between them. The area of overlap between them is not very wide at the present time, and a change from one species to the other may take place in a very narrow zone. In 1962 such an abrupt change was recorded while driving east from the Texas line on Oklahoma 33. Colonies of *californicum lutescens* were numerous on wild plum, and were occasionally found on *Ribes* sp. and *Prunus virginiana* growing along fence rows and gullies. Between Miami, Texas, and 5 miles NE. of Guthrie, Oklahoma (approximately 25 miles north of Oklahoma City), 25 stops were made, and more than 200 tents were examined. All of them contained only larvae of *c. lutescens*. Six miles NE. of Guthrie the first colony of *americanum* was found along with five colonies of *c. lutescens*. Table 3 shows what was found between Guthrie and Perkins, 26 miles NE. of Guthrie.

TABLE 3.—*Numbers of colonies of* M. americanum *and* M. californicum lutescens *found at localities between Guthrie and Perkins, Oklahoma. All colonies were found on wild plum.*

Locality	Colonies of *americanum*	Instar	Colonies of *lutescens*	Instar
7 mi. W. Guthrie	0		26	last
4 mi. NE. Guthrie	0		12	late last
5 mi. NE. Guthrie	0		2	late last
6 mi. NE. Guthrie	1	next to last	5	last
1 mi. E. Langston	6	next to last, few last	3	last
1 mi. E. Cimarron River	1	early last	1	late last
7 mi. E. Cimarron River	20	next to last, and last	1	last
9 mi. E. Cimarron River	40	next to last, and last	0	
11 mi. E. Cimarron River	6	next to last, and last	0	
3 mi. E. Perkins	20	last, few next to last	0	

From this table it can be seen that in a distance of approximately 15 miles (6 miles NE. Guthrie to 7 miles E. of the Cimarron River) there is a complete replacement of *M. californicum lutescens* by *M. americanum*. Both species were sufficiently abundant to defoliate many of the wild plum thickets along the highway. Both species appear to have nearly identical requirements. Both lay their eggs in the same way, prefer wild plum, build the same kind of tent, and seem to be very much alike in other respects. The only thing noted to be different in the field situation was the more nearly mature condition of the *c. lutescens* caterpillars. Most of them were in the last instar, but most of the *americanum* were only in the next to last instar or early last instar. It is not known whether this is due to a difference in hatching dates, different developmental rates, a different number of instars, or some other factor, but the end result is the same—*c. lutescens* matures sooner than *americanum*. This possibly could be advantageous during years of very high populations since the faster maturing *c. lutescens* conceivably could starve out the slower maturing *americanum* by consuming all the available foliage before any *americanum* larvae were large enough to pupate. Even a few days difference could be critical, since last instar larvae eat about four times as much foliage as all the earlier instars combined (Hodson, 1941). Hodson's work was done on *M. disstria*, but there is no reason to believe there would be any great difference in the other species.

It is not known whether this narrow area of overlap in distribution between *c. lutescens* and *americanum* is a stable situation which has existed for many hundreds of years or longer, or whether it is a situation which is changing in favor of one species. This would take many years of careful observation to determine. Certainly, however, it is an ideal situation for studying the competition between two very similar species under field conditions, as they are easily located and readily identified yet are closely similar in their requirements. It is possible that *c. lutescens* is better adapted to the drier, more severe climatic conditions found in the western part of the Great Plains, while *americanum* may be better adapted to the more humid and less severe conditions found eastward from the central Great Plains. A similar type of adaptation could account for the similar distributional pattern found between *americanum* and *M. californicum pluviale* at the northern edge of *americanum*'s distribution (fig. 2), and the same type of study could be carried out there.

Specimens supposedly identified as *americanum* have been reported in the literature as occurring west of the central Great Plains, but none have been seen in any of the specimens borrowed from various institutions except for three specimens that were probably mislabeled. Such reports of its occurrence are probably misidentifications of certain individuals of *M. californicum* and its subspecies (especially *M. californicum lutescens*) which may resemble *americanum* in general appearance. This is particularly true of early instars which are difficult to identify for all species except *M. disstria.*

It is likely that climatic conditions are suitable for *americanum* in many parts of the West, especially the Pacific Northwest, but whether it would be able to compete successfully with the native populations of *M. californicum* is difficult to say. In southwestern Texas the distribution of *americanum* seems to be limited by a lack of suitable food plants, rather than by competition with other species, since *c. lutescens* was not found in that area either. Suitable food plants occur in Big Bend National Park and in the Davis Mountains, but no tent caterpillars of any species were found there, and only a single museum specimen of *M. californicum* from Big Bend National Park has been seen.

SPECIMENS EXAMINED.—2120 (Museum specimens—906 males, 184 females, 860 larvae; reared specimens—103 males, 67 females, plus numerous larvae and egg masses). See Appendix I for data on collections made during this study. *Malacosoma americanum* is generally distributed throughout the states which are solidly checkered in figure 2. The following list includes only localities from states or provinces which lie outside this area.

UNITED STATES.—FLORIDA: Fernandina; Gainesville; Monticello; Orlando; Quincy; Torrey State Park. KANSAS: Douglas Co.; Riley Co. NEBRASKA: Dorsey

(Holt Co.); Lincoln. OKLAHOMA: Hinton. SOUTH DAKOTA: Volga; "S. Dak." TEXAS: College Station; Eastland Co.; "Texas."

CANADA.—MANITOBA: Bernie Lake; 10 mi. E. Braintree; Charles Wood; Garson; Gull Lake; Sandilands Forest Reserve; Stead; Tuelon; Winnipeg; Winnipeg Beach. NOVA SCOTIA: Digby; Truro. ONTARIO: Asheribos Island, Georgian Bay; Bracebridge; Britannia; Brockville; Bruce Mines; Constance Bay; Dunnville; Grand Bend; Hamilton; Iron Bridge; Kemptville; Manitoulin Island (Lake Huron); Mer Bleue; Merivale; Muskoka, Lake Joseph; North Bay; Ontonque Lake; Ottawa; Paris; Parry Sound; Simcoe; Sprucedale; Sudbury; Toronto; Trenton; "N. Ontario." QUEBEC: Beachgrove; Kazubezua; Kingsmere; Kirks Ferry; Knowlton; Lac Mondor, Ste. Flore; Meach Lake; Norway Bay.

The Western Tentbuilders—A Comparison of *Malacosoma californicum* and *Malacosoma incurvum* in the Southwestern United States

Specimens of all life stages of *M. disstria*, *M. constrictum*, *M. tigris*, and *M. americanum* can be positively identified by the diagnostic characters listed for each species. Any remaining specimens will be *M. californicum* or *M. incurvum* and their subspecies. Correct identification of these two species and their subspecies is often difficult and sometimes impossible, but with good data and as many life stages as possible it becomes much easier.

Malacosoma californicum and *M. incurvum* are very closely related species which cannot be absolutely separated from each other in every case by any known characters of any life stage. Nevertheless, there are some differences between them in the areas where they are known to occur together which permit most specimens to be correctly identified. They appear to present a very good example of the phenomenon of character displacement as proposed by Brown and Wilson (1956). They are not recognized as distinct species because of these differences alone, however, since field observations made on them in Arizona and Utah indicate that reproductive isolation is well developed, although probably not 100 percent effective. It remains to be seen whether or not these differences will be found in other parts of the Southwest, and what will be found in the large and totally unstudied area stretching from southern Arizona to Mexico City. Still, the observed differences should be recognized in some way, and regarding them as distinct species seems to be the best way at the present time.

Malacosoma californicum and *M. incurvum* were found in the same vicinity only at several places in Utah. These localities were along the Virgin and Santa Clara Rivers in Washington County, at Buckhorn Wash near the San Rafael River in Emery County, at the foot of the

La Sal Mountains in San Juan County, and 10 miles west of Huntington in Emery County. Both species were found in Arizona, but not at the same locality. Those populations of *incurvum* found in central and southern Arizona are named *M. incurvum incurvum* (fig. 4), and those centered in southern Utah are named *M. incurvum discoloratum* (fig. 4). The populations of *M. californicum* found in southwestern Utah and northwestern Arizona are called *M. californicum fragile* (fig. 2), and those found in the remainder of Utah and Arizona are called *M. californicum* (central populations) (fig. 2).

The egg masses of *i. discoloratum* differ from those of *californicum* which were found at the same locality. Those of *i. discoloratum* (similar to fig. 117) are covered with nearly white spumaline which contains many small bubbles and no microscopic "specks." Those of *californicum* are covered with grayish spumaline which contains bubbles of various sizes and also possesses numerous minute dark "specks" (fig. 118) scattered throughout the spumaline. (See the introductory section on egg masses for a discussion of these "specks" and their occurrence in various populations and subspecies of *M. californicum*, page 21).

No completely reliable differences for separating the larvae of *californicum* from *incurvum* are known, but larvae of *incurvum discoloratum* usually can be distinguished from those populations of *californicum* or *californicum fragile* found in the same locality by the characters given in the larval diagnosis for *discoloratum* (page 179). Some larvae of both species fall within the range of variation found in the other species and cannot be positively identified.

The adults do not differ structurally as far as is known, but male *incurvum discoloratum* usually can be separated by their color pattern from *californicum fragile* and *californicum*. Females are nearly impossible to separate, but see the adult diagnosis for *incurvum discoloratum* for a discussion of both males and females (page 178).

In 1961 along the Virgin and Santa Clara Rivers *i. discoloratum* occurred primarily on *Populus fremontii*, the southwestern cottonwood, although it also was found on ornamental poplars and rarely on fruit trees. *M. californicum fragile* occurred on *Prunus fasciculata*, the desert almond, and on fruit trees. At several places colonies of *i. discoloratum* were found on small cottonwood trees and tents of *c. fragile* were found on desert almond growing immediately beneath the cottonwood trees. In every case the *c. fragile* larvae were much further along in their development than the *i. discoloratum* larvae.

For example, at one site near Shivwits, Washington County, Utah, the *c. fragile* larvae were nearly mature, but the *i. discoloratum* larvae were only about halfway through the penultimate instar. Adult emergence dates for pinned adults which were reared from both of these populations confirm this difference. All adults of both populations emerged during May, and if the emergence dates for each are averaged, the average emergence date for *c. fragile* is the 11th, and for *i. discoloratum* the 20th. The last few *c. fragile* to emerge overlapped the first emergence of *i. discoloratum*, so there is a limited possibility of some gene exchange between these populations.

These differences in development are believed to be due to more than just differences in microclimate. It could be argued that the *c. fragile* egg masses and larvae are closer to the ground than the *i. discoloratum* egg masses and larvae, and they may, therefore, develop faster under the warmer conditions that could be expected near the ground. Collections of both *c. fragile* and *i. discoloratum*, however, made on the same apricot tree near Leeds, Washington County, Utah, suggest that there may be other factors responsible for the differences. Several colonies of *c. fragile* were found on this apricot tree, and all contained nearly mature larvae. A single colony of *i. discoloratum* found on this tree contained mostly penultimate instar larvae, and nearby cottonwood trees contained many colonies of *i. discoloratum* in the same stage of development. The colony of *i. discoloratum* on the apricot tree was reared, as was one colony of *c. fragile*. The average emergence dates of adults from these two colonies show the same differences of approximately 10 days as the Shivwits populations, even though both colonies must have been subjected to similar environmental conditions since they were located within a few feet of each other. This suggests that there may be inherent differences in hatching times or developmental rates between *c. fragile* and *i. discoloratum*.

Comparable differences were found at other sites along the Santa Clara and Virgin Rivers. No matter what the real reason is for the difference of about 10 days in developmental rates, it means that the vast majority of the *c. fragile* adults will emerge, mate, and die before the majority of *i. discoloratum* adults emerge, resulting in seasonal isolation which has undoubtedly restricted gene exchange between these two populations to a very low level.

Large populations of *i. discoloratum* were observed on cottonwoods in Buckhorn Wash upstream from the bridge across the San Rafael River as far as cottonwoods grew. These caterpillars were middle to mature last instars. No *californicum* colonies were found in the immediate vicinity, but typical *californicum* colonies were found several miles up the wash. They were on *Cercocarpus ledifolius* and *Amelanchier utahensis*, but only a few stragglers and cocoons could be found, indicating that *californicum* was considerably ahead of *i. discoloratum* in development even though they were located at a somewhat higher elevation. West of Huntington the situation was similar; the *i. discoloratum* larvae feeding on *Populus angustifolia* were in the last instar, but the tents of *californicum* found nearby on *Amelanchier utahensis* were deserted and only a few cocoons could be found. At the foot of the La Sal Mountains in San Juan County, last instar *i. discoloratum* were found on *Populus angustifolia*, but only a few fully mature larvae of *californicum* were found on *Cercocarpus montanus* nearby.

This seasonal difference in development is further demonstrated by what was found in Arizona. Sixteen miles north of Wikieup, Mohave County, at an elevation of approximately 2700 feet, 3d, 4th, and last instar larvae of *incurvum incurvum* were found on cottonwood. No *californicum* were found nearby, but in the Aquarius Mountains to the east at an elevation of approximately 4200 feet several colonies of *californicum* were found, but very few larvae were present. Most of the tents had been torn open by birds, and most of the larvae were gone. Those that remained were mostly 3d and 4th instars, indicating that the *californicum* larvae were not far behind in development, if any (since the birds may have eaten only the larger larvae), even though they were approximately 1500 feet higher (Coll. Nos. 208 and 209).

It is not known whether the earlier emergence of adult *californicum* at these various localities is due to an earlier date of hatching or to a faster rate of development, or some other factors, but the end result is the same . . . most of the *californicum* adults emerge before the *incurvum* adults, thereby greatly limiting any gene exchange which might take place if they emerged synchronously. Under laboratory conditions they readily mate and produce normal egg masses which appear to complete their embryological development satisfactorily. It is not known whether any breakdown occurs in the F_1 or F_2 since it was not possible to rear them for the reasons already given.

Neither *californicum* nor *incurvum* are greatly restricted in their choice of hosts, but they do show certain host preferences in some localities that are worth comparing. *M. incurvum discoloratum* was most often found on *Populus fremontii* in Utah, but also was found on *Salix* sp., *Populus angustifolia*, *Populus alba*, and fruit trees. In Arizona *incurvum incurvum* was found on *Populus fremontii*, *Prunus virens*, *Salix* spp. and fruit trees. *M. californicum fragile* was most commonly found on *Prunus fasciculata* in southwestern Utah, but was also found on *Amelanchier utahensis*, *Purshia tridentata*, and fruit trees. *M. californicum* was found on *Cercocarpus ledifolius*, *Cercocarpus montanus*, *Amelanchier utahensis*, and fruit trees in the areas in Utah where it was found at the same locality as *incurvum discoloratum*. It also occurs on a wide variety of other shrubs and trees in Arizona and other parts of its range in western North America.

In the areas where *californicum fragile* and *californicum* occurred together with *incurvum discoloratum*, colonies of *i. discoloratum* were never found on *Prunus fasciculata*, and colonies of *californicum fragile* and *californicum* were never found on *Populus fremontii*. Thus, to some extent each is restricted to its preferred host, although both of them may be found on hosts such as fruit trees which are not native to the area.

Observations made on *californicum fragile* at Kingman and Valentine, Arizona, indicate that this host preference is quite strong for some populations. At Kingman numerous colonies of *c. fragile* were found on *Prunus fasciculata* just north of town, but not a single tent could be located on several large cottonwoods growing a few hundred yards closer to town. Many moths must be attracted to lights in Kingman, and if they were attracted to streetlights near cottonwoods, they would have ample opportunity to lay their eggs on them, but apparently they do not do so. Near Valentine, the situation was even more conducive to oviposition on cottonwoods since many *c. fragile* colonies were found in *Prunus fasciculata* thickets which were growing beneath the cottonwoods. Not a single tent could be located in any of the cottonwoods.

It seems unlikely that *incurvum* is merely a population of *californicum* that has developed the described differences simply because it usually lives on a different host (cottonwood), since the same differences were found when both species were on fruit trees, which are not the native host of either one. Nevertheless, it is desirable that each species be reared on the other's preferred host, if possible, (maybe for several generations) in order to determine what influence the host may have on these differences, if any.

In this regard, there is considerable work that can be done on *incurvum* and its relationships to other populations of what are presently regarded as *californicum* in this revision. These include nearby populations of *californicum* which lay egg masses that do not have any specks, and the populations of *californicum* which occur on aspen at higher elevations. These populations are more fully discussed in the next sections (pages 130, 134).

It is possible that all of the populations of *incurvum* and *californicum* could be linked together at various elevations to form a very complex community that would not be adequately described by any formal names we could apply to them. To demonstrate whether this is true or not for any given area (and there are many areas), several seasons of field study would be required, plus good fortune in avoiding the numerous problems that may be encountered if rearing and overwintering of egg masses is to be done.

Until this can be done it seems best to recognize *incurvum* and *californicum* as species, name certain geographic subpopulations as subspecies, and refer to other subpopulations with names which have no nomenclatorial significance. Even if it should eventually be shown that these two species intergrade it would probably be best to recognize the low elevation cottonwood populations (*incurvum*) as a separate species because they are so different in some respects from other populations (*californicum*) which occur in the same areas and more distant areas.

Malacosoma californicum (Packard)

Suggested common name: WESTERN TENT CATERPILLAR[8]

Clisiocampa californica Packard, 1864, p. 387.—Packard, 1877, p. 794.—Edwards, 1889, p. 77.—Packard, 1890, p. 459.—Packard, 1890, pp. 119–121 (in part, Salt Lake City and Colo.).—Packard, 1893, pp. 179–181.—Neumoegen and Dyar, 1894, p. 156 (in part).

Bombyx drupacearum Boisduval, 1868–69, p. 82. Type: Lectotype, here designated, male, California, United States National Museum Type No. 34883.

Bombyx pseudoneustria Boisduval, 1868–69, p. 82. Type: Lectotype, here designated male, California, United States National Museum Type No. 34883.

Clisiocampa fragilis var. *perlutea* Neumoegen and Dyar, 1893, p. 31.—Neumoegen and Dyar, 1894, p. 156. Type: Holotype, male, Colorado, United States National Museum Type No. 33663. NEW SYNONYMY.

Clisiocampa fragilis Stretch *sensu* the following authors: Dyar, 1893, pp. 41–42 (in part, larva).—Packard, 1893, p. 179 (in part, larva from Virginia City, Mont.).—Cockerell, 1893, p. 112.—Neumoegen and Dyar, 1894, p. 155 (in part).—Dyar, 1895a, pp. 189–191 (in part).—Dyar, 1895c, p. 23.—Cockerell, 1901, pp. 25–26.—Caudell, 1902a, p. 77.—Caudell, 1902b, p. 36.

Malacosoma fragilis (Stretch) *sensu* the following authors: Dyar, 1898, p. 6.—Dyar, 1903, p. 262 (in part).—Essig, 1926, p. 697 (in part).—Dyar, 1928, p. 623, pl. 86a (in part).—Van Dyke, 1928, p. 92 (in part).—Collier, 1936, p. 114.—McDunnough, 1938, p. 138 (in part).—Swain, 1939, pp. 76–77.—Keen, 1952, pp. 95, 210, figs. 37, 101.—Clark and Reiner, 1956, pp. 653–659 (in part, Modoc population).

Malacosoma californica (Packard), Dyar, 1903, p. 262.—Holland, 1903, p. 313, pl. 10, fig. 11.—Essig, 1926, p. 697 (in part).—Collier, 1936, p. 100.—Keen, 1952, p. 95 (in part).

Malacosoma fragilis perlutea (Neumoegen and Dyar), Dyar, 1903, p. 262.—Dyar, 1928, p. 623.—Collier, 1936, p. 115.—McDunnough, 1938, p. 138.

Malacosoma americana (Fabricius) *sensu* Essig, 1926, p. 697 (in part, N. Mex., Colo., Mont., Idaho, B.C.).—*sensu* Keen, 1952, p. 95 (in part, Rocky Mountain region).

Malacosoma fragile (Stretch) *sensu* the following authors: Clark, 1956a, pp. 131–142 (in part, Modoc-Lassen population).—Langston, 1957, pp. 5–6 (in part).—Steinhaus, 1962, p. 433 (in part, No. 1196).

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[8] See Appendix III (page 289).

Malacosoma californicum (Packard). Langston, 1957, p. 6 (in part, Guerneville, Healdsburg and vicinity).

Malacosoma sp., Langston, 1957, p. 7.

Malacosoma pluviale recenseo Dyar, *sensu* Langston, 1957, pp. 8–9 (in part, Modoc Co. population E. of Sierra Nevada-Cascade divide in Calif.).

Rocky Mountain tent caterpillar, Clark, 1958, pp. 132–139.

Malacosoma pluviale (Dyar), *sensu* Steinhaus, 1962, p. 433 (in part, Nos. 1046, 1047, 1049, 1051, 1105, 1599).

Malacosoma californicum with its subspecies is the most variable North American tent caterpillar. Variation in the color pattern ranges from practically none in some populations to others in which several conspicuously different color patterns can be obtained by rearing larvae from a single isolated tent, which presumably hatched from a single egg mass. Any attempt to include in a description the many variations in pattern and color found in this species throughout its range is doomed to failure because of this. Therefore, the following description is quite general, and more detailed descriptions are given for the recognized subspecies. The important fact to remember is not that the recognized subspecies may be difficult to distinguish in some life stages, but that they are subpopulations of a single species, *M. californicum*, rather than several different species as has been believed up to the present time.

ADULT MALES (males in figs. 176–284 except figs. 206–208).—Color varying from dark reddish-brown to yellow or gray, and many intermediate shades. Lines on forewings almost always present, appearing lighter or darker than the ground color, but if darker, usually bordered by a narrow lighter area. (For a discussion of the components of the wing color pattern see the introductory section on adults, page 34.) Specimens from the Great Basin, Mojave Desert, and southern Rocky Mountains often have indentations along the veins which may meet to cut off "islands" as in figure 270. These indentations are greatest along Cu2. (Specimens of *americanum*, *tigris*, *constrictum* and *disstria* never have indentations along the veins.) Hindwing lighter or darker than forewing, often about same color, and sometimes with a contrasting band. Lower surface of both forewings and hindwings usually somewhat darker than ground color of upper surface, and both wings usually crossed ventrally by a single contrasting line. Epiphysis usually small, about the size of second segment of foretarsus, but rarely larger.

MALE TERMINALIA.—Posterior edge of seventh sternite (figs. 64–71) not distinctive, varying from heavily sclerotized and with distinct "teeth" to practically unsclerotized and smooth; often with a median notch and sometimes with the lateroposterior tips more heavily sclerotized so they appear to be "detached" from the main part. Genitalia (fig. 36) indistinguishable from those of *M. incurvum* (fig. 35) and quite variable; most similar in shape to those of *americanum* (fig. 31), but the absolute size of *californicum* is smaller for moths of similar size in other respects (compare the size of the eighth sternite of *americanum* (fig. 40) with those of *californicum* in figs. 44–51). Also, the arc of curvature of the "arms" of the eighth sternite near the points is usually greater for *californicum* than for *americanum*. Prongs of accessory claspers (figs. 19–26) usually sharply pointed; distance between tips of prongs variable, but usually equal to or less than their length as in figure 23 for specimens from the Pacific Coast region and northern Canada. Distance between the prongs usually greater than their length as in figure 24 on specimens from other areas. However, considerable variability is found, and intermediates such as figures 20 and 26 are not uncommon in both regions.

ADULT FEMALES (females in figs. 176–284 except figs. 206–208).—Color varying from reddish-brown to yellowish or grayish, and many intermediate shades. Lines on forewings same as described for the males, but if with indentations along the veins, they rarely meet to form "islands" as in the males. Hindwing usually about same color as forewing, but sometimes darker, especially on yellowish specimens. Lower surface of both forewings and hindwings about same color as ground color of upper surface, and both wings usually crossed by a single contrasting line. Epiphysis absent or very small, usually much smaller than second segment of foretarsus, if present.

FEMALE TERMINALIA (figs. 91, 92, and 97–102).—Genital plate varying from nonsclerotized to completely sclerotized; ostium centrally located. Ovipositor lobes with pronounced ventral and dorsal lobes as in figure 100, or with the dorsal lobe reduced as in figure 98 in populations from the Pacific Coast and northern Canada. See "comments."

ADULT DIAGNOSIS.—Many males can be separated from other species by the color pattern, and in doubtful cases positive identification can be made for all species except *incurvum* by the genitalic characters given for each species. Specimens of *incurvum* cannot be positively separated from *californicum* by any known characters, but see the diagnoses for *incurvum* (page 171), *i. incurvum* (page 174), and *i. discoloratum* (page 178) for suggestions as to the best way to separate both males and females. Except for *incurvum*, male *americanum* are most likely to be confused with *californicum*, but *americanum* can be separated by the larger absolute size of the genitalia in relation to the size of the specimens, and by the arc of curvature of the "arms" of the eighth sternite near the points. Also, the total length of the eighth sternite almost always is distinctly greater than the length of the foretibia for *americanum*, but it almost always is distinctly less for *californicum*.

Female *californicum* with light lines on the forewings are most likely to be confused with *americanum*, but *americanum* always can be identified by the heavily sclerotized genital plate with the ostium near the anterior edge. Female *californicum* may have a heavily sclerotized genital plate, but the ostium is never near the anterior edge. Female *californicum* with dark lines may be confused with *disstria*, *constrictum*, or *tigris*, but those species can be positively identified by the ovipositor characters given for them (pages 86, 94, 103, respectively).

MATURE LARVAE (figs. 352–389).—Color pattern highly variable, especially in the Great Basin and Rocky Mountains. Middorsal area with or without a stripe, but usually with a broken stripe formed by a blue-white to bluish dash on each segment. Addorsal area black or mixed orange and black. Subdorsal, supraspiracular, and subspiracular areas varying combinations of orange, black, and blue. Many larvae have a vertical black bar on each segment; some specimens have additional black markings on both anterior and posterior sides of the bar which may merge with it to form the "torso" mark. Both primary and secondary dorsal setae usually orange, but occasionally white, and rarely the primary setae may be black. Primary lateral setae usually orange or white, rarely black. Secondary lateral setae orange or white, sometimes somewhat tufted.

LARVAL DIAGNOSIS.—Larvae of *disstria*, *americanum*, *constrictum*, and *tigris* can be separated from *californicum* by the characters given in the larval diagnosis for each of them. Any larva which has a broken middorsal stripe formed by a blue-white to bluish dash on each segment is probably *californicum*, since the only other larvae which have similar markings are some specimens of *incurvum*. See the larval diagnosis for *i. incurvum* (page 175) for the best way to separate *incurvum* from *californicum* in Arizona, and the larval diagnosis for *i. discoloratum* (page 179) for the best way to separate them in the southern Utah region. Larvae without the broken middorsal stripe usually are completely unmarked dorsally except that the black middorsal area may be outlined by orange markings on both sides. Such specimens may occur in many areas, but the yare most often found around San Francisco Bay in California and in the "four-corners" area of the Southwest (37° N. Lat., 109° W. Long.).

EGG MASSES (figs. 105, 112, 115, 116).—The egg mass is always laid as a basically flat, clasping mass, the amount of curvature depending on the size of the twig or branch on which it is laid. They may be laid on small twigs, larger branches, or even on small trunks of young trees or shrubs. They are always covered with spumaline which varies considerably, ranging in color from dark brown to pale gray or even gray-white, depending on the area. The only species which lay similar clasping egg masses are *americanum* and *incurvum*. See the descriptions of their egg masses for the best way to distinguish them (pages 114 and 172).

TENTS.—Tents are relatively large, and similar to those of *americanum* and *incurvum* from which they cannot be separated.

COCOONS.—Cocoons are loosely to compactly constructed, often with an outer envelope of silk, especially in the more northern populations. Cocoons usually are dusted with a yellowish powder in northern and far western populations. The powder is usually whiter in the more southern populations, especially in the Mojave Desert area.

FOOD PLANTS.—The number of shrubs and trees on which this species will oviposit is quite large, to say nothing of those on which it will feed. See the collection data in Appendix I for the host plants on which *californicum* and its subspecies were collected during this study.

TYPE.—See *M. californicum californicum* (page 141).

DISTRIBUTION.—*Malacosoma californicum* and its subspecies occur throughout most of western North America wherever suitable host plants grow (figs. 2, 3). The subspecies *californicum pluviale* extends eastward through Canada almost to the Atlantic Coast. Its northern distributional limits are not definitely known, but it may extend as far north as suitable hosts grow. No specimens from Alaska have been seen, but *c. pluviale* probably occurs there, at least in the southeastern coastal region. Its southern distributional limit has not been established, but it should occur in many parts of the Mexican plateau.

Few specimens of *californicum* from Southern California have been seen (excluding *M. californicum fragile* which occurs in the desert areas). Specimens from the following six localities in Southern California have been plotted in figure 2: Lebec (Kern Co.), Temecula (Riverside Co.), Bouquet Canyon (Los Angeles Co.), El Cajon and Upland (San Bernardino Co.), and Tub. Canyon, Borrego (San Diego Co.). All of these records are single adults except for three from Upland and two from Tub. Canyon, Borrego. No preserved larvae have been seen from Southern California, and no colonies could be located in the field despite extensive surveys in both 1960 and 1961.

Some of these records may be due to errors in labeling, but it seems unlikely that all of them are. Nevertheless, it is doubtful if these nine specimens were taken from populations which are native to Southern California. The most likely explanation for them is that they either were brought there as cocoons on cars, freight, etc., or they were introduced as egg masses on transplanted trees of various sorts, most likely fruit trees.

Climatic conditions in Southern California are quite different from those in more northern areas, so northern forms of *californicum* would not be expected to do well if introduced. Nevertheless, they should be able to survive in some areas, especially at certain elevations in the mountains. They may have become temporarily established on several occasions, and they may presently exist at some of the listed localities or others, but we are not aware of any authentic reports of them from Southern California. Therefore, any reports of large tents should be investigated to determine if they are *M. californicum fragile*, the only tentbuilder which is certain to be native to parts of Southern California, or whether they are some other subspecies or population of *californicum* that has been introduced from non-Southern California localities.

ECONOMIC IMPORTANCE.—*M. californicum* including its subspecies has caused heavy defoliation of many different hosts in many areas, but most of its hosts are scrubby species of little commercial value. The most serious damage to date is probably that reported by Clark (1956a) in which defoliation in combination with other factors has resulted in the death of bitterbrush, *Purshia tridentata*, in parts of northeastern California, and its replacement by less desirable species. *Purshia tridentata* is a valuable browse species for both domestic stock and wild game. Possibly the defoliation of aspen in the southern Rocky Mountains should also be regarded as serious, but throughout most of its range *californicum* will have to be classified along with *americanum* and *incurvum* as more of a nuisance than a serious pest.

COMMENTS.—Both males and females of *M. californicum* and its subspecies can be divided into two large groups which differ from each other in a single genitalic character. These differences, however, intergrade between groups, and individuals of one group having characters which more closely fit the other group may be found.

The first group is composed of *californicum ambisimile*, *californicum californicum*, *californicum recenseo*, *californicum pluviale*, the Mendocino-Trinity population of *M. californicum*, and other populations of *californicum* found along the Pacific coast. This group is called the northwestern group. The second group is composed of *californicum lutescens*, *californicum fragile*, and the remaining central populations of *M. californicum*. This group is called the southeastern group.

Males of the northwestern group (figs. 19–23) usually have the prongs of the accessory claspers closer together than do males of the southeastern group (figs. 24–26), but some specimens in both groups are more or less intermediate (figs. 20 and 26). Females of the northwestern group (figs. 91 and 97–99) usually have the dorsal lobe of the ovipositor reduced, while females of the southeastern group (figs. 100–102) usually have more distinct dorsal lobes, but some specimens of both groups are more or less intermediate (figs. 91 and 101).

These differences certainly are not constant enough to warrant splitting *californicum* into two species since the two groups are alike in many other ways, but the differences may be an indicator of geographical isolation which took place between ancestral populations at some time in the past.

The six subspecies of *M. californicum* that are recognized here lie at the periphery of a huge central region (figs. 2 and 3) containing many populations which are highly variable in many characteristics. None of the populations occurring in this central region have been found to be consistently different enough to warrant formal recognition, so they are all referred to as *M. californicum.* A couple of them, however, are worthy of some additional comments.

The Mendocino-Trinity Population

In northern California between the distributional ranges of *M. californicum californicum* on the south (fig. 3) and *M. californicum pluviale* on the north (fig. 2) is found a highly variable population of *californicum* which has never been formally named, but was called *Malacosoma* sp. by Langston (1957). Colonies are commonly found on *Quercus agrifolia*, *Cercocarpus betuloides*, *Ceanothus* spp., *Salix* spp., and fruit trees, but may be found on other hosts, too. Egg masses, tents, and adults are the same as those of nearby populations of *californicum*, except that adult males are often more variable and the dominant color of those reared from single colonies may range from yellow to red-brown.

The major difference between this population and neighboring ones is in the larval color pattern (figs. 358–363), and the variability is nearly as great as that found in the Great Basin and the southern Rocky Mountains. The most striking feature is the frequent presence of extensive lateral blue areas and the occurrence of white secondary lateral setae on many specimens (figs. 362 and 363). The closest populations of *californicum* which possess either of these characteristics are *M. californicum ambisimile* in the Santa Cruz Mountains (figs. 354 and 355), and populations of *M. californicum* and *M. californicum fragile* (figs. 366 and 367) which occur east of the Cascades and the Sierra Nevada. Neither of these characters, however, nor any others were found to be constant enough to warrant recognition of this population as a subspecies. It is referred to, therefore, as the Mendocino-Trinity population of *M. californicum.* It may be a remnant of the original stock which gave rise to the other Pacific Coast subspecies of *californicum* since it seems to possess all of the characteristics which they possess, and more.

Only two collections were made on the west slope of the outer Coast Ranges in northern California (Coll. Nos. 68 and 69). Neither of these could be reared beyond the third instar, and because of this they are called *M. californicum* and included in the Mendocino-Trinity population, although it is possible they could be *M. californicum pluviale* which may extend southward along the Pacific Coast in the fog belt.

The Aspen Populations

The most interesting of the Great Basin and Rocky Mountain populations are those which occur on aspen in the southern Rocky Mountains. Defoliation of aspen by *M. californicum* in Arizona, New Mexico, Utah, Colorado, and Wyoming has been reported either in the literature or was observed during this study. *M. californicum* also has been occasionally found on aspen in other parts of the West, but aspen does not seem to be a preferred host in these other areas and heavy defoliation has not been reported, although it must be pointed out that aspen is less extensive in these areas and tends to occur in smaller, more isolated patches (Baker, 1925).

Most of the collections made on aspen during this study were made in Arizona, Utah, and Wyoming but adults collected by Dyar and Caudell in 1902 near Half Way House on Pikes Peak, Colorado, also have been examined. Caudell (1902a) reported that the aspen near Half Way House was completely defoliated, so the adults that he and Dyar collected had been feeding, no doubt, on aspen as larvae. These adults are similar to those which have been reared from aspen in other areas, except for having less reddish-brown in the color pattern. The larvae of tent caterpillars, which in recent years have defoliated aspen in southern Colorado and northern New Mexico, are similar to larvae collected on aspen in northern Arizona and southern Utah, and are regarded as the same. No egg masses or reared adults of these populations have been available, but adults collected at high elevations in other parts of New Mexico are similar to those from Arizona and Utah except that they are not as reddish or orange-brown.

One characteristic that is common to all of the aspen populations is the complete lack of any specks in the spumaline of any egg masses collected from aspen or in the spumaline of unspent females of these populations. (See the section on egg masses for a discussion of the specks (page 20), and figure 5 for a map of the area within which populations containing specks in their spumaline may be found.)

In southern Arizona in the Chiricahua Mountains egg masses found on aspen (Coll. 246) contained no specks and the spumaline was the same brown color as egg masses found on *Prunus virens* growing nearby (Coll. 247). None of the egg masses collected from any locality in the Chiricahuas contained any specks, however, although it would not be surprising to find populations with specks if more intensive collecting is done. The same situation occurred in Wyoming on aspen (Coll. Nos. 360, 361, 363, and 364), but specks have never been found in any egg masses collected on any host in Wyoming or more northern areas.

The situation in Colorado, New Mexico, southern Utah, and northern Arizona is different. In these areas populations which feed on various brush species growing beneath the aspen may have spumaline which contains specks. Other populations on the same brush species may have no specks in their spumaline or reduced numbers of specks. A comparison between these populations can best be made by breaking them down into three subgroups as follows:

1. Those which occur on aspen and whose spumaline contains no specks (Coll. Nos. 308, 309, 437, 442, 443, 446, 449, and 450). These are referred to as the "A" (aspen) population.

2. Those which occur on brush species and whose spumaline contains no specks (Coll. Nos. 439, 441, 444, and 448). These are referred to as the "B" (brush) population.

3. Those which occur on the same brush species and whose spumaline contains specks (Coll. Nos. 306, 311, 438, 441a, 445, and 451). These are referred to as the "BS" (brush-specks) population. These collections were made in the Bryce Canyon National Park area and in the Kaibab Plateau area north of the Grand Canyon, but similar situations may be present wherever aspen is found within the area outlined in figure 5.

In nearly every respect population B is closer to population A than it is to population BS. The following comparison clearly shows this. ADULT COLOR: males of all three populations were variable, but those of A (figs. 255–259) showed various mixtures of reddish-browns, browns, and yellows, with rarely any traces of gray. Male BS's were similarly colored, but more frequently showed shades of gray in some localities. Females of all three populations were various shades of dull medium brown with relatively weak yellowish markings (fig. 260), and rarely with a grayish tinge. SIZE: Specimens of A and B were generally somewhat larger than BS specimens, but this may be the result of rearing the BS's on nonnative hosts, since the natural host usually was not available. Some of the B's, however, also were reared on non-native hosts, and they were very close to the A's in size, so there may be a real size difference between the smaller BS's and the larger A's and B's. SPUMALINE: The spumaline of the A's and B's varied from tan to brown and contained no specks; that of the BS's varied from gray to brownish and, of course, contained specks. MALE TERMINALIA: The terminalia of the A's and B's were similar in size and shape; those of the BS's were essentially the same except for being slightly smaller, as were the moths. FEMALE TERMINALIA: The genital plate of the A's and B's usually was almost entirely sclerotized (similar to fig. 95); the genital plate of the BS's generally was less completely sclerotized (similar to fig. 102). The ovipositor lobes of all three populations were basically the same. LARVAE: All three populations show much variability in markings and colors, and no consistent differences of any kind were found which will positively separate them, although a higher proportion of the A's and B's have the conspicuous D1 black spots (figs. 388 and 389) than do the BS's which more often have the black addorsal areas more similar to figures 385 or 387.

Additional support for these differences can be obtained by comparing collections 441, 441a, and 442. Collection 441 was made on clumps of chokecherry growing in the open along the roadside. Nearly all of the larvae were gone and the few that remained were wandering about on the foliage so they could not be associated with any single tent or egg mass. Tents were numerous and nine old egg masses were collected. Later, after the existence of specks in the spumaline had been discovered, these egg masses were examined. Four of them were found to contain specks (referred to as 441a) and five of them did not contain specks (referred to as 441). In addition, the color of the spumaline of the 441a's was grayish and all four egg masses had been laid near the base of the main stem, while the color of the 441's was tan-brown and all five egg masses had been laid on twigs. This difference in oviposition site should not be regarded as constant, since the oviposition site of other species such as *M. americanum* is known to vary similarly, and in collections such as 438 (with specks) and 448 (without specks) egg masses were found on both twigs and large branches. Nevertheless, the normal oviposition site of the A's is on small twigs, and if the B's are regarded as being part of the A's, one would expect most of them to lay their eggs on twigs when they oviposited on brush species.

A check of the adult females which had been reared from the larvae which were collected on chokecherry showed that all eight females had no specks in their spumaline, indicating that all of them probably had hatched from the 441 egg masses which contained no specks and were laid on the twigs. Any larvae which may have hatched from the 441a egg masses containing specks either had pupated already or had died already when the collection was made. Most likely they had already pupated. Colonies on aspen growing nearby (Coll. 442) contained larvae in the next to last and last instar, and these larvae were virtually identical to the 441's, as were the egg masses. In addition, adult 441's emerged between 29 June and 2 July, and adult 442's emerged between 30 June and 5 July, indicating that there was no important difference in developmental rates, although those on aspen were a few days later on the average. This same situation was found at other localities (309, aspen vs. 310, *Ribes;* 443, aspen vs. 444, *Ribes;* 449, aspen vs. 448, *Ribes*), where there was no great difference in the stage of development between populations found on aspen and those found on *Ribes*. All of this means that there is little chance of isolation between the 441's and 442's due to differences in adult emergence dates, but suggests that there may be some isolation between the 441a's and the other two, since no 441a larvae were found at the time the 441's and 442's were collected.

The only other area where three similar populations were found in the same immediate locality was 8 miles north of Boulder, Garfield County, Utah. Collection 438 (with specks) was taken from bitterbrush, *Purshia tridentata*, and Collection 439 (without specks) was taken from chokecherry. In addition, notes were taken indicating that Collection 439 was similar to colonies found on aspen at the same site. This situation was similar to that just described from Bryce Canyon National Park except for the following minor differences. The egg masses of the BS's (438) were laid on both twigs and large branches, and the egg masses of the B's (439) were like those found on aspen except that they were laid on larger branches as well as on twigs. The BS larvae were more mature than the B larvae, even though they were shaded during part of the day. However, emergence dates of the adult B's were earlier than the BS's, ranging from 3 to 6 July. The BS adults emerged from 6 to 10 July. This is just the opposite of what should have happened, since the BS's were more mature when they were collected. Possibly the difference is due to the fact that the BS's could not be reared on their native host after collection, while the B's could be reared on chokecherry. No matter what the reason is, it points out the importance of making observations on developmental rates under field conditions if at all possible, since many factors which affect development under field conditions cannot be duplicated in the laboratory, and other factors which may be of little importance in the field may become important in the laboratory. After all, it is the emergence dates of adults under field conditions which determine whether any gene exchange is possible between different populations which would otherwise be capable of interbreeding.

These comparisons were made on limited numbers of colonies from only two localities, and they were made on preserved specimens since the existence of specks in the spumaline was not known when the collections were made. Therefore, more extensive field observations would have to be made before any absolute statements can be made concerning the differences between these populations, but from the little that is known it is apparent that the B's are nearly identical to the A's, and should be regarded as the same population. It is also apparent that the BS's are different from the A's and B's in some respects, and they are regarded as a different, although closely related population of the same species.

This brings up the question of how these populations are related to other populations of *californicum*. The BS populations are no doubt continuous with similar BS populations found at lower elevations and which are known to intergrade with other neighboring populations of *californicum*, some of which have specks and some which do not. The relationship of the A populations is not as obvious, but the occurrence of the virtually identical B populations on brush species in the same locality as the A's suggests that the A's are related through the B's to other populations without specks which occur on brush.

When many different characteristics are considered in comparing neighboring populations of *californicum* in Utah and Arizona, it must be concluded that the populations which most closely resemble the A's are those populations of *californicum* without specks which occur on various species of brush. These populations probably intergrade with the A's through the B's. They also intergrade with other populations of *californicum*, including those which have specks, so it can be seen that the A and B populations are linked with the BS populations through intermediate populations which occur at lower elevations, even though direct gene exchange between the A's and BS's is probably reduced where they occur together at higher elevations. If any exchange does take place, it may be in only one direction (from the A's to the BS's) since egg masses containing specks have never been found on aspen to date. (Assuming the presence of specks is an inherited character, and not influenced by the host. This remains to be determined.)

Possible Relationships Between the Aspen Populations of *Malacosoma californicum* and Populations of *Malacosoma incurvum*

Previously it was pointed out that *incurvum* and *californicum* are closely related species which cannot be separated from each other in every case by any known character of any life stage. In some respects the aspen populations of *californicum* are very close to *incurvum*, but in others they are quite different. Egg masses of both do not have specks, but the spumaline of the A's is tan to brown, while that of *incurvum* is usually whitish, but may be dark brown in some populations. The spumaline of *incurvum* is also tougher and contains smaller bubbles than that of the A's. Larvae of both species are highly variable, and some larvae of *incurvum discoloratum* which have conspicuous black spots surrounding setal group D1 (fig. 395) could easily be confused with larvae of the A's that are similarly marked (figs. 388–389). On the other hand, *incurvum* larvae never have a vertical black bar like some of the A's, and larvae similar to *incurvum* larvae such as those in figures 390–394 have never been seen among the A's. The preferred host of the A's is aspen and that of *incurvum* is cottonwood, so they occur on related hosts, but it is not known if they would do well on the other's host. Both of them also occur on other hosts, and both build conspicuous tents. Most adult males (figs. 257–259) and females (fig. 260) of the aspen populations are basically soft reddish-brown, and differ from most male and female *incurvum* which are gray-brown or yellow-brown (figs. 291–308), but they cannot be separated by any known morphological characters.

The differences in development between *incurvum discoloratum* and the populations of *californicum* and *californicum fragile* which occur at the same localities have already been discussed in the comparison of *californicum* and *incurvum* in the southwestern United States (page 118). These differences are similar to the differences in development between the A's and BS's which were just described, but the A's cannot be considered to be conspecific with *incurvum* because of the differences between them given above. This does not mean, however, that connecting populations of some kind do not exist because a few collections were made at intermediate elevations which showed combinations of characters that may be the result of gene exchange between *incurvum*, the A's and *californicum* on other hosts at intermediate elevations. Two examples of such collections are Nos. 252 and 263 (figs. 261 and 262), but they have been classified as *californicum* because they resembled *californicum* more than *incurvum*.

It is obviously impossible for direct gene exchange to take place between populations occurring at elevations which differ by several thousand feet, since the low elevation population may develop and emerge weeks or even months earlier. Nevertheless, it would be possible for genes to be carried from one population to another over a period of years, since some mated females could fly to higher or lower elevations before laying their eggs. During the next year these egg masses would then be subjected to the same climatic conditions as those of the native population. They would hatch, therefore, at the same time and develop at the same rate as the native colonies if there were no inherent differences. Adults would then emerge at the same time and some would mate with the native population if there were no other isolating mechanisms. Theoretically, in the absence of other forces such as natural selection, this sequence of events could go on indefinitely until genes of high altitude populations were eventually introduced into low altitude populations, and vice versa.

This does not appear to be an effective means of exchange, however, because, if it were, populations such as *incurvum* would not be able to maintain their distinctive characteristics. Several factors could act to reduce this exchange:

1. Natural selection undoubtedly favors some gene combinations, and it must be assumed that in most cases the gene combinations of the native population are better adapted to the native habitat than most new combinations that result from the introduction of different genes.
2. The number of females which fly to higher or lower localities is probably quite small, resulting in a relatively low number of genes being introduced into the native population.
3. Mating preferences for members of their own population could be present, further reducing the number of genes introduced into the native population.
4. The number of genes from the original population carried by a "hybrid" female to the next higher or lower level would probably be reduced with each succeeding generation, resulting in relatively few genes eventually being introduced from a low elevation population into a high elevation population or vice versa. In addition to these factors, there are such things as possible host preferences which could prevent successful movement to new areas where the preferred host did not grow, and gaps in the distribution of suitable hosts that could be difficult to cross.

Granting that it is possible for some gene exchange to take place between *incurvum* populations and populations of *californicum* which occur at higher elevations, this exchange appears to be quite low in areas that have been studied. It may be greater in other areas, especially Mexico, but, even if this turns out to be true, it probably still will be desirable to recognize some populations as the species *incurvum* for the reasons already given.

Specimens Examined.—6,362 (Museum specimens—1,411 males, 499 females, 806 larvae; reared specimens—2,106 males, 1,540 females plus numerous larvae and egg masses). See Appendix I for data on collections made during this study (page 259).

United States.—arizona: Alpine, Apache Indian Res., White Mountains; Baboquivari Mountains (Pima Co.); Bear Wallow Trail, Santa Catalina Mountains; Bright Angel Point, Grand Canyon; Catalinas; Catalina Springs; Chiricahua Mountains; Christopher Creek, Mogollon Rim (Gila Co.); Cibola (Yuma Co.); Cochise Co.; Concho; Dewey; Fairview; Flagstaff; Greer; Kohl's Ranch, Mogollon Rim (Gila Co.); Palmerlee, Miller Canyon, Huachuca

Mountains; McNary, White Mountains; N. Rim Grand Canyon; Paradise; Parks (Coconino Co.); Payson; Pinal Mountains (Gila Co.); Pine Crest, Mt. Graham, Pinaleno Mountains; Prescott; S. Catalina Mountains; Sedona; Senator (10 mi S. Prescott); Shonto; Summerhaven (Pima Co.); Todd's Lodge, Oak Creek Canyon; Tonto Creek State Fish Hatchery, Mogollon Rim (Gila Co.); Webber's Cabin; Wheeler Canyon, Hualpai Mountains; White Mountains; Williams; Yavapai Co.; "Arizona"; "Ariz.". CALIFORNIA: Alpine Lake (Marin Co.); Anderson Springs (Lake Co.); Big Valley (Lake Co.); Bray (Siskiyou Co.); Calistoga; Canby; 15 mi. N. Canby; Cazadero (Sonoma Co.); near Cedarville (Modoc Co.); Crescent City; Davis Creek (Modoc Co.); 3 mi. E. Davis Creek; Egan Ranch (Napa Co.); Elk Mountain Summit (Lake Co.); Geyserville; 5 mi. S. Geyserville; Guerneville; 3 mi. NE. Guerneville; Healdsburg; Hopland; Kelseyville; 11 mi. N. Laytonville; Meadow Vista; Modoc Co.; Mt. St. Helena (Sonoma Co.); Occidental (Sonoma Co.); near Peavine (Sierra Co.); Petaluma; Pitt River (Modoc Co.); Saddle Camp (Tehama Co.); Santa Rosa; 4 mi. N. St. Helena; 6 mi. N. St. Helena; Siskiyou Co.; Sonoma Co.; Ukiah; 4 mi. N. Ukiah; Warner Mountains (Modoc Co.); "California"; "Calif."; "Cala."; "Middle Cala.". SOUTHERN CALIFORNIA LOCALITIES: Boquet Canyon (Los Angeles Co.); El Cajon (San Bernardino Co.); Lebec (Kern Co.); Temecula (Riverside Co.); Tub. Canyon, Borrego (San Diego Co.); Upland (San Bernardino Co.).

COLORADO: Boulder; Breckenridge; Colorado Springs; Cub Creek (Clear Creek Co.); Cucharas Pass, San Isabel National Forest; Cumbres Pass, Rio Grande National Forest; Custer Co.; Denver; Empire; Estes Park; Flattop Mountain, Rocky Mountain National Park; Big Springs Ranch, Florissant (Teller Co.); Glenwood Springs; Gothic (Gunnison Co.); Gould; Halfway House, Pikes Peak; Hayden Mountains (Ouray Co.); La Manga Pass, Rio Grande National Forest; La Veta Pass; Leadville; Lyons; Manitou; Maysville; Mesa Verde National Park; Montezuma Co.; Nederland (Boulder Co.); Plainview; Plainview Mountain (Jefferson Co.); Pueblo; Ripple Creek; Rock Creek Camp, near Colorado Springs; Rock Creek Canyon (near Alamosa); Rocky Mountain National Park; Salida; Silver Cliff; Trujillo Meadow Camp, 3 mi. N. Cumbres (Conejo Co.); Valley View Lodge, 10 mi. S. Steamboat Springs; West Cliff; "Colorado"; "Colo."; "Col.". IDAHO: Alturas Lake (Blaine Co.); DeLamar (Owyhee Co.); Duncan Creek (near Boise); Island Park (near W. Yellowstone); 4th of July Creek, N. of Salmon; 6 mi. SE. Malta (Cassia Co.). OREGON: Chief Joseph Mountain, Joseph (Wallowa Co.); 20 mi. E. Chemult; Freewater (Umatilla Co.); Lazy T Ranch, near Joseph; Millican; Whitney (Baker Co.); "Oregon." NEVADA: Alfred (E. Humboldt Mountains); E. Humboldt Mountains; Kingston Canyon, Toiyabe Range (Lander Co.); Lamoille Canyon, Ruby Mountains; Mt. House; Pyramid Lake; Reno; Ruby Valley; Secret Pass (Ruby Mountains). NEW MEXICO: Arroyo Hondo; Bursum Camp, 18 mi. E. Alma (Catron Co.); Calaveras Creek Camp, Jemez Mountains (Sandoval Co.); Carrizozo; Carson National Forest; Cedar Creek Camp, 2 mi. N. Ruidoso; Frijoles Canyon (near Santa Fe); Grants; High Rolls; Hopewell (Rio Arriba Co.); Horseshoe Springs Camp, 2 mi. W. La Cueva (Sandoval Co.); Jemez Mountains (Sandoval Co.); Jemez Springs; Koehler; Las Vegas

HS; Lordsburg; McMillan Camp, 13 mi. N. Silver City; Organ Mountains (Dona Ana Co.); Santa Cruz; Sante Fe Canyon; 14 mi. N. Silver City; Simpson's Ranch, 5 mi. E. LaJara; Taos; Taos Mountain; Tesuque Canyon (near Santa Fe); Top of range between Sapello and Pecos Rivers; "New Mexico "; "N.M." SOUTH DAKOTA: Lead; Black Hills. TEXAS: Big Bend (Brewster Co.). UTAH: Beaver; Blue Lake, Geyser Pass, LaSal Mountains (Grand Co.); Brigham; Bryce; Bryce Canyon National Park; Buckboard Flat Camp, 7 mi. W. Monticello; Bucksk(in) Valley (Iron Co.); Callao; Cedar Breaks; Coal Creek (near Cedar City); Deep Creek (Daggett Co.); Dividend; Duchesne; Eureka; Fish Lake (Sevier Co.); Green Canyon; Henry Mountains, 20 mi. S. Hanksville (Garfield Co.); Hooper; Junction; Kents Lake, 16 mi. E. Beaver; Logan; Logan Canyon; Loop Camp, 13 mi. SW. Grantsville (Tooele Co.); Marysvale; 17 mi. E. Mayfield (Sanpete Co.); Millville (Cache Co.); Monticello; Nebo Junction (E. of Nephi); Nephi; Ogden; Pavant; Provo; Red Canyon Camp, 11 mi. SE. Panguitch (Garfield Co.); St. George; Salt Lake; Salt Lake City; Stockton; Tropic; Vernal; Vinyard; East Entrance, Zion National Park; Lava Point Lookout, Zion National Park; "Utah"; "So. Utah." WASHINGTON: Pullman; Yakima; "Was.". WYOMING: Big Piney; Bottle Creek Camp, 7 mi. SW. Encampment (Carbon Co.); Cody; Douglas; Evanston; Guernsey; Jackson; Jenny Lake; Lake Creek Camp, 13 mi. SE. Cooke City, Montana (Park Co.); Lower Green River Lake, Wind River Range (Sublette Co.); Moose Flat Camp, 27 mi. SE. Alpine (Lincoln Co.); Moran; National Park; Old Ford on Green River, 27 mi. S. LaBarge (Sweetwater Co.); Pole Mountain Game Refuge (Albany Co.); Reuter Canyon Camp, 5 mi. N. Sundance (Crook Co.); Sacajawea Camp, 24 mi. W. Big Piney (Sublette Co.); Mammoth, Yellowstone National Park; Mammoth, at Museum, Yellowstone National Park; N. of Mammoth, Yellowstone National Park; Old freight road, N. of Mammoth, Yellowstone National Park; Mammoth, ½ mi. E. Museum, Yellowstone National Park; 2½ mi. E. Mammoth, Yellowstone National Park; 3 mi. E. Mammoth, Yellowstone National Park; 4½ mi. E. Mammoth, Yellowstone National Park; 3 mi. S. Mammoth, Yellowstone National Park; Tower Junction, Yellowstone National Park; Wheatland.

Malacosoma californicum californicum (Packard)

Clisiocampa californica Packard, 1864, p. 387.—Packard, 1881, p. 41.—Stretch, 1881, p. 64.—Edwards, 1889, p. 77 (in part).—Packard, 1890, pp. 119–121 (in part).—Dyar, 1893, p. 41 (larva).—Neumoegen and Dyar, 1894, p. 156 (in part).

Gastropacha californica Packard, Packard, 1877, pp. 807–808.—Packard, 1881, p. 43. (Both citations—Packard copied Henry Edwards' slip of the pen in a letter to Packard).

Clisiocampa thoracica Stretch, 1881, p. 68. Type: Holotype, male, Congress Springs, San Mateo Co. [sic], Calif. American Museum of Natural History. NEW SYNONOMY[9].

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[9] The type of *thoracica* is quite dark and has a good superficial resemblance in size, color, and pattern to the type of *erosa* Stretch (a synonym of *disstria*). The

Malacosoma californica (Packard), Dyar, 1898, p. 6.—Dyar, 1903, p. 262.—Essig, 1926, p. 697 (in part).—Dyar, 1928, p. 623, pl. 86c.—McDunnough, 1938, p. 138.—Langston, 1957, p. 6 (in part).

Malacosoma pluviale (Dyar), *sensu* Steinhaus, 1962, p. 433 (in part, No. 782).

ADULT MALES (figs. 176–178 and 205).—Color variable, ground color ranging from yellow (fig. 176) to deep reddish-brown (fig. 178), and all intermediate shades. Lines on forewings appearing light or dark, depending on the ground color; lines usually bordered by yellow on inner side of inner line and on outer side of outer line. Yellowish specimens appear to have brown lines crossing wings; brownish specimens may have darker brown lines, but they usually have yellowish lines or brown lines bordered by yellow. Median area variable, ranging from yellow to brown on yellowish specimens, and brownish on brown specimens; median area never light enough to be considered a yellow band on any specimens examined to date. Hindwing brown, usually about same shade as darkest brown of forewing, occasionally crossed by a faint line. Lower surface of both forewings and hindwings about same color as upper surface of hindwing, and both wings usually crossed by a single contrasting line. Terminalia (figs. 19, 44, and 64) as described for the northwestern populations of *M. californicum* under "comments" (page 128).

ADULT FEMALES (figs. 179–181 and 203).—Color more constant than males, and usually lighter; ground color ranging from light yellow (fig. 179) to a light orange-brown (fig. 181) and all intermediate shades. Lines on forewings brownish, bordered with yellow as in males, but the yellow border is only conspicuous on darker specimens. Median area usually about same color as inner and outer areas. Hindwings usually somewhat darker than forewings, often crossed by a contrasting line. Lower surface of both forewings and hindwings about same color as upper surface of hindwing, and both wings crossed by a single contrasting line; occasionally a faint second line is present ventrally on forewing, corresponding in position to inner line on upper surface. Genital plate usually unsclerotized or only slightly so. Ovipositor lobes as in figures 91 and 92, but usually with the dorsal lobe reduced so it is more like figure 98. See description of terminalia for northwestern populations of *M. californicum* under "comments" (page 128).

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terminalia and epiphysis identify it as *californicum*, however. The fact that the type has a good superficial resemblance to *disstria* and the erroneous association of *disstria* larvae to the name "*thoracica*" by several early workers has caused it to be listed as a synonym or form of *disstria* in the past. See the discussion of Stretch's types in Appendix II (page 283).

ADULT DIAGNOSIS.—Indistinguishable as adults from adjoining populations of *californicum* to the north with which they intergrade; indistinguishable as adults from *M. californicum ambisimile* to the south, except that yellowish males similar to figure 176 from the area around San Francisco Bay are probably *californicum californicum* since very few yellowish male *californicum ambisimile* have been seen to date.

Males are not likely to be confused with the other two species found in the same area (*disstria* and *constrictum*), but see the diagnosis for them for characters which will positively identify them (pages 86 and 94). Light females with dark lines may be confused with female *disstria*, but *disstria* can always be identified by the characters given for it (page 87). Locality information is essential to identify adults to subspecies, since *californicum californicum* is largely recognized on larval differences.

MATURE LARVAE (figs. 352, 353).—Head black, sometimes lightly mottled with blue, sparsely covered with fine yellow-orange setae. Middorsal area of body black, almost invariably without a stripe, but rarely with a faint whitish line on some segments. Addorsal area black with weak, longitudinal, irregular, wavy orange lines which are totally obscured in many specimens. The orange lines are more distinct in preserved specimens and in early instars. Subdorsal area black. Posterior subdorsal spot sometimes present as a smaller blue-white dot; rarely both spots are absent and larva will be entirely black; occasionally both spots will be quite distinct, in which case the amount of black is reduced, the addorsal orange lines are more prominent, and the vertical black bar between setal groups D1 and SD becomes visible. Subdorsal line usually absent, but occasionally visible as a broken yellow-orange line. Supraspiracular and subspiracular areas black, occasionally streaked with orange. Ventral area black, sometimes mottled with gray-white, especially on those specimens where other markings are most pronounced. Primary and numerous secondary dorsal setae orange. Primary and secondary lateral setae also orange; secondary setae quite numerous and sometimes slightly tufted anteriorly on each segment around setal group L2. Rarely, some larvae may have yellowish-white lateral setae.

LARVAL DIAGNOSIS.—*M. californicum californicum* larvae are the only ones found in the San Francisco Bay area which are almost entirely black with little or no middorsal or addorsal markings, and which have orange primary and secondary dorsal and lateral setae. They intergrade to the north with those larvae of *M. californicum* in which the markings are more distinct so that some kind of pattern is evident (figs. 358–360), and in which the lateral setae may be orange, or more rarely white (especially in the Mendocino-Trinity population as in figs. 361–363). To the south they intergrade (figs. 356 and 357) with larvae of *M. californicum ambisimile* which possess white lateral setae and bluish lateral areas (figs. 354 and 355). If it is eventually shown that *M. californicum pluviale* extends southward along the Pacific Coast to Sonoma or Marin counties, then *M. californicum californicum* should be found to intergrade with it, too.

EGG MASS.—Eggs are laid as a clasping mass on twigs or branches. The spumaline is dark brown and along with the spumaline of other Pacific Coast populations (especially in California) differs somewhat from that of populations found in the Great Basin and eastward. The bubbles often are collapsed to a certain extent, resulting in a more compact covering for the eggs. This is most apparent in egg masses which have hatched, since there is often a separate hole in the spumaline where each caterpillar has eaten its way through as in figure 115. In more eastern populations of *californicum* bubbles in the spumaline usually remain uncollapsed, and hatching larvae often follow the routes used by other caterpillars in finding their way through the less compact spumaline (fig. 116).

TENTS.—They construct large tents similar to other populations of *californicum*, *americanum*, and *incurvum*.

COCOONS.—Cocoons are fairly tightly spun, with or without an outer envelope of silk, and dusted with a yellowish powder.

FOOD PLANTS.—Egg masses were found on the following trees and shrubs: *Quercus lobata*, *Quercus agrifolia*, *Quercus kelloggii*, *Salix* sp., *Rosa* sp., apricot, almond, peach, prune, plum, and apple. It was most commonly found on fruit trees, but also was abundant on *Quercus agrifolia* at many different locations around San Francisco Bay and on willows at several locations. See Appendix I for more complete data. The native hosts before the introduction of fruit trees were most likely *Quercus agrifolia* and willows.

Plum seems to be a relatively poor host, since larvae fed on plum grew very slowly compared with larvae fed on other hosts. For example, some first instar larvae from Collection No. 5 which had been collected on almond were fed plum, and others were fed *Q. agrifolia*, a preferred host. Both groups were treated essentially the same, but when those on *Q. agrifolia* were in the last instar, those on plum were only in the late third instar. A similar difference was noted in the field for Collection No. 18 where colonies on plum were at least one instar behind those on apricot. In the insectary, whenever larvae were given a choice of several difference hosts, plum was always one of the last to be eaten. Apparently plum is either less palatable or less nutritious, or both.

TYPE.—Neotype, here designated, a male in the American Museum of Natural History. Size: 27 mm. wingspread. This specimen is in nearly perfect condition. Data: Calif., 101. No. 8774, Collection Hy. Edwards. Neotype, *Malacosoma californicum* (Packard), male, F. W. Stehr 1963. Genitalia in microvial labeled: Neotype, *Malacosoma californicum* (Packard), male genitalia, F. W. Stehr 1963. See Appendix II for a complete discussion of this designation (page 283).

DISTRIBUTION (figs. 3, 6).—Restricted to the immediate area around San Francisco Bay; extending south on the San Francisco Peninsula until it intergrades with *M. californicum ambisimile* near Los Altos; extending south on the east side of the Bay to just east of San Jose; extending east to Oakley, and extending a variable distance north of San Pablo Bay where it intergrades with *M. californicum*. See *M. californicum ambisimile* for a discussion of the relationships between *M. californicum californicum* and *M. californicum ambisimile* (page 145).

COMMENTS.—This subspecies is probably the least distinctive of those recognized in this revision, and it should be restricted to the populations around San Francisco Bay in which most of the larvae are nearly black with either a small amount or no addorsal orange, which rarely have any middorsal markings, which have one or two (or rarely no) small blue-white subdorsal spots, and in which both the primary and secondary setae are orange (figs. 352–353). Populations north of the Bay which do not meet these requirements should be referred to as *Malacosoma californicum* (Packard). (They can be called the Mendocino-Trinity populations of *M. californicum* to distinguish them from other populations.)

SPECIMENS EXAMINED.—530 (Museum specimens—87 males, 62 females, 23 larvae; reared specimens—180 males, 178 females, plus numerous larvae and egg masses). See Appendix I for data on collections made during this study, and for data on collections of intermediates between *M. californicum californicum* and *M. californicum ambisimile* (page 270).

CALIFORNIA.—Alameda; Alameda Co.; Albany Hill (Alameda Co.); Alum Rock Park (Santa Clara Co.); Antioch; Berkeley; Strawberry Canyon, Berkeley Hills; Colma; Concord; Contra Costa Co.; Fairfax; Lafayette; Mill Valley; Mission San Jose (Alameda Co.); Mountain View; Napa; Novato; Palo Alto; Petaluma; San Francisco; San Leandro; Walnut Creek.

INTERMEDIATE POPULATIONS.—Intermediates between *M. californicum californicum* and *M. californicum ambisimile:* Mountain View; Tunitas Canyon, 6 mi. S. Half Moon Bay. Also see Appendix I (page 270).

Malacosoma californicum ambisimile (Dyar), new status

Clisiocampa ambisimilis Dyar, 1893, pp. 40–41.—Neumoegen and Dyar, 1894, pp. 156–157.

Variety of *C. californica* Packard, Packard, 1893, pp. 181–182.

Malacosoma ambisimilis (Dyar), Dyar, 1898, p. 6.—Dyar, 1903, p. 262.—Dyar, 1928, p. 623, pl. 86c.—Collier, 1936, p. 98.—McDunnough, 1938, p. 138.
Malacosoma californica (Packard), *sensu* Essig, 1926, p. 697 (in part).
Malacosoma ambisimile (Dyar), Langston, 1957, p. 7–8.

This subspecies is not distinguished by adult characters. Most adults are identical with the adjoining subspecies *M. californicum californicum*, and cannot be separated from them except by locality data (see page 140).

ADULT MALES (figs. 182–184).—Male *californicum ambisimile* are more uniformly colored than male *californicum californicum* which range from dark reddish-brown to light yellowish. Male *c. ambisimile* are usually various shades of reddish-brown (fig. 184) and have the wings crossed with yellowish lines as do dark *c. californicum*, but very few of the lighter, yellowish specimens have been seen from the distributional range of *c. ambisimile*. Terminalia (figs. 20, 45, and 65) are as described for the northwestern populations of *M. californicum*, with the prongs of the accessory claspers usually closer together than in figure 20; more like figure 19. See description of terminalia for northwestern populations of *M. californicum* under "comments" (page 128).

ADULT FEMALES (figs. 185–187).—Female *c. ambisimile* are also similar to female *c. californicum*, ranging from light yellowish to medium yellow-brown, with dark lines crossing the forewings which are bordered by lighter areas in darker specimens. Genital plate unsclerotized or only slightly so. Ovipositor lobes as in figure 97, usually with the dorsal lobe reduced. See description of terminalia for northwestern populations of *M. californicum* under "comments" (page 128).

MATURE LARVAE (figs. 354 and 355).—Head black, sometimes lightly mottled with blue, covered with fine yellowish to whitish setae. Middorsal area of body black, usually without a stripe, but occasionally with a fine whitish line on some segments. Addorsal area black with weak, longitudinal, irregular, wavy orange lines which are obscured in many specimens. The orange lines are more distinct in early instars and preserved specimens. Subdorsal area black, the posterior subdorsal spot generally present as a distinct blue-white spot which is usually conspicuous, but may be small or absent on some specimens, or extended ventrally to form a vertical dash; anterior subdorsal spot present or absent; if present it may be smaller than posterior spot or about same size, in which case it may be extended anteriorly and posteriorly to form an oblong horizontal mark. Subdorsal line usually absent, but occasionally visible as a broken yellow-orange to orange line. Supraspiracular and subspiracular areas generally conspicuously blue-white to blue-gray, sometimes streaked with orange when bluish color is weak. Ventral area usually mottled gray-white and black, and with a median black area on each segment. Primary and numerous secondary dorsal setae orange. Primary and secondary lateral setae white; secondary setae numerous and somewhat tufted anteriorly on each segment around setal group L2 on many specimens.

LARVAL DIAGNOSIS.—Larvae intergrade to the north with *c. californicum* from which they are most easily separated by the white lateral setae and the bluish lateral areas which emphasize the white setae. Larvae of *c. californicum* have orange lateral setae and black lateral areas.

EGG MASSES, TENTS, AND COCOONS.—The same as described for *c. californicum* (page 141).

FOOD PLANTS.—Egg masses were found on the following trees and shrubs: *Ceanothus thyrsiflorus*, *Ceanothus incanus*, plum, prune, apricot, apple, *Salix* sp., and *Quercus agrifolia*. It was collected on *Quercus agrifolia* only once near Santa Cruz. *Quercus agrifolia* does not appear to be a preferred host, although there is plenty of it available. The native hosts were probably *Ceanothus* spp. and *Salix* spp. In this respect it differs from *c. californicum* which is often found on *Quercus agrifolia*, a point that will be discussed below under "comments."

TYPE.—Lectotype, here designated, a male in the United States National Museum. USNM Type No. 34896. Size: The type is a semiadult in that it is a specimen which did not wholly emerge from pupal case; only the antennae, unexpanded wings, and the top of the head are visible. This no doubt accounts for Dyar's statement in the original description saying, "My specimens are too poor to enable me to give characters to separate the moths from *C. californica*, which they much resemble, but the larvae are abundantly distinct." Data: TYPE; *ambisimilis* Dyar; BB345; male genitalia No. 1—on slide, 6 July 1933, C. H. [Carl Heinrich's initials]; Lectotype, *Malacosoma ambisimile* (Dyar), male, F. W. Stehr 1963. The number "BB345" refers to Dyar's brown notebook number 345 which contains his field notes. This notebook indicates he collected them on apple and cherry at Watsonville, California, on 16 April 1892. It also contains about two pages of larval descriptions of various instars. Genitalia mounted on a slide bearing the following labels: *Malacosoma ambisimilis* Dyar, "BB-345," TYPE, male genitalia, slide, 6 July 33, C. H. No. 1.

TYPE LOCALITY.—Watsonville, California.

PARALECTOTYPES.—A single female semiadult, but with only the unexpanded wings and the tip of the abdomen showing. USNM.

DISTRIBUTION (figs. 3 and 6).—On the southwest side of San Francisco Bay it extends north to the Los Altos area where it intergrades with *c. californicum* east of the ridgeline of the Santa Cruz Mountains. On the west side of the ridge of the Santa Cruz Mountains the situation is not well known since *c. ambisimile* was not collected north of Big Basin Redwoods State Park in 1960, and *c. californicum* was not found west of the ridgeline at all. One vial, however, of twelve larvae in the collection of the California Department of Agriculture that was collected on *Ceanothus thyrsiflorus* in Tunitas Canyon, 6 miles south of Half Moon Bay, San Mateo County, contains larvae which must be regarded as coming from an intermediate population since characters of both *c. ambisimile* and *c. californicum* are present in varying combinations. More extensive collections on the west side should reveal a situation similar to that found on the east side (see comments). East of the Bay its northern distributional limit seems to be the San Jose area since 10 larvae from Silver Creek Hills (SE. edge of San Jose) are typical *c. ambisimile.* A single specimen from Alum Rock Park just east of San Jose is a typical *c. californicum.* The southern limits of its distribution are not definitely known, but it was taken 8 miles south of Hollister in San Benito County during this study, and one adult specimen from Carmel in Monterey County has been seen. There seems to be no reason why it should not occur farther south since fruit trees have been introduced into much of the area south of Monterey Bay, but it may be adapted to the more humid climate north of there.

COMMENTS.—The area near Los Altos where *c. ambisimile* intergrades with *c. californicum* was studied more intensively than other areas in order to obtain a better understanding of the relationships between the two populations. Figure 6 shows the collections in which only typical *c. californicum* or *c. ambisimile* were found, and the collections in which a mixture of various intergrading forms of larvae were found. Larval collections made by other persons are included in the map, but, even so, the number of collections is small, despite the fact that nearly all of the roads between Saratoga and Menlo Park were traveled in searching for colonies. In the area around Los Altos where colonies were abundant, every conceivable kind of intermediate color pattern was found, ranging from the extremes of bluish-sided larvae with orange lateral setae (fig. 356) to the opposite extreme of black larvae with white lateral setae (fig. 357) (*c. californicum* normally is black with orange setae and *c. ambisimile* is bluish laterally with white setae). Practically no colonies were found in this area which were 100 percent one subspecies or the other, indicating that the variation was real, and not due to larvae of different colonies becoming mixed after hatching.

In one case a single tent was collected on apricot ½ mile southwest of Los Altos (Coll. No. 20). The caterpillars were in the process of molting from the second to the third instar, indicating that all had developed at about the same rate and had probably hatched from the same egg mass. No other tents were found on the same tree or on any other trees in the area. Only a single egg mass was found on the branch bearing the tent, making it reasonably certain that all caterpillars in the tent had hatched from the same egg mass. The caterpillars appeared to be a mixture of some with white and some with orange lateral setae, so they were reared to the last instar and then segregated into separate cages on the basis of setal color. Three groups resulted: one group with orange lateral setae, another with white lateral setae, and a third group which had yellowish setae that were not clearly white or orange. All three groups contained larvae with varying amounts of lateral blue. The adult males and females which emerged from all three groups were quite similar in every respect and could not be segregated into groups.

The similarities between *c. ambisimile* and *c. californicum* are many and the differences are few. The only differences that have been observed are those in the larval color pattern, possible differences in native host preferences, and an indication that *c. ambisimile* may sometimes have one more larval instar than *c. californicum*. Measurements of head capsules of some collections indicate that *c. ambisimile* may go through six instars, and dates of adult emergence for at least one collection which contained larvae of both types indicate that larvae with orange lateral setae may emerge on the average slightly earlier than those with white lateral setae. Other similar collections gave no such indication, however, and the number of larval instars is known to be influenced by many different factors, so carefully controlled rearings would have to be carried out with different local populations before any positive statements concerning the number of instars could be made. Even if such a difference exists, it does not appear to be great enough to isolate effectively the two populations, as is demonstrated by the occurrence of numerous intermediates where the two populations meet.

The apparent difference in native host preference between *c. ambisimile* and *c. californicum* is also of interest. It appears that *c. ambisimile* originally preferred *Ceanothus* spp. while *c. californicum* preferred *Quercus agrifolia*. Both of them occur on *Salix* spp. and both have readily accepted fruit trees of various kinds. Many of the older references to *c. californicum* indicate it was abundant on *Q. agrifolia*, but Langston (1957) found it (including populations of *M. californicum* found farther north) on oaks in only three localities, despite extensive surveys of oaks. During this study *c. californicum* was collected on *Q. agrifolia* more often than on any other host. *Malacosoma c. ambisimile* was collected on *Q. agrifolia* only once, but was commonly found on *Ceanothus* spp., willows, and fruit trees. *Malacosoma c. californicum* was not collected on *Ceanothus* at all, although this may be due to the lack of the right species of *Ceanothus* in most areas where it was found. For example, *Ceanothus thyrsiflorus*, a preferred host of *c. ambisimile*, was never found where *c. californicum* was found.

The failure of *c. ambisimile* and *c. californicum* to overlap could be due to one of two opposite reasons as suggested by Mayr, Linsley and Usinger (1953). First, the zone of contact may connect two very different ecological areas, which certainly does not appear to be the case in the Los Altos area. Secondly, the ecological requirements may be so similar in every respect that the two populations compete with each other, with *c. ambisimile* slightly superior on its side, and with *c. californicum* superior on the other side. They are indeed quite similar in many respects, but if it is true that *c. ambisimile* does not prefer *Q. agrifolia* and *c. californicum* does prefer it (all the evidence indicates this), there appears to be no reason why *c. californicum* should not occur in the same area as *c. ambisimile*, since *Q. agrifolia* grows commonly in the area and competition would be practically nonexistent on *Q. agrifolia*. There would be some competition on other hosts such as willows and fruit trees, but this should not be severe enough to prevent their occupation of the same geographical area. It can only be concluded that such a situation is prevented by complete interbreeding and intergradation of *c. ambisimile* with *c. californicum* wherever their distributions meet.

It is possible that *c. ambisimile* occupied a very restricted area in the Santa Cruz Mountains before the arrival of settlers, and that only relatively recently has it come into contact with *c. californicum* after the planting of fruit trees throughout much of the area. Even if this is true, however, it is obvious that *c. ambisimile* has not been separated from *c. californicum* long enough in the past for the development of isolating mechanisms which would permit coexistence in the same area. Therefore, *c. ambisimile* is regarded as a subspecies because this most accurately represents its relationships to the adjacent populations as far as they are known.

SPECIMENS EXAMINED.—333 (Museum specimens—69 males, 42 females, 50 larvae; reared specimens—89 males, 83 females, plus numerous larvae and egg masses). See Appendix I for data on collections made during this study, and for data on collections of intermediates between *M. californicum ambisimile* and *M. Californicum californicum* (page 271).

CALIFORNIA.—Mountains back of Alma (Santa Clara Co.); Ben Lomond Ridge (Santa Cruz Co.); Big Basin; 3 mi. SE. Big Basin; Big Basin Redwoods State Park; Carmel; 1 mi. N. Holy City; La Honda Road (San Mateo Co.), Las Uvas Cr.; Los Gatos; Monterey Co.; Mt. Madonna Co. Park (Santa Clara Co.); 3 mi. E. Mt. Madonna Co. Park; Santa Clara Co.; Santa Cruz; Santa Cruz Mtns.; Saratoga; 5 mi. W. Saratoga; Silver Creek Hills (Santa

Clara Co.); Uvas Canyon, Watsonville Roads; Waterman Gap (Santa Cruz Co.).

INTERMEDIATE POPULATIONS.—See *M. californicum californicum* and Appendix I (pages 142, 253).

Malacosoma californicum recenseo (Dyar), new combination

Malacosoma fragilis (Stretch), *sensu* the following authors: Essig, 1915, p. 411, figs. 419, 420.—Van Dyke, 1928, p. 92 (in part).—Clark and Thompson, 1954, pp. 268–272 (in part).—Clark, 1955, pp. 373–376 (in part, Shaver Lake—Dinkey Creek and Truckee populations).—Clark and Reiner, 1956, pp. 653–659 (in part, Truckee population).

Malacosoma pluvialis recenseo Dyar, 1928, p. 623, pl. 86c.—McDunnough, 1938, p. 138.

Malacosoma pluvialis form *recenseo* Dyar, Collier, 1936, p. 140.

Malacosoma fragile (Stretch), *sensu* the following authors: Clark, 1956a, pp. 131–142 (in part, Truckee Basin population).—Clark, 1956b, pp. 728–732 (in part, Blue Canyon population).—Steinhaus, 1962, p. 433 (in part, Nos. 617, 635, 1178).

Malacosoma pluviale recenseo Dyar, Langston, 1957, pp. 8–9 (in part).

This subspecies is recognized mainly by differences in the color of adult males, and because of its relatively restricted distribution due to physical and ecological barriers.

ADULT MALES (figs. 188, 189).—Most males are very dark reddish-brown (fig. 188) with darker lines on forewings which may be nearly absent on some specimens. Hindwings are usually same dark reddish-brown as forewings, and usually without markings. Lighter specimens are found in some collections, especially in populations adjoining the northern end of the distributional range (fig. 3). These specimens range from nearly normal dark ones to light yellowish specimens found in some California populations of *M. californicum* and *M. californicum californicum.* Varying numbers of the typical dark reddish-brown males also are found in adjoining populations of *M. californicum* found in northern California, southern Oregon, southwestern Idaho, and parts of northern Nevada, but in these populations the lighter forms predominate and the larval color pattern contains much more blue and black than typical *c. recenseo* larvae. Lower surface of both forewings and hindwings of dark specimens the same dark reddish-brown color as upper surface, usually without markings; lower surface of lighter specimens also lighter, but marked with a single contrasting line across both forewings and hindwings that is most distinct on the lightest specimens. Terminalia (figs. 21, 46, and 66) as described for the northwestern populations of *M. californicum* under "comments" (page 128).

ADULT FEMALES (fig. 190).—Females are more constant in color than males, usually being fairly light pale yellow with dark lines, but some specimens vary toward the light orange-brown forms of adjoining populations of *M. californicum* and *M. californicum pluviale.*

ADULT DIAGNOSIS.—Females are most likely to be confused with female *disstria*, but both males and females are distinguished easily from *disstria* (page 86) and *constrictum* (page 94), the only other species which occur in the same area, by the characters given for those species in the adult diagnoses. Females cannot be separated from those of other nearby populations of *M. californicum*, but most males can be separated by their dark reddish-brown color with dark lines or the lack of distinctive lines on the forewings. Populations at the distributional edges which do not possess at least 75 percent dark males should be called *M. californicum* (Packard).

MATURE LARVAE (fig. 364).—Larvae intergrade completely with adjoining populations at the northern end of the distributional range and as far south on the east side of the Sierra Nevada as the Lake Tahoe area, but it is not known what situation exists along the crest of the Sierra Nevada to the south since it was not possible to collect any specimens there. Head mottled blue and black, sparsely covered with fine yellowish to orange setae. Middorsal area various combinations of black and reddish-orange, but the black may only be visible as a border of the broken stripe formed by a series of elongate, blue-white, somewhat pointed dashes, one per segment. Addorsal area a mixture of black and somewhat reddish-orange, irregular, longitudinal markings, but usually with the orange predominating. Rarely, this area may be nearly black. Area around setal group D1 black and extending ventrally to setal group SD to form the vertical black bar which usually has weaker black markings on both sides in the subdorsal area that merge with it to form a rather distinct torso mark (figs. 7 and 9). Anterior and posterior subdorsal spots blue, usually not prominent; remainder of subdorsal area mixed orange and black like addorsal area. Subdorsal line orange, irregular, and speckled with fine black markings. Supraspiracular and subspiracular areas a mixture of irregular, fine orange, blue, black and gray markings, generally appearing more orange than blue or gray, but occasionally quite blue or gray when the addorsal and subdorsal orange is reduced. Ventral area gray-white, mottled with black, and with a black area crossing the middle of each segment. Primary and secondary dorsal setae orange. Primary and secondary lateral setae usually orange, but sometimes white, especially near the edges of the range where intergradation with adjacent populations takes place. Both dorsal and lateral secondary setae rather sparse, short and not noticeably tufted.

LARVAL DIAGNOSIS.—Larvae can best be characterized as having a more or less even blend of reddish-orange, black, and blue so that no one color dominates the others. If any color is more dominant it is the reddish-orange that is redder than the more yellow-orange that is typical of the subspecies *pluviale* found to the northwest (figs. 370 and 371). Populations adjoining on the east (figs. 366 and 367) and the west (figs. 361–363) usually have much more dorsal black and lateral blue, but some populations from areas east of the Cascades may be very similar (fig. 365). In such cases the adult males generally have light yellowish lines on the forewings instead of the normal dark lines of *c. recenseo*. There is no possibility of confusing *c. recenseo* with either *M. disstria* or *M. constrictum constrictum*.

EGG MASSES.—Eggs are laid as a basically flat, clasping mass, with the more or less compact, dark brown spumaline covering them that is similar to that of *M. californicum californicum* (page 141).

TENTS AND COCOONS.—Similar to those of *M. californicum californicum* (page 141).

FOOD PLANTS.—Egg masses were found on the following hosts: *Ceanothus cordulatus*, *Ceanothus velutinus*, *Purshia tridentata*, *Prunus emarginata*, *Rosa* sp., *Ceanothus integerrimus*, and *Prunus virginiana*. Neither tents nor egg masses were found on fruit trees, but fruit trees are not common throughout most of its range, so this is not surprising. In the insectary larvae readily accepted both apple and apricot, and some larvae hatched from eggs found on *Ceanothus cordulatus* did very well on oak until they became diseased with the same disease that afflicted other collections.

TYPE.—Lectotype, here designated, a male in the United States National Museum. USNM Type No. 34890. Size: 26 mm. wingspread. The left front part of the thorax is missing. Data: *Malacosoma recenseo* Dyar, male; Siskiyou County, Calif.; 568; male genitalia, slide, 13 March 1941, W.D.F. No. 1282; Lectotype, *Malacosoma pluviale recenseo* Dyar, male, F. W. Stehr 1963. Genitalia mounted on slide labeled: *Malacosoma recenseo* (Dyar), Type, Siskiyou County, Calif. Type No. [blank] USNM; male genitalia, slide 13 March 1941, W.D.F. No. 1282. The lectotype is not as dark as many specimens of *c. recenseo*, but it has dark lines on the forewings and falls within the range of variation for *c. recenseo*.

TYPE LOCALITY.—The lectotype bears a printed label saying only "Siskiyou Co., Cal.," but Siskiyou County is the largest county in northern California, and larvae having many different color patterns can be found there. In the original description Dyar lists the locality as "the mountains of California (Truckee and Siskyou [sic])." Truckee is near Lake Tahoe in Nevada County. We are not aware of any present-day town named Siskyou or Siskiyou in Siskiyou County, have not found one in old atlases, and such a town is not listed in Gudde (1960) *Place Names of California, a Geographical Dictionary*. The printed label on the lectotype saying "Siskiyou Co., Cal." must be regarded as accurate, so the type locality must be restricted to some place in Siskiyou County.

Larvae collected near McCloud, Siskiyou County, Calif. (Coll. Nos. 163 and 164) were quite uniform in coloration and were typical of what is regarded as *c. recenseo*. In addition, pinned adult males from this area are mostly dark reddish-brown. Therefore, the type locality is restricted to McCloud, Siskiyou County, Calif., which is near the southern boundary of Siskiyou County, and about as close to the center of the range of *c. recenseo* as it is possible to be and still remain in Siskiyou County.

PARALECTOTYPES.—One female in the USNM.

DISTRIBUTION (fig. 3).—As herein restricted, *c. recenseo* includes the populations of *californicum* found west of the divide of the southern Sierra Nevada, and extending as far north as southern Siskiyou County. Its westward distribution is limited by the Central Valley of California, but it is more likely to be found there now, following the planting of numerous fruit trees. To the east, north, and northeast it intergrades with adjoining populations of *M. californicum* and it is difficult to set a definite boundary. The southern limit of its distribution is not known, but it is possible that it could intergrade with *M. californicum fragile* at the southern end of the Sierra Nevada. This also could be the case near the crest of the Sierras.

COMMENTS.—If *c. recenseo* were surrounded on all sides by intergrading populations such as those which are present at the northern end of its distribution it would probably not be given subspecific status, but since it appears to be effectively separated from nearby populations on the west, south, and east by physical and ecological barriers, and since many of the larvae and males are distinctively colored, it is recognized as a subspecies.

SPECIMENS EXAMINED.—707 (Museum specimens—95 males, 87 females, 351 larvae; reared specimens—110 males, 64 females, plus numerous larvae and egg masses). See Appendix I for data on collections made during this study (page 273).

CALIFORNIA.—Baxter (Placer Co.); Baxter's Camp; Blue Canyon (Placer Co.); Boca Lake (Nevada Co.); 1 mi. N. Brockway (Placer Co.); Burney Mountain (Shasta Co.); Burney Springs Plantation (Lassen Co.); Chester; junction of Cal. 32 and Cal. 36, 8 mi. E. Childs Meadow (Tehama Co.); Cisco (Placer Co.); Dardanelles; Donner State Park (Placer Co.); Dunsmuir (Siskiyou Co.); Echo Lake (Shasta Co.); Echo Summit (El Dorado Co.); Emigrant Gap (Placer Co.); 1 mi. W. Fish Camp (Mariposa Co.); Goodyear

Creek (Sierra Co.); Gold Lake (Sierra Co.); Huntington Lake (Fresno Co.); Kyburz (El Dorado Co.); Lake Tahoe; 2 mi. W. La Porte (Plumas Co.); McCloud; 5 mi. W. McCloud on Cal. 89; Miami Lab. (Mariposa Co.); Mt. Shasta; 5 mi. NE. Mt. Shasta; Nevada City; Norden (Nevada Co.); 4 mi. W. Pinecrest (Tuolumne Co.); Placer Co.; Shasta Retreat (Siskiyou Co.); Shaver Lake (Fresno Co.); Sierra Nev.; Siskiyou Co.; Sisson (=Mt. Shasta, Siskiyou Co.); Top Lassen (Shasta Co.); Truckee; N. edge of Truckee; near Truckee Airport (Nevada Co.); Tuolumne Co. in mountains; Westwood (Lassen Co.).

NEVADA.—Galena Creek (Washoe Co.); 1 mi. W. Incline, N. end of Lake Tahoe (Washoe Co.).

Malacosoma californicum pluviale (Dyar), new status

Larva No. 1, Stretch, 1883, pp. 19–20.

Clisiocampa pluvialis Dyar, 1893, pp. 42–43.—Neumoegen and Dyar, 1894, p. 156.—Dyar, 1895b, pp. 259–260.

Malacosoma pluvialis (Dyar), 1898, p. 6.—Dyar, 1903, p. 262.—Baird, 1920, pp. 101–102.—Essig, 1926, p. 697.—Dyar, 1928, p. 623, pl. 86c.—Collier, 1936, p. 140.—McDunnough, 1938, p. 138.—Atwood, 1943, pp. 203–205.—Keen, 1952, pp. 95–96, fig. 38 ("E" only).

Malacosoma fragilis (Stretch), *sensu* Dod, 1906, pp. 53–54 (in part, Pine Creek population).

Malacosoma pluviale (Dyar), Langston, 1957, p. 8.—Steinhaus, 1962, p. 433 (in part, Nos. 640, 805, 813, 815, 959).

There are numerous references in which the names *M. pluvialis* (Dyar) and *M. pluviale* (Dyar) have been used, but it is quite evident from the localities given in these works that *M. californicum pluviale* (Dyar) is the subspecies involved, so most of these references have not been listed.

ADULT MALES (figs. 191–196).—Ground color varying from medium orange-brown (figs. 193 and 194) to dark orange- or reddish-brown (figs. 191 and 192), rarely yellowish (fig. 196) except in areas of intergradation where specimens may vary from dark reddish-brown to light yellow. Lines on forewings yellowish. Inner area often somewhat lighter than outer area, median area dark, about same color as outer area, or darker. Hindwings same color as darkest part of forewings, and rarely crossed by a contrasting line. Lower surface of both forewings and hindwings about same color as hindwing, and both wings usually crossed by a single contrasting line. Terminalia (figs. 22, 23, 47, 48, 67, and 68) as described for the northwestern populations of *M. californicum* under "comments" (page 128), but sometimes somewhat more heavily sclerotized and with the base of eighth sternite sometimes more distinctly three-lobed than in other populations of *M. californicum*.

ADULT FEMALES (figs. 197–202).—Color varying from yellowish to orange-brown to yellowish gray-brown. Lines on forewings appear light or dark, or dark bordered by light, depending on the amount of contrast presented by the ground color. Outer line with or without small indentations along some veins. Median area usually somewhat darker than inner and outer areas. Hindwing usually darker than forewing, about same color as darker areas of forewing. Lower surface of both forewings and hindwings about the same color as upper surface of hindwing, with a single contrasting line which often divides both forewings and hindwings into a darker inner region and a lighter outer region.

ADULT DIAGNOSIS.—Females may rarely be confused with female *M. disstria*, but both males and females are easily distinguished from *disstria* (page 86) and *constrictum* (page 94) by characters given for those species in the adult diagnoses. The distribution of *Malacosoma americanum* adjoins that of *c. pluviale* along the eastern United States-Canadian border, but both male and female *americanum* can be positively separated from *c. pluviale* by the characters given for *americanum* in the adult diagnosis (page 112).

Neither males nor females can be positively identified to subspecies without locality data since some similarly colored specimens can be found throughout much of the range of *M. californicum*. The subspecies is recognized mainly on the basis of the larval color pattern. In the Canadian prairie provinces, however, where the distributions of *c. pluviale* and *M. californicum lutescens* adjoin, the majority of the male *c. pluviale* have the points of the accessory claspers closer together as in figure 23 than do male *c. lutescens* (fig. 24), but intermediates also are found. Also, the outer line on male *c. lutescens* is often more curved toward the tip of the wing at the costal margin as in figures 210 or 221 than on *c. pluviale* (figs. 191–196). Female *c. pluviale* often have the dorsal lobe of the ovipositor reduced as in figure 98, and female *c. lutescens* frequently have a more distinct dorsal lobe similar to figure 100. Intermediates similar to figure 101 may be found in both subspecies.

MATURE LARVAE (figs. 370–372).—Head mottled blue and black, sparsely covered with fine yellow-orange setae. Middorsal area of body varying combinations of orange and black, but the black usually visible only as a border of the broken middorsal stripe formed by a series of elongate, blue-white, somewhat pointed dashes, one per segment. Addorsal area predominantly yellow to yellow-orange with some fine irregular black markings on most specimens. Area around setal group D1 black and extends ventrally to setal group SD to form the vertical black bar. Vertical black bar usually with adjoining irregular black areas both anteriorly and posteriorly, with the posterior one often split longitudinally by yellow; this combination of the vertical black bar and the anterior and posterior black areas forms the "torso" mark, or the "tailed-torso" mark if the black is more extensive on the lower, posterior part. Subdorsal area basically yellow or yellow-orange, but marked with irregular longitudinal black areas which may obscure much of the yellow in some specimens and some populations (fig. 372). Anterior and posterior subdorsal spots blue, variable in size, but usually not large enough to obscure the anterior and posterior "arms" of the torso or tailed-torso mark. Subdorsal line yellow to yellow-orange, irregular, and speckled with black. Supraspiracular and subspiracular areas usually varying combinations of mixed yellow and black, sometimes with bluish or grayish mixed in, but usually not predominantly blue or gray. Ventral area mottled gray-white and black, with a median black area on each segment that is most prominent on light specimens. Primary and secondary dorsal setae orange; sometimes a few of the thoracic primary setae may be blackish. Primary and secondary lateral setae also orange or yellowish. Specimens of *c. pluviale* with white setae have never been seen except near the zones of intergradation with other populations. Both dorsal and lateral secondary setae rather sparse, short, and not noticeably tufted.

LARVAL DIAGNOSIS.—The subspecies is best recognized by differences in the larval color pattern, but intergradation with adjoining populations is complete and gradual west of the Great Plains. In general, *c. pluviale* larvae are predominantly black and yellow or yellow-orange, with the anterior and posterior subdorsal blue spots small to moderate in size and not conspicuous. The supraspiracular and subspiracular areas are usually mixed black and orange with little blue or blue-gray, and all setae are some shade of yellow-orange. Adjoining populations generally have conspicuously larger anterior and posterior subdorsal blue spots which may be confluent, the supraspiracular and subspiracular areas are usually more bluish or grayish, and the lateral setae may be white. Many populations in the area of intergradation will be almost exactly intermediate in the color combinations of blue, orange, and black, but they should not be regarded as *c. pluviale* unless the black and yellow-orange dominate.

EGG MASSES.—Laid as a basically flat, clasping mass (fig. 105) and covered with brown to dark brown spumaline that is sometimes more compact in the Pacific populations than in the more eastern ones.

TENTS AND COCOONS.—Similar to those of *M. californicum californicum* (page 141).

FOOD PLANTS.—Egg masses were found on the following hosts: *Alnus oregona*, *Alnus* sp., *Amelanchier* sp., *Purshia tridentata*, *Rosa* spp., *Salix* spp., *Prunus virginiana*, *Ribes* sp., *Ceanothus cuneatus*, *Betula glandulosa*, apple, plum, cherry, and *Populus tremuloides*.

TYPE.—Lectotype, here designated, a male in the United States National Museum. USNM Type No. 34888. Size: 27 mm. wingspread, the wings somewhat drooping. Data: TYPE; *pluvialis* Dyar; 7814; male genitalia on slide, Dec. 10, 1938, J.F.G.C. No. 2245. The number "7814"=7806 which is Dyar's catalog number referring to "BB356" which are his field notes on this collection in his brown notebook. These notes are mostly larval descriptions, but some of them are interesting because he apparently was undecided at first whether to describe this as a new species or regard it as *Clisiocampa fragilis* Stretch.

TYPE LOCALITY.—The original description says it was found abundantly at Seattle, Washington, and rarely at Portland, Oregon. Dyar's notes indicate it was very common on alder at Lake Union, Seattle, Washington, so his reared specimens most likely came from there. Therefore, the type locality is restricted to the area around Lake Union, Seattle, Washington.

PARALECTOTYPES.—Two adult males, one inflated and four preserved larvae in the USNM. The inflated larva is mostly orange and black with a small amount of blue laterally, and is a typical *c. pluviale* larva. It would have been selected as the lectotype since this subspecies is most clearly recognizable as a larva, except for the "*pluvialis* Dyar" label in Dyar's handwriting on the adult male.

DISTRIBUTION (fig. 2).—As herein restricted, *c. pluviale*'s distribution follows fairly well the areas of higher rainfall west of the Cascades in Oregon and Washington. It may extend southward in the fog belt along the northern California coast, but only two early instar collections were made along the coast (Nos. 68 and 69) and they were not successfully reared beyond the third instar, so they are regarded as *M. californicum*. The Oregon-California border is set arbitrarily as the southern boundary for *c. pluviale* until information demonstrating that it occurs farther south along the coast is obtained.

The southern boundary of the distribution from Washington to Montana is next to impossible to define since this is an area of very gradual transition from predominantly orange and black larvae in the north to larvae farther south having progressively more blue in the color pattern. Therefore, a more or less arbitrary boundary has been selected which restricts the subspecies *c. pluviale* to northern and western Washington, and treats those populations found in the Palouse area as *M. californicum*. In Montana the Continental Divide is a good rough boundary, although *c. pluviale* occurs on the east side in some places, and in the foothills of the Canadian Rockies in Alberta. Across central Canada the southern boundary closely follows the prairie-boreal forest ecotone. To the south *c. pluviale* is replaced by *M. californicum lutescens*. See "The *pluviale-lutescens* relationship" (page 60) in the section on crosses for a discussion of *M. californicum pluviale* and *M. californicum lutescens* in Canada. Near Winnipeg, Manitoba, *c. pluviale*'s distribution meets the northwestern extreme of *M. americanum*'s distribution. From Winnipeg eastward there is a slight overlap between *c. pluviale* to the north and *americanum* to the south, but there is no indication that they ever interbreed. The factors which prevent either one from invading the other's territory more extensively are unknown. For an account of a similar situation, see the discussion of the relationship between *M. californicum lutescens* and *M. americanum* under "comments" for *americanum* (page 115).

COMMENTS.—In the past when *c. pluviale* was regarded as a species it had been given the common name of the "western tent caterpillar." The Canadians, however, have established that it extends as far east as Quebec, and it probably will be found all the way to the Atlantic Ocean, so the name is hardly appropriate. The name "western tent caterpillar" can most appropriately be applied to all the populations of *M. californicum* (including all subspecies) since they occupy virtually all of the area west and north of the area occupied by *M. americanum*, the eastern tent caterpillar. If a common name is desired for *c. pluviale* (there is no need for one) it should be called the "northern tent caterpillar" since this is more truly what it is. See Appendix III for a discussion of common names (page 289).

The Bog Populations of *M. californicum pluviale*

This form of *c. pluviale* was first reported by Grant (1957) and recorded as occurring over a large part of central and northern British Columbia. It was reported to feed only on *Betula glandulosa* and one or two species of willows growing in association with it. It was not found in nearby upland forests even though they usually contained many of the hosts which are quite acceptable to more southern populations of *c. pluviale*. The basic larval color pattern was reported to be predominantly black (fig. 372), but with some individuals having the conspicuous orange markings characteristic of more southern populations (figs. 370 and 371). The egg mass was reported to be laid as a band encircling the twig in contrast to those of *c. pluviale* in southern British Columbia, which usually do not form a complete band. Egg masses were found only within 2 feet of the ground, and they were laid on small twigs and not on main branches. Another unusual behaviorism was that larvae were reported to have a tendency to spin cocoons together, with anywhere from one to six pupae being found per communal cocoon.

In 1960 a local outbreak of *c. pluviale* was studied along Weiparous Creek, near Fallen Timber Creek Campground about 60 miles northwest of Calgary, Alberta, in the foothills of the Canadian Rockies (Coll. No. 180). This population was in a boggy area, on *Betula glandulosa* and associated willows, had a predominantly black larval color pattern (fig. 372), and spun many "communal" cocoons near the ground (fig. 337). It is believed therefore, that this population was the same form as that reported by Grant.

A careful examination of the egg masses showed them to be laid as a basically flat clasping mass, and not as a complete band around the twigs as reported by Grant. Most egg masses were laid on small twigs, and consequently many *appeared* to surround the twigs, but several were found on larger twigs and branches and clearly did not encircle them. Some even were laid relatively flat on large branches. Structurally, all life stages are indistinguishable from "normal" *c. pluviale* except for the minor color differences already described. They differ in the behavioral characteristics mentioned by Grant.

Populations were very heavy in the boggy areas, but less than 100 yards away on slightly higher ground where many larger and seemingly better individuals of *Betula glandulosa* grew, there were no tents and not a single egg mass could be found. The only differences noticed between the scrub birch at these two sites was that the birch growing in the boggy area appeared to have been very heavily browsed (by big game?) so that there were many small basal shoots, while that on higher ground had apparently been only lightly browsed.

Tents were constructed close to the ground almost invariably, and in many cases they were actually touching the grass. There appeared to be three species of willows growing in the area. Two of these were untouched, but the third one had egg masses on it and the larvae had completely stripped it. Despite their rejection of these two species of willows, larvae reared in the insectary readily accepted a plant as different as rose, and did quite well on it.

It is difficult to imagine any advantage that can be obtained by using a bog habitat instead of one on higher ground. There does not appear to be an oviposition preference for *Betula glandulosa* which could account for the difference, since there was plenty of it available on higher ground that eggs were not laid on, and eggs were also laid on one species of willow in the bog. Maybe there is something about the conditions in the bog when the adults are present that attracts the females, but whatever the reason may be, this is certainly an unusual behavior pattern that is worthy of further investigation.[10]

The question arises as to whether these bog populations should be recognized. To describe them as a new species seems to be out of the question on the basis of information currently available. In British Columbia there is absolutely no information on their relationships with neighboring populations of *M. californicum pluviale* to the south, west, and north, since no adjoining populations have been reported to date. To the east, the situation is no better known, since it is not even known whether populations of "normal" *pluviale* are present between the bog populations and the prairie subspecies *M. californicum lutescens.* In 1960 one of the authors (FWS) was unable to find any *Malacosoma* in this area to the east, but was able to attempt crossing specimens of the bog populations with those of *M. californicum lutescens* from Beauvallon and Derwent, Alberta, about 100 miles east of Edmonton (see table 2, R27, R28, R35, R36, and the discussion of "The *pluviale-lutescens* relationship"). In the F_1 generation, fertility and viability were "normal" for the cross of female *lutescens* × males of the bog population, but the reciprocal cross of male *lutescens* × females of the bog population showed reduced fertility (page 60).

The only chance to cross individuals of the bog population with individuals of what has been regarded as typical *pluviale* was in cross R31 of table 2, in which males of typical *pluviale* (Coll. No. 122C, Eugene, Ore.) were crossed with females of the bog population (Coll. No. 180). The F_1 showed no reduced fertility or viability, and in fact, R31 was one of the most successful of all the F_1 egg masses which were reared. This cross is of the same kind (males of some population × females of the bog population) as that which showed reduced fertility between *lutescens* and the bog population (R27 and R36). Although only a single egg mass was reared and the reciprocal cross was not attempted due to timing difficulties, there is no indication of any genetic barrier between the bog population and "normal" *pluviale* similar to that which appears to be present between the bog populations and at least some of the *lutescens* populations. Of course, this kind of information can only demonstrate whether or not two populations *are able* to interbreed successfully; whether they *do or not* is an entirely different question, and can only be determined by field studies in areas where the populations in question occur together. Since at present there is no known area where "normal" *pluviale* and the bog populations are found together, evidence of reproductive isolation in the field is entirely lacking. On the basis of available data, the bog populations of

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[10] Since this was written, very similar bog populations have been discovered in the Upper Peninsula of Michigan on *Betula pumila*, a very close relative of *B. glandulosa*.

Alberta and British Columbia can best be regarded as local populations of *M. californicum pluviale*, and referred to as the "bog" form of *M. californicum pluviale*.

Specimens Examined (bog *pluviale* included).—2239 (Museum specimens—372 males, 200 females, 1300 larvae; reared specimens—173 males, 194 females, plus numerous larvae and egg masses). See Appendix I for data on collections made during this study, and for data on collections of intermediates between *M. californicum lutescens* and *M. californicum pluviale* (page 274).

United States.—idaho: Moscow; Wallace. michigan: "Mich."; Isle Royale. minnesota: Grand Marais. montana: Camel's Hump Ranger Station (Missoula Co.); Darby; E. Shore, Flathead Lake; Glacier Park; Hot Springs; Lookout Pass (Mineral Co.); Missoula; Yaak River, Kootenai National Forest. new hampshire: White Mountains. new york: Saratoga; Huntington, Long Island (nursery stock?); Westburg, Long Island (nursery stock?). oregon: Ashland; Astoria; Bay City; Coos Head; Corvallis; Dallas; 2 mi. S. Dayton; Diamond Lake (Douglas Co.); 2 mi. E. Elsie; 5 mi. W. Eugene; Gold Hill (Jackson Co.); Grants Pass; 3 mi. N. Grants Pass; 4 mi. N. Grants Pass; 10 mi. N. Grants Pass; Keizer; Kirby; McMinnville; Mission Bottom; Murphy; Newburg; Portland; Tillamook; Trail on Rogue River; Waldport; Woodburn; "Oregon". washington: Bellingham; Brighton; Rosemary Inn, Crescent Lake (Clallam Co.); Eaton; Easton; Felida (Clark Co.); Lemolo (Kitsap Co.); Long Beach; Olympic Hot Springs; Puyallup; Seattle; Tacoma.

Canada.—alberta: Banff; Beaver Mines; 10 mi. W. Beaver Mines; 15 mi. W. Beaver Mines; Belloy; Bezanson; Border of Bow and Bighorn Reserve; Calgary; head of Pine Creek, near Calgary; mouth of Fish Creek, near Calgary; Chancelor Camp; Cherry Point; 5 mi. NE. Cherry Point; 5 mi. S. on Chief Mountain Road; Clear Prairie; 3 mi. N. Clearwater Ranger Station; 12 mi. N. Eureka River; Fairview; 6 mi. W. Grande Prairie; High River; 10 mi. W. High River; Little Smokey; Longview; McMurray; 24 mi. SW. Nanton; Notakewin River, Peace River District; Nordegg; Peace River; Okatoks; Radium; Red Deer Ranger Station; Rycroft; Shaftesbury; E. Simon Lakes; Siroux Lake; Spirit River; 20 mi. S. Tompson Highway and Trunk Junction; 10 mi. S. Thompson Highway and Trunk Junction; Turner Valley; Wandering River P.O.; Waterton; Watins; Whitecourt. british columbia: Alaska Highway, mile 323; Alberni Highway Summit, Alberni, Van. Island; Bella Coola Valley; Pineline Trail, near Bella Coola; Canyon Creek; Cranbrook; Duncan, Van. Island; Elko-Waldo Junction; Fernie; Field; Ft. Steele; 9 mi. E. Grand Forks; Hardwicke Island; Heart? Lake; Hope Mountains; 3 mi. S. Invermere; Mission City; Kamloops; Kaslo; Kaslo Creek; Shingle Creek Road, Keremeos; Ta Ta Creek, ¼ mi. S. Junction on Highway 3 (near Kimberley); Lac du Bois; Lake Cowichan, V. I.; Lillooet; McLean; 8 mi. N. Nicholson (near Golden); Okanagan Lodge; Oliver; Osoyoos; Pemberton; Penticton; Big Oliver Creek, 33 mi. NE. Terrace; Little Oliver Creek, 30 mi. NE. Terrace; Tseax River, 40 mi. NW. Terrace; Quanichan District, V. I.; Raspberry Creek, 8 mi. W. Ft. Nelson; Remo Road, Remo; Rolla; Royal

Oak; Roseland; Saltspring Island; Sandon; Saturna Island?; Sidney; Skeena R.; Diamond Head Trail, Squamish; Summerland; Vancouver Island; Vernon; Victoria; Warfield; Wellington, V. I.; Youbou, V. I. MANITOBA: Aiken's Lake; Calder's Dock; Cat Lake; Davidson Lake; Long Lake; Moar Lake; Otter Lake on Churchill River drainage system; Red Rock Lake, Whiteshell Prov. Park; Rennie: Sasaginnigak Lake; Siderock Lake; The Pas; 3 mi. E. The Pas. NORTHWEST TERRITORY, DISTRICT OF MACKENZIE: Hay River; Yellowknife; Fort Smith. ONTARIO: Bourkes; Cedar Lake Field Station, 20 mi. N. Vermillion Bay; Charlton; Hudson; Hurkett; McDiarmid; Manitonwadge; Ottawa; Sault Sainte Marie; Sudbury; Sultan; Terrace Bay; Timmins. QUEBEC: Laniel. SASKATCHEWAN: Amisk Lake; English Bay, Lac La Ronge; Nemeiben River, N. Side of Lac La Ronge.

Malacosoma californicum lutescens (Neumoegen and Dyar), new status

Clisiocampa sp., Packard, 1881, p. 42 (in part, Helena, Mont.).

Clisiocampa californica Packard, *sensu* Packard, 1890, p. 120 (in part, Virginia City and Helena, Mont.).

Clisiocampa fragilis var. *lutescens* Neumoegen and Dyar, 1893, p. 31.

Clisiocampa fragilis var. *constrictina* Neumoegen and Dyar, *sensu* Neumoegen and Dyar, 1894, p. 155 (in part).

Malacosoma fragilis constrictina (Neumoegen and Dyar), *sensu* Dyar, 1903, p. 262 (in part).—Dyar, 1928, p. 623 (in part).

Malacosoma americana (Harris), *sensu* Dod, 1906, p. 53. Misidentified.

Malacosoma fragilis form *lutescens* (Neumoegen and Dyar), McDunnough, 1938, p. 138.

Malacosoma lutescens (Neumoegen and Dyar), Freeman, 1949, p. 233.

ADULT MALES (males in figs. 209–223).—Color highly variable, ranging from dark reddish-brown to very light yellow, but usually a combination of reddish-brown and yellow in varying proportions. The percent of dark males is greater in the northern part of the range. Lines on forewings almost invariably light yellowish except in very light specimens; rarely, the lines may be absent and the specimen may be entirely reddish-brown (fig. 214) or pale yellow (fig. 213). Median area nearly always the darkest area; inner and outer areas usually about the same color, or outer area slightly darker. Hindwing usually darker than forewing, about the same color as darkest part of forewing, and often crossed by a yellowish band of scales. Lower surface of both wings about the same color as upper surface, but tending to be darker overall, and both wings crossed by a single contrasting line which is usually lighter. Terminalia (figs. 24, 25, 49, 50, 69, and 70) as described for the southeastern populations of *M. californicum* under "comments" (page 128).

ADULT FEMALES (females in figs. 209–223).—Color variable, but not as extreme as in the males, ranging from yellowish to medium reddish-orange brown, with more dark specimens from the northern part of the range than from the south. Lines on forewings almost invariably light yellowish except in very light specimens and those in which the median band is dark and bordered by pale yellow inner and outer areas. Median area nearly always a uniform dark color and bordered by a lighter inner area; outer area usually darker than inner area, but somewhat lighter than median area. Hindwing about same color as median band on forewing, often crossed by a relatively faint band of light scales. Lower surface of both forewings and hindwings about same color as median band of forewing or darker, and with both wings crossed by a single contrasting line. Terminalia (fig. 101) as described for the southeastern populations of *M. californicum* under "comments" (page 128).

ADULT DIAGNOSIS.—Neither males nor females can be positively separated in every case from similarly colored specimens of other populations of *M. californicum*. See the adult diagnosis for *pluviale* for the best way to separate them (page 153), and the diagnosis for *americanum* for good characters to separate them (page 112). No other species is likely to be confused with *c. lutescens* within its range, although *M. disstria* occurs throughout its range, and *M. tigris* may be found at the southern end of its range.

MATURE LARVAE (figs. 373–376).—Highly variable in some respects, but always with conspicuous pale blue lateral areas. Head blue, mottled with black, sparsely covered with fine whitish to orange setae. Middorsal area of each segment with an elongate, somewhat pointed, blue-white dash of variable width; these dashes together form the broken middorsal stripe which is nearly always present to some degree. Addorsal area varying from black to yellow or orange, but usually black with varying amounts of irregular, longitudinal, yellow-orange markings. Area around setal group D1 always black, but usually blended with the other black markings so as to be inconspicuous. The black area around setal group D1 often extends ventrally to setal group SD to form the vertical black bar which is nearly always present in southern populations, but which is progressively less common northward; there are no anterior or posterior extentions or "arms" of the vertical black bar as in *M. californicum pluviale*. Subdorsal and supraspiracular areas blue, speckled with small black spots around the setal bases. Subdorsal line absent or only faintly present as irregular, pale yellow marks. Subspiracular area bluish to whitish to blue-grayish. Ventral area mottled black and gray-white, sometimes very dark, but often quite light and with a median black area on each segment.

Primary and secondary dorsal setae orange or yellowish. Primary and secondary lateral setae varying from white to yellowish to deep orange. Both dorsal and lateral secondary setae moderately dense, of medium length, and not noticeably tufted.

LARVAL DIAGNOSIS.—Larvae cannot be positively separated from adjoining and intergrading populations of *M. californicum* to the west in the United States, but they can be separated from adjoining populations of *M. californicum pluviale* in Canada by the conspicuous blue lateral areas and the lack of any anterior or posterior extensions or "arms" on the vertical black bar if one is present. Larvae of *c. pluviale* have predominantly mottled orange and black lateral areas and conspicuous anterior and posterior extensions or "arms" of the vertical black bar. Larvae of *M. americanum* may be confused with *c. lutescens* larvae, but see the larval diagnosis for *americanum* for the best ways to distinguish them (page 113).

EGG MASSES.—Laid as a basically flat, clasping mass and covered with light brown to somewhat grayish spumaline, without specks, and usually containing many bubbles of various sizes.

TENTS.—They construct large tents like those of other populations of *M. californicum.*

COCOONS.—Fairly tightly constructed, with little or no outer envelope of silk, and dusted with a pale yellow-white powder.

FOOD PLANTS.—Egg masses were found on the following hosts: *Prunus virginiana*, *Amelanchier* sp., *Rosa* sp., *Ribes* sp., *Salix* sp., wild plum, *Ribes aureum.*

TYPE.—Lectotype, here designated, a male in the United States National Museum. USNM Type No. 34893. Size: 26 mm. wingspread, the wings somewhat drooping, left forewing torn, and left antenna missing. It is also somewhat faded and rubbed. Data: TYPE; #3, 7-11-90; var. *lutescens;* H. G. Dyar, No. 5332; Lectotype, *Malacosoma fragile* var. *lutescens* (Neumoegen and Dyar), male, F. W. Stehr 1963. The number "5332" in Dyar's catalog contains the following information: 5331-2, C. A. Wiley, Miles City, Montana, *Clisiocampa californica*? Apparently this is another instance where Dyar hesitated before describing *lutescens* as a variety of *fragile*. Genitalia in microvial labeled: Lectotype, *Malacosoma fragile* var. *lutescens* (N. & D.), male genitalia, F. W. Stehr 1963.

TYPE LOCALITY.—Probably somewhere in the vicinity of Miles City, Montana, although Dyar's catalog and the original description only say that the specimens were received from Mr. C. A. Wiley of Miles City, Montana, not that they were collected there. However, larvae from that area of Montana are colored typically, so the type locality is restricted to Miles City, Montana.

PARALECTOTYPES.—One male, in the USNM.

DISTRIBUTION (fig. 2).—*M. californicum lutescens* extends north to the northern edge of the prairies in Canada, and southward into central Texas. See "The *pluviale-lutescens* relationship" in the section on experimental crosses for a discussion of the relationships between *M. californicum lutescens* and *M. californicum pluviale* (page 60). The western boundary is impossible to set exactly because of gradual intergradation with other populations of *M. californicum*, but *c. lutescens* should be restricted to the Great Plains area east of the Rocky Mountains. Its eastern limit overlaps the western limit of *M. americanum* in a relatively narrow zone. This is more fully discussed under "comments" for *americanum* (page 115).

SPECIMENS EXAMINED.—2144 (Museum specimens—521 males, 199 females, 1117 larvae; reared specimens—197 males, 110 females, plus numerous larvae and egg masses). See Appendix I for data on collections made during this study, and for data on collections of intermediates between *M. californicum lutescens* and *M. californicum pluviale* (page 275).

UNITED STATES.—KANSAS: Hamilton Co. MINNESOTA: Melrose. MONTANA: Bozeman; ½ mi. E. Ft. Peck; Glasgow; 1 mi. W. Glasgow; 6 mi. W. Glasgow; 8 mi. W. Glasgow; Havre; Hill Co.; 10 mi. NE. Hinsdale; Jordan (Garfield Co.); 4 mi. W. Livingston; 5 mi. S. Livingston; 10 mi. S. Livingston; Miles City; Montana Experiment Station (Hill Co.); Nashua; Paxton (Dawson Co.); Poplar; Richele Lodge (near Red Lodge, Carbon Co.); 8 mi. NW. Saco (Phillips Co.); Tampico; Yellowstone Co. NEBRASKA: Canyon region N. of Harrison (Sioux Co.); Sioux Co. NORTH DAKOTA: Bottineau; Sulleys Hill National Game Preserve, Devils Lake; Ft. Totten Indian Res.; Mandan; North Dakota Badlands; 13 mi. SW. Walhalla. SOUTH DAKOTA: 5 mi. W. Midland (Haakon Co.); Spring Creek Camp, 11 mi. NE. Hill City (Pennington Co.). WYOMING: Cody.

CANADA.—ALBERTA: Bassano; Beauvallon; 10 mi. SW. Bonnyville; Brooks; Clandonald; Cold Lake; Consort; Coronation; 13 mi. E. Coronation; Craigmyle; Czar; Derwent; Dewberry; 15 mi. SW. Edmonton; Elk Point; Elkwater; 10 mi. N. Frog Lake; Gibbons; Hanna; 14 mi. SE. Hanna; Hilda; Irvine; 10 mi. S. LeGoff; Lethbridge; 13 mi. N. Lloydminster; 28 mi. S. Lloydminster; Dom. Ranger Sta., Mannyberries; Marwayne; 30 mi. S. Medicine Hat; 40 mi. S. Medicine Hat; Munson; Pashley; Provost; Red Deer River, 50 mi. NE. Gleichen; Rosebud Junction; Sunnydale, Lloydminster; Taber; Vermilion; 32 mi. E. Wainwright; Wetiskow. MANITOBA: Alonsa; Ashern; Aweme; Beaver Creek; Beulah; Cowan; ½ mi. N. Cowan; Carberry; Cartwright; 1 mi. W. Elphinstone; Erickson; Fisher Branch; Glenboro; Griswold; Lundar; Melbourne; Miniota; 6 mi. S. Minnedosa; 8 mi. S. Minnedosa; Moosehorn; Narcisse; Neepawa; Poplarfield; Riding Mountain National Park; Rorketon; Sidney; Spruce Woods Forest Reserve; "Manitoba"; "Man." SASKATCHEWAN: Admiral; Archerwill; Ardath; Armley; Arran; Attons Lake, Cut Knife; Brewer; Broadview; Burstall; Canora; Carlton; Caron; Caverly;

Cecil; Chellwood; Christie Lake; Crest; Cypress Hills; Dollard; Duperon; Drake; Elbow; Empress; Fenton; Fir Mountain; Fox Valley; Furnace; Gainsboro; Glaslyn; Gull Lake; Harlan; Hazlet; Holbein; Homes; Honeymorn; Indian Head; Katepwa; Keeler; Kindersley; Qu'Appelle River; Qu'Appelle Valley; Lac Pelletier; Lake Katepwa; Limerick; Little Manitow Lake; Lloydminster; Lucky Lake; Lumsden; MacDowell; Maple Creek; Meadow Lake; Melfort; Mohmes; Nisbet Prov. Forest; Norquay; North Battleford; Ogema; Pelly; Pickthall; Prelate; Prince Albert; Radville; Redvers; Regina; Rivercourse; Roadene; Robsart; Rosetown; Rutland; Samburg; Saskatoon; Scott; Shackleton; Shaunavan; Spiritwood; Strasbourg; Stewart Valley; Sturgeon Valley; Success; Swift Current; Trossachs; Wawota; Webb; Weyburn; Whitefox; White Fox Tower; Yellow Grass; Yorkton.

Malacosoma californicum fragile (Stretch), new status

Clisiocampa fragilis Stretch, 1881, pp. 64–65.—Edwards, 1888, p. 61.—Edwards, 1889, p. 78.—Neumoegen and Dyar, 1893, p. 31.—Packard, 1893, pp. 178–179 (in part, Sierra Nevada larva).—Neumoegen and Dyar, 1894, p. 155.

Clisiocampa mus Neumoegen, 1893, p. 4. Type: Lectotype, here designated, male, SW. Utah, United States National Museum Type No. 33660.

Clisiocampa fragilis var. *mus* Neumoegen, Neumoegen and Dyar, 1894, p. 155.

Malacosoma fragilis (Stretch), Dyar, 1903, p. 262 (in part).

Malacosoma fragilis mus (Neumoegen), Dyar, 1903, p. 262.—Dyar, 1928, p. 623, pl. 86i.—Collier, 1936, p. 115 (in part).—McDunnough, 1938, p. 138.

Malacosoma fragile (Stretch), Clark, 1956a, pp. 131–142 (in part, Mammoth Lakes population).—Langston, 1957, pp. 5–6 (in part).

ADULT MALES (figs. 270–277).—Color more uniform than many other populations of *Malacosoma;* usually with chocolate-brown markings on a grayish background, the gray often with a faint yellowish tint, and the chocolate-brown usually dusted with grayish scales. Lines on forewings generally appearing chocolate-brown and bordered with a narrow gray or yellow-gray area; usually lines with many indentations along veins which may meet to cut off distinct "islands" of brown as in figure 270. Veins often covered with light scales. Median area often somewhat darker than inner and outer areas, both of which are covered with mixed brown and grayish scales. Hindwing usually darker than forewing, about same chocolate-brown as darkest part of forewing and often crossed by a contrasting line of lighter scales. Lower surface of both forewings and hindwings mixed brown and gray, often somewhat lighter than upper surface; veins usually outlined by light scales on lower surface, and both forewings and hindwings crossed by a single contrasting line. Terminalia (figs. 26, 51, 71) as described for the southeastern populations of *M. californicum* under "comments" (page 128).

ADULT FEMALES (figs. 278–284).—Basically same color as males, though more often brownish or grayish without as much of a yellowish tint. Lines on forewings with indentations as in males, but rarely meeting to form "islands." Median area usually darker than inner and outer areas which vary from brown to gray-brown to nearly pure, pale yellowish-gray in rare specimens (fig. 280). Wings usually conspicuously dusted with light scales. Hindwings usually somewhat darker than forewings, dusted with some lighter scales and often crossed by a contrasting line of scales. Lower surface of forewings and hindwings about same color as upper surface; both wings crossed by a single contrasting line which divides wing into a darker inner region and a lighter outer region.

ADULT DIAGNOSIS.—Both males and females usually can be easily separated from other populations of *M. californicum* by the distinctive grayish color in combination with the light veins and indentations which often meet to form "islands" in the males. It intergrades with populations of *M. californicum* to the north, northeast, and east, and many specimens from these areas of intergradation will be intermediate between typical *c. fragile* from the desert area, and the darker, more orange-brown specimens of *M. californicum* from adjacent areas. Specimens from adjoining populations generally do not have lighter scales along the veins, and the indentations of the lines on the forewings, if present, will usually be reduced in number, although they may still form "islands." The only species found in the same area which can possibly be confused with *c. fragile* is *M. incurvum discoloratum*. See the adult diagnosis for *M. incurvum discoloratum* for the best characters to separate them (page 178).

MATURE LARVAE (figs. 366–369, 380–382).—Head blue, mottled with black, sparsely covered with fine white and black setae. Middorsal area of body usually marked by an elongate, blue-white, somewhat pointed dash on each segment which together form a broken middorsal stripe; this stripe is sometimes absent (fig. 382) or reduced (fig. 381), especially near the zone of intergradation. Addorsal area black, with a few irregular orange longitudinal lines which are often faint. Subdorsal and supraspiracular areas blue-white to blue. Anterior and posterior subdorsal blue-white spots not visible since they have either been expanded to form the subdorsal and supraspiracular blue-white areas, or they have been engulfed by these areas. Area around setal group D2 usually black and appearing as a small spot (fig. 380) which may be partially or wholly obscured by the addorsal black, depending on how extensive it is. Area around setal group SD also black and varying in size and shape from a small dot to an elongate longitudinal dash; some specimens from the areas of intergradation may have a vertical black bar as in figure 367. Subdorsal line usually not present, but sometimes visible as a small yellowish area on each segment. Both subdorsal and supraspiracular areas blue, speckled with small black spots surrounding bases of secondary setae. Subspiracular area gray-blue-white, speckled with black spots at setal bases. Ventral area mottled gray-white and black, with a black median spot on each segment. Primary dorsal setae varying from orange to blackish; secondary dorsal setae orange. Primary lateral setae black or white; secondary lateral setae white. Secondary setae moderate in length and density, and not noticeably tufted.

LARVAL DIAGNOSIS.—Typical specimens have white lateral setae, orange dorsal setae, a broken blue-white middorsal stripe bordered by black, and bluish lateral areas which usually do not have a vertical black bar. All of these characteristics intergrade with those of neighboring populations of *M. californicum. M. incurvum discoloratum* is the only species likely to be confused with *c. fragile*. Not all larvae of *c. fragile* can be separated from those of *i. discoloratum* (figs. 395–399) where they occur together, but in general, those of *c. fragile* usually have a conspicuous middorsal, broken, blue-white line bordered with addorsal black which contains a few inconspicuous orange markings. Larvae of *i. discoloratum* generally have some dorsal black which may be reduced to a black spot around setal group D1, but they usually have more conspicuous orange markings, and a less prominent bluish to blue-white middorsal stripe which is often about the same color as the subdorsal area. Also, in southwestern Utah setae SD1 and SD2 are black on *c. fragile* and white on *i. discoloratum*. This character should separate the larvae found there, but it cannot be relied on as a general character since setal color may vary within or between populations found in other areas.

EGG MASSES.—The eggs are laid as a basically flat, clasping mass on twigs or branches. The spumaline is usually gray or gray-brown and contains numerous minute dark specks (fig. 118) scattered throughout it. See the section on egg masses for a discussion of these specks (page 20). Southern Mojave Desert populations of *c. fragile* probably have the highest density of specks and the least variation in density between different egg masses from the same population. More northern populations which are intergrading with the adjoining central populations of *M. californicum* may have variable densities of specks or none at all in egg masses from the same local population.

TENTS (fig. 335).—They construct large tents like those of other populations of *M. californicum.*

COCOONS.—Cocoons are more compactly spun than those of many other populations, almost always with little or no outer envelope of silk, and are dusted with a whitish powder (fig. 310).

FOOD PLANTS.—Egg masses were found on the following hosts: *Prunus fasciculata*, *Prunus andersonii*, *Purshia tridentata*, *Purshia glandulosa*, *Ribes* sp., peach and apricot.

TYPE.—Lectotype, here designated, a male in the American Museum of Natural History. Size: 26 mm. wingspread. Data: Nevada; 2492; *Clisiocampa fragilis* Stretch; No. 8791, Collection Hy. Edwards; *M. fragilis* Stretch, Lectotype, male, J. McD., 1942; Slide No. Mal 1; Lectotype, *Malacosoma fragile* (Stretch), male, F. W. Stehr 1963. Genitalia mounted on slide labeled: Lab. No. Mal 1, *Malacosoma fragilis* Stretch, Loc. Virginia City, Nevada, Div. Ent. Ottawa, male lectotype, J. McD. Dec. '42.

Dr. McDunnough selected this specimen as the lectotype in 1942, but never published it, so it has been redesignated here. This specimen is browner than typical *c. fragile* collected in the Mojave Desert, lacks the white scales along the veins, and the lines on the forewings are conspicuously indented at only one point where they meet. See the discussion of Stretch's *Malacosoma* types in Appendix II (page 283).

TYPE LOCALITY.—Virginia City, Nevada. Specimens were collected there in July according to entry "2492" in Henry Edwards' personal catalog of his collection in the American Museum of Natural History. Virginia City is at the extreme northwestern edge of what can be considered the range of *c. fragile*. It is unfortunate that this is the case, since both larvae and reared adults which were collected 2 miles north of Virginia City during this study (Coll. No. 135) show a great range of variation in color and pattern that clearly indicates this area is a zone of intergradation between *M. californicum recenseo* to the west and the central populations of *M. californicum* to the north and east. The name "*fragile*," however, has priority over "*Clisiocampa mus* Neumoegen," which was described from southwestern Utah in 1893, so *fragile* is retained, even though most specimens from southwestern Utah which feed on *Prunus fasciculata* are more typically like central Mojave Desert *c. fragile* than are most specimens from the Virginia City area. It must be remembered that specimens collected near Virginia City may vary greatly, and often will not look like specimens of *c. fragile* collected farther south.

PARALECTOTYPES.—One male, four females, one cocoon, all in the AMNH and bearing the Henry Edwards' personal catalog No. "2492."

DISTRIBUTION (figs. 2, 3).—It is not possible to set exact distributional boundaries to the north, northeast, and east because of the lack of specimens from some areas, but mainly because of the very gradual and complete intergradation of *c. fragile* with the adjoining central populations of *M. californicum* over a very large area. In the northwest it intergrades with *M. californicum recenseo* near Lake Tahoe. Its westward distribution seems to be limited by the Sierra Nevada, although its relationship to *M. californicum recenseo* along the ridgeline and at the southern end is completely unknown. Only a single adult from Yosemite Valley on the west slope of the Sierras is known and it could have flown or been blown there from the east side. South of the Sierras, only one adult (from Malibu), and no larvae have been seen from farther west than Cajon Pass in San Bernardino County, although it seems likely it could extend farther west and even northward in the Coast Range since *Prunus fasciculata*, its favorite host in the Mojave Desert, extends into Santa Barbara and San Luis Obispo counties. No specimens, however, of *c. fragile* or any other form of *M. californicum* were found in the area between San Benito County on the north (where *M. californicum ambisimile* is found) and Los Angeles County on the south, even though there does not appear to be any good reason why some form should not be present. The only species known to occur in that area is *M. constrictum.*

The southern distributional limit of *c. fragile* also is unknown, but no larvae have been collected south of Morongo Valley, San Bernardino County, despite extensive surveys of Riverside and San Diego Counties in both 1960 and 1961. Adults are recorded from Palm Springs, and three males from the Gavilan Hills, near Perris, Riverside County, bear labels indicating they emerged on 27 April 1946, so they were probably collected as larvae. Here again there appears to be no good reason why *c. fragile* should not be found farther south, since *Prunus fremontii*, the desert apricot, is quite common and extends into Baja California. This should be an acceptable host, but no specimens have been collected on it to date.

COMMENTS.—Of all the populations which are given subspecific status in this study, *M. californicum fragile* is the most different in the most ways from adjoining populations. Intergradation with these populations of *M. californicum*, however, is so complete in every way that there is no doubt that it has not yet developed the isolating mechanisms necessary to maintain itself as a distinct species.

SPECIMENS EXAMINED.—1608 (Museum specimens—175 males, 143 females, 224 larvae; reared specimens—589 males, 477 females, plus numerous larvae and egg masses). See Appendix I for data on collections made during this study (page 278).

UNITED STATES.—ARIZONA: Kingman; Mohave Co. CALIFORNIA: Argus Mountains; Benton (Mono Co.); Benton Station; 25 mi. NE. Bigpine; Cajon Pass; 12 mi. S. Cave Spring, Mohave Desert; Clark Mountains; Conway Summit, 12 mi. S. Bridgeport on US 395; Coso Valley (Inyo Co.); Glacier Lodge (Inyo Co.); Granite Wells (San Bernardino Co.); Independence; Leevining; 10 mi. SE. Leevining; Malibu (Los Angeles Co.); Mammoth Camp (Mono Co.); Mono Lake; Junction Cal. 108 and US 395 (Mono Co.); Morongo; Morongo Valley; Morongo Wash; New York Mountains; Owens Valley; Palm Springs; near Perris, Gavilan Hills; Phelan (San Bernardino Co.); Pleasant Valley (Alpine Co.); Providence Mountains; Bonanza Mine, Providence Mountains; Randsburg; Silver Lake (Mono Co.); Smokey Valley (Tulare Co.); Split Rock Tank, Mojave Desert; 4 mi. N. Tom's Place; Junction Highway 89 and 395 near Topaz (Mono Co.); Walker River (Mono Co.); White Mountains; Yermo; Yosemite Valley. NEVADA: Clark Co.; Goodsprings (Clark Co.); Hiko (Lincoln Co.); Kyle Canyon, Charleston Mountains; Lehman Creek, Mt. Wheeler (White Pine Co.); 7 mi. N. Minden (Douglas Co.); Mountain Springs Summit (Clark Co.); Mt. Charleston (Clark Co.); Pioche (Lincoln Co.); Virginia City (Storey Co.); Wellington (Lyon Co.). UTAH: Beaver; Bellevue (Washington Co.); Bucksk(in) Valley (Iron Co.); Hurricane; Junction; St. George; Zion Canyon; "S.W. Utah"; "Utah."

Malacosoma incurvum (Henry Edwards), new status

Suggested common name: SOUTHWESTERN TENT CATERPILLAR[11]

See the subspecies for synonymy.

ADULT MALES (males in figs. 285–308).—Color pattern variable, but not as highly variable as *M. californicum.* Color ranging from pale yellowish-gray to rather dark gray-brown; never orange-brown as many *M. californicum* may be. Forewings crossed by dark or light lines; if dark, usually bordered by a narrow lighter area except on the darkest specimens. Median area sometimes darker than inner or outer area and appearing as a dark band as in figure 292. Inner area about same color as outer area, or somewhat lighter. Lines with or without indentations along veins, but rarely deep enough to cut off "islands," although they sometimes meet along Cu 2, especially in lighter specimens. Hindwings usually slightly darker than forewings, or same color, sometimes crossed by a contrasting band of scales. Lower surface of both forewings and hindwings about same color as upper surface or slightly darker; both wings crossed by a single contrasting line, with the region inside this line sometimes darker than the region on the outside. Epiphysis variable in size, ranging from about length of second segment of foretarsus to length of first segment of foretarsus. Some specimens

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[11] See Appendix III (page 289).

of *incurvum* are the only ones which have an epiphysis (fig. 77) which even approaches *M. disstria*'s in length, but *disstria*'s is shaped differently (fig. 75).

MALE TERMINALIA (figs. 35, 16–18, 41–43, and 61–63).—The terminalia are indistinguishable from those of the southeastern populations of *M. californicum* as described under "comments" (page 128), but many specimens can be separated from the northwestern populations of *M. californicum* by the greater distance between the prongs of the accessory claspers as described there (page 128). This is of no importance, however, since the northwestern populations of *M. californicum* do not occur where *incurvum* is found. Posterior edge of seventh sternite (figs. 61–63) not distinctive, varying from heavily sclerotized and uneven to practically unsclerotized and smooth, often with a median notch. Genitalia (fig. 35) virtually identical with those of *M. californicum* (fig. 36); somewhat similar in shape to those of *M. americanum* (fig. 31), but the absolute size of *incurvum* is smaller for moths of similar size in other respects (compare the size of the eighth sternite of *americanum* (fig. 40) with those of *incurvum* in figs. 41–43). Also, the arc of curvature of the "arms" of the eighth sternite near the points is usually greater for *incurvum* than for *americanum*.

ADULT FEMALES (females in figs. 285–308).—Color more uniform than males, varying from fairly dark chocolate-gray-brown to lighter, more yellowish-brown. Lines on forewings appearing light or dark, usually both, since the darker median area is usually bordered by a narrow pale area. Lines usually with some small indentations along the veins, but never meeting to cut off "islands." Median area usually darker than inner or outer areas, but sometimes about same color. Hindwing generally about same color as median band of forewing, and sometimes crossed by a faint lighter line. Lower surface of both forewings and hindwings about same color as upper surface of hindwing, and crossed by a single contrasting line. Epiphysis varying from absent to about as long as second tarsal segment of foreleg on some specimens.

FEMALE TERMINALIA (figs. 93–96, 103).—The terminalia are indistinguishable from those of the southeastern populations of *M. californicum* as described under "comments" (page 128), but many specimens can be separated from the northwestern populations of *M. californicum* (page 128) by the dorsal ovipositor lobes, which are often reduced in the northwestern populations, but are usually quite distinct for *incurvum*. This is of no importance, however, since the northwestern populations of *M. californicum* do not occur where *incurvum* is found. Genital plate varying from nonsclerotized to completely sclerotized; ostium centrally located.

ADULT DIAGNOSIS.—Male *incurvum* usually can be separated from male *M. californicum fragile* by the more yellow-brown colors of *incurvum* in the localities where they occur together, compared with the more yellow-gray or whitish-gray colors of *c. fragile.* Also, male *c. fragile* usually have the lines on the forewings more conspicuously indented along the veins so they cut off "islands," while *incurvum* males have no indentations or less conspicuous ones which rarely meet to cut off "islands." Females are more difficult to separate, but female *incurvum* generally are more uniform brown or yellowish-brown, and the lines on the forewings are more even with small indentations along the veins. Female *c. fragile* are generally paler, with a distinct gray or whitish-gray appearance, and the lines on the forewings are less even and with more jagged indentations.

There is no good way to separate other populations of *M. californicum* from *incurvum* except that in general, both male and female *californicum* are more reddish to orange-brown than *incurvum.* Specimens which cannot be placed with certainty in either species are bound to be encountered, but, as has been pointed out (page 118), the relationships between *incurvum* and other populations of *californicum* are incompletely known, and reproductive isolation does not appear to be completely developed, so these intermediate specimens are to be expected. All other species (*americanum*, *disstria*, *tigris*, and *constrictum*) can be easlly identified by the diagnostic characters given for them.

MATURE LARVAE (figs. 390–399).—Variable, but not as highly variable as *M. californicum* throughout its range. Head mottled blue and black, sparsely covered with whitish setae. Middorsal area black, with or without a blue-white to bluish line. Addorsal areas varying from black to orange; if the orange is conspicuous it often resembles a pair of exclamation marks (!!) on each segment as in figure 392. Subdorsal area varying from blue to blue-green to blue-gray or black. Subdorsal line, if present, consisting of only a pale yellowish mark on each segment immediately ventral to a variable black area surrounding setal group SD. Supraspiracular area same bluish color as subdorsal area, or more blue-gray if subdorsal area is largely black. Subspiracular area pale whitish blue-gray. Ventral area mottled gray-white and black to nearly black, with a conspicuous black median area on lighter specimens. Primary dorsal setae yellowish to white; secondary dorsal setae orange. Primary and secondary lateral setae white, and conspicuously tufted around setal group L2 in some populations.

LARVAL DIAGNOSIS.—There is no easy way to separate larvae of *incurvum* from those of *M. californicum*, but see the diagnosis under *M. incurvum discoloratum* (page 179) and *M. incurvum incurvum* (page 175) for the best ways to separate the larvae in the areas where these subspecies occur. Larvae of *disstria*, *tigris*, and *americanum* can be separated by the diagnostic characters given for them. Larvae of *M. constrictum* have apparently been confused with larvae of *M. incurvum incurvum* in the past since *constrictum* has erroneously been reported from Arizona. See the larval diagnosis for *M. incurvum incurvum* for the best ways to separate these two (page 175).

EGG MASSES (figs. 114, 117).—The eggs are laid as a basically flat, clasping mass, covered with relatively tough spumaline which contains many small, fairly uniformly sized bubbles. The spumaline may be nearly white in some populations, but in others it is dark brown, or some intermediate color. No reason is known for this great difference, but it should be investigated to determine whether it is hereditary, host influenced, environmentally influenced, or due to some other factor.

Egg masses of *M. californicum fragile* always can be separated from those of *M. incurvum discoloratum* by the small specks in the spumaline (fig. 118) which are absent in *i. discoloratum*. Egg masses of other populations of *M. californicum* cannot be positively separated, but they are generally covered with spumaline which is more medium brown or grayish, instead of white or dark brown, and the bubbles are of various sizes (those of *incurvum* are nearly uniform in size). *M. americanum* does not occur in the same area as *incurvum*, but the spumaline on its egg masses is dark brown, and the bubbles are of various sizes.

TENTS.—They are essentially the same as those built by *M. americanum* and *M. californicum*, but quite often larvae from several egg masses combine their efforts and construct very large tents, especially on cottonwood. This also happens with *americanum* and *californicum*, but their tents are rarely as large.

COCOONS.—Cocoons are fairly tightly constructed, usually without an outer envelope of silk, and dusted with a whitish powder which may occasionally have a pinkish tint.

FOOD PLANTS.—The favorite host appears to be *Populus fremontii*, the southwestern cottonwood, in Arizona and Utah, but other trees are also attacked. These are listed for each subspecies.

DISTRIBUTION (fig. 4).—*M. incurvum* with its subspecies ranges from the Grand Junction area of western Colorado, south through Utah, Arizona, and Mexico to the vicinity of Mexico City. It probably occurs in extreme western New Mexico. No tents could be located along the Rio Grande River in New Mexico at Albuquerque, or from Truth or Consequences, New Mexico, south to Fort Hancock, Texas, or in Big Bend National Park, although cottonwood is abundant along the river. Adults definitely referable to *incurvum* have not been seen from Texas, and only a single questionable male from Silver City, New Mexico, has been seen.

No tents were found on cottonwoods in the Imperial Valley of California either, although conditions appear to be suitable there at the present time, even though they may not have been before irrigation and the planting of cottonwoods. A single male in the United States National Museum from the Barnes Collection labeled "Palm Springs, Riverside Co., Calif., 1–7 April," and two females from the O. Buchholz Collection in the American Museum of Natural History labeled "Bishop, Cal., 6–14–37, E. C. Johnston" and "Cal., IV–27" are the only specimens which are supposed to be from California. All three of these specimens are similar to those found near Phoenix, Arizona. If the data on these specimens are reliable, it seems most likely that they were carried into California as larvae or cocoons, since we are not aware of any reports of tent caterpillars on cottonwoods in California.

ECONOMIC IMPORTANCE.—*M. incurvum* (including its subspecies) has caused heavy defoliation of cottonwoods and willows in Utah and Arizona, and defoliation of willows in the vicinity of Mexico City. Nevertheless, it must be regarded as more of a nuisance than a serious pest since these hosts usually are classified as ornamentals, or even undesirables if they grow along irrigation canals and use valuable water. No important defoliation has been reported on other hosts.

Malacosoma incurvum incurvum (Henry Edwards)

Clisiocampa incurva Henry Edwards, 1882, p. 125.—Neumoegen and Dyar, 1893, p. 30.—Dyar, 1893, p. 43.

Clisiocampa incurva var. *constrictina* Neumoegen and Dyar, 1893, p. 30. Type: Holotype, male, Arizona, United States National Museum Type No. 33662.

Clisiocampa fragilis Stretch, *sensu* Neumoegen and Dyar, 1894, p. 155 (in part).

Clisiocampa fragilis var. *constrictina* Neumoegen and Dyar, Neumoegen and Dyar, 1894, p. 155 (in part).

Malacosoma fragilis incurva (Henry Edwards), Dyar, 1903, p. 262 (in part.)—Dyar, 1928, p. 623, pl. 86i (in part).—Collier, 1936, p. 114.—McDunnough, 1938, p. 138.

Malacosoma fragilis constrictina (Neumoegen and Dyar), Dyar, 1903, p. 262 (in part.)—Dyar, 1928, p. 623 (in part).

Malacosoma constricta (Stretch), *sensu* Essig, 1926, p. 697 (in part, Arizona population).—*sensu* Keen, 1952, p. 95 (in part, Arizona population).

Malacosoma fragilis azteca ab. *constrictina* (Neumoegen and Dyar), Collier, 1936, p. 114.

Malacosoma fragilis incurva form *constrictina* (Neumoegen and Dyar), McDunnough, 1938, p. 138.

Malacosoma constrictum (Stretch), *sensu* Langston, 1957, pp. 9–10 (in part, Arizona population).

ADULT MALES (males in figs. 291–299).—Color ranging from light yellowish-brown to fairly dark chocolate-brown. Lines on forewings varying from dark to light, depending on background color which determines whether the dark line or the narrow lighter border is more conspicuous. Lines with or without indentations along the veins, but, if present, usually not very deep; occasionally deep enough to meet along Cu 2, and rarely deep enough along two veins to cut off an "island." Median area often about same color as inner and outer areas, but sometimes dark enough to form a distinct dark band across wing as in figure 292. Hindwings usually about same color as outer area of forewing, or slightly darker, often crossed by a faint, contrasting band of scales. Lower surface of both forewings and hindwings usually about same color as upper surface or slightly darker; both forewings and hindwings crossed beneath by a single contrasting line which may be faint on hindwing; region inside this line sometimes darker than outer region. Epiphysis variable, ranging in size from about length of second segment of foretarsus to about length of first segment of foretarsus, but often fairly large as in figure 77. If large, however, it does not have *disstria*'s distinctive shape (fig. 75).

MALE TERMINALIA (figs. 16, 41, 61).—As described for *M. incurvum* (page 170), and indistinguishable from those of *M. californicum.*

ADULT FEMALES (females in figs. 291–299).—Color usually slightly darker than most males, ranging from light brown to darker chocolate-brown, often with a slight yellowish tint. Lines on forewings appearing light or dark as in the males; lines usually with some indentations along veins, especially the outer line, but very rarely meeting. Median area generally somewhat darker than inner and outer areas, but usually not strikingly so. Hindwings not noticeably darker than forewings on most specimens. Lower surface of both forewings and hindwings about same color as upper surface, crossed by a single contrasting line which may be faint, especially on hindwings.

FEMALE TERMINALIA (figs. 93–95).—As described for *M. incurvum* (page 170) and indistinguishable from those of *M. californicum* which occur in the same area.

ADULT DIAGNOSIS.—Neither males nor females can be positively separated from populations of *M. californicum* which occur nearby, but in many areas only *i. incurvum* is known to occur. Male *i. incurvum* are usually yellowish-brown to gray-brown or chocolate-brown, and the lines on the forewings often are not sharply contrasting, while male *californicum* are generally, though not always, more reddish-brown or orange-brown, and the lines on forewings are usually more sharply contrasting. Female *i. incurvum* are usually a soft brownish color and the lines on the forewings are usually not sharply contrasting, while *californicum* females generally are more reddish-brown or orange-brown, and the lines are more sharply contrasting as in the males. These differences are admittedly poor, but there are no known structural characters which will separate them.

MATURE LARVAE (figs. 390–394).—Color quite variable, but larvae are more easily identified than adults. Head mottled blue and black, sparsely covered with whitish setae. Middorsal area blackish, almost always without a stripe, but rarely with a faint, broken whitish stripe which is most prominent anteriorly. Addorsal area varying from black to orange. If the orange is conspicuous there is no whitish middorsal stripe of any kind, the orange is broken up into a pair of marks which roughly resemble a pair of exclamation points (!!) on many specimens, and the orange, together with the bordering black, forms an oval-shaped mark on each segment (fig. 392). Subdorsal area varying from bluish to nearly black on some specimens; other specimens about half blue and half black, resulting in a longitudinal black stripe which encompasses setal group SD at the lower edge of the subdorsal area (fig. 393). Bluish specimens speckled with fine black spots at the bases of the secondary setae. Subdorsal line, if present, consisting of only a pale yellowish mark on each segment immediately ventral to the variable black area surrounding setal group SD. Supraspiracular area the same bluish color as subdorsal area in bluish specimens; more gray-blue in blackish specimens (fig. 394). Subspiracular area pale whitish blue-gray. Ventral area mottled gray-white and black, to nearly black, with a conspicuous median black area on lighter specimens. Primary dorsal setae usually white, but sometimes yellowish; secondary dorsal setae orange, but more golden on darker specimens. Both primary and secondary lateral setae white, and secondary setae conspicuously tufted around setal group L2.

LARVAL DIAGNOSIS.—There is no positive way to separate all *incurvum incurvum* from larvae of *M. californicum*, but *i. incurvum* never have a vertical black bar as far as is known, and they rarely have even a faint middorsal stripe. Larvae of *californicum* may have a vertical black bar, and often have a middorsal stripe. In addition, *i. incurvum* larvae usually have the lateral setae conspicuously tufted about setal group L2 (figs. 390–392), and larvae of *californicum* usually do not have the lateral setae conspicuously tufted around setal group L2.

Larvae of *M. constrictum constrictum* have apparently been confused with *i. incurvum* in the past since *constrictum* has erroneously been reported from Arizona. This has been due no doubt to the superficial resemblance in the dorsal orange markings of some *i. incurvum*, and the tufting of the lateral setae in a way that is very similar to *constrictum* (compare figs. 392 and 345). Larvae of *constrictum* can most easily be separated by the long, blackish primary dorsal setae which are always present, and which *i. incurvum* never has (they are yellowish to white on *incurvum*). Also, the dorsal orange markings of *constrictum* are hourglass-shaped and have a conspicuous black spot on either side of the constriction of the hourglass. The dorsal markings of *i. incurvum* are bordered laterally by black so that the black and orange together form an oval mark on each segment.

EGG MASSES.—Eggs are laid as a basically flat, clasping mass, covered with relatively tough spumaline which contains many small, fairly uniformly sized bubbles. It is nearly white or cream colored (fig. 117) in the populations north of Tucson, Arizona, but in the Tucson area some egg masses are covered with darker spumaline which may even be very dark brown (similar to fig. 114). The spumaline never has any specks in it as do many egg masses of *M. californicum* (page 20).

TENTS AND COCOONS.—As described for *M. incurvum* (page 172).

FOOD PLANTS.—Egg masses were collected on the following hosts: *Populus fremontii*, *Prunus virens*, *Salix* sp., and peach.

TYPE.—Lectotype, here designated, a male in the United States National Museum. USNM Type No. 33658. Size: 26 mm. wingspread. Data: Arizona; *Clisiocampa incurva* Hy. Edw., Type, male; Typicum specimen; Lectotype, *Malacosoma incurvum* (Hy. Edwards), male, F. W. Stehr 1963. Genitalia in microvial labeled: Lectotype, *Malacosoma incurvum* (Hy. Edwards), male genitalia, F. W. Stehr 1963.

PARALECTOTYPES.—One female, USNM.

TYPE LOCALITY.—The original description gives only "Arizona H. K. Morrison." H. K. Morrison collected in Arizona in 1881 and in many other parts of the West (Mann, 1885). The lectotype falls within the variation found in many populations of *i. incurvum* collected during this study along stream beds and in the irrigated lands from Wickenburg southeastward to the Mexican border. It seems likely that Morrison collected in the Phoenix area in 1881, and since the specimens reared from the Phoenix area are very close to the type, the type locality is restricted to the Salt River Valley at Phoenix.

DISTRIBUTION (fig. 4).—As presently known its distribution in the United States seems to be limited primarily to areas in central and southern Arizona along watercourses and irrigated lands where cottonwoods and willows grow abundantly. Specimens were also collected at higher elevations, however, especially in canyons (Coll. Nos. 211, 243, 244, 250). Its distribution in Mexico is completely unknown, but some specimens from the vicinity of Mexico City and 6–10 miles W. of El Salto, Durango, are identical in some respects with many specimens collected from Tucson southward to the border. The Mexican specimens are treated as the subspecies *M. incurvum aztecum* because of the differences between them and most of the U.S. *incurvum incurvum*, and because of the nearly complete lack of any specimens from the area between the United States border and Mexico City. When more information is available it will be necessary to revise the subspecific ranges of *i. incurvum* and *i. aztecum*.

COMMENTS.—The relationships of what is herein considered *M. incurvum incurvum* to the populations of what is considered *M. californicum* which occur at higher elevations in Arizona are not completely known, but enough collections have been made to indicate that these populations are not completely isolated from each other. See the discussion of these relationships in the introductory section on "The Western Tentbuilders" (page 118).

SPECIMENS EXAMINED.—1466 (Museum specimens—169 males, 85 females, 74 larvae; reared specimens—642 males, 496 females, plus numerous larvae and egg masses). See Appendix I for collections made during this study (page 279).

UNITED STATES.—ARIZONA: Ajo; Baboquivari Mountains (Pima Co.); Coolidge; Fish Creek, Tonto National Forest; Globe; Huachuca Mountains; Madera Canyon, Santa Rita Mountains; Nogales; Oracle; Patagonia; Phoenix; Pima Co.; Ramsay Canyon, Huachuca Mountains; near Roosevelt Dam; Safford; San Carlos; Santa Catalina Mountains; Tempe; Tucson; White Mountains; Yuma; "S. Arizona"; "Arizona." NEW MEXICO: Silver City.

DOUBTFUL LOCALITIES.—CALIFORNIA: Palm Springs; Bishop; "Cal."

Malacosoma incurvum discoloratum (Neumoegen), new status

Clisiocampa mus var. *discolorata* Neumoegen, 1893, pp. 4–5.
Clisiocampa fragilis (Stretch), *sensu* Neumoegen and Dyar, 1894, p. 155 (in part).
Malacosoma fragilis incurva (Henry Edwards), *sensu* Dyar, 1903, p. 262 (in part).—Dyar, 1928, p. 623 (in part).
Malacosoma fragilis incurva var. *discolorata* (Neumoegen), Collier, 1936, p. 115.
Malacosoma fragilis mus form *discolorata* (Neumoegen), McDunnough, 1938, p. 138.

ADULT MALES (males in figs. 300–308).—Color various shades of medium yellowish-brown, lightly dusted with brownish scales. Forewings crossed by two fairly evenly curved brownish lines which often have a narrow lighter border that may be more apparent than the lines themselves on some specimens; lines usually without indentations or with only small ones, but occasionally with some that may meet along Cu 2 as in figure 303. Inner line almost invariably evenly curved and without any indentations along veins. Median area usually only slightly darker than inner or outer areas, but sometimes much darker. Hindwings usually darker than forewings, and about same brown color as lines on forewings, and sometimes crossed by a faint lighter band of scales. Lower surface of both forewings and hindwings variable in color, but lower surface of hindwing often lighter than upper, and lower surface of forewing usually about same color as upper surface or slightly darker. Both forewings and hindwings crossed ventrally by a single contrasting line which may be faint, especially on hindwing. Hindwing often with darker area at anal angle on lower surface.

MALE TERMINALIA (figs. 17, 42, 62).—As described for *M. incurvum* (page 170), and indistinguishable from *M. californicum fragile* and other populations of *M. californicum* found in the same area.

ADULT FEMALES (females in figs. 300–308).—Color usually slightly darker than males, ranging from light gray-brown to more yellowish-brown. Lines on forewings light or dark, depending on background color and whether it contrasts with the line or with the lines' narrow, lighter border. Lines usually with a few small indentations, especially in outer line, but never cutting off "islands." Median area often somewhat darker than inner and outer areas, but usually not strikingly so. Hindwings not noticeably darker than forewings on most specimens, and about same color. Lower surface of both forewings and hindwings about same color as upper surface, and crossed by a single contrasting line which may be faint, especially on hindwings.

FEMALE TERMINALIA (fig. 103).—As described for *M. incurvum* (page 170) and indistinguishable from *M. californicum fragile* and other populations of *M. californicum* found in the same area.

ADULT DIAGNOSIS.—Males usually can be separated from *M. californicum fragile* and other populations of *M. californicum* which occur in the same areas by their medium yellowish-brown color, with the forewings crossed by light, brownish lines, and the somewhat darker hindwings. The inner line is also quite evenly curved and usually without indentations along the veins; the outer line may have a few small indentations, or rarely deeper ones. Male *c. fragile* (figs. 270–277) are more whitish-gray and chocolate-brown, the lines on the forewings may appear light, and they often have many conspicuous indentations along the veins which frequently cut off "islands." Males of other populations of *M. californicum* are usually more reddish- or orange-brown, the lines on the forewings usually appear light, and the lines may or may not have conspicuous indentations along the veins.

Females are much more difficult to separate, but female *i. discoloratum* are usually a softer, yellowish gray-brown, the lines on the forewings are less sharply contrasted with the background color, and they are more evenly curved, with fewer and smaller indentations. Females of *c. fragile* (figs. 278–284) are more gray-white in color, the lines on the forewings often have many indentations ranging from small to quite jagged, and the lines contrast more with the background color. Females of other populations of *M. californicum* usually are more orange-brown with more sharply contrasting lines on the forewings, but otherwise are closely similar to female *i. discoloratum.* Other species such as *M. tigris* and *M. disstria* which might be collected in the same area can be separated by the diagnostic characters given for them (pages 103 and 86).

MATURE LARVAE (figs. 395–399).—Head blue, mottled with black, sparsely covered with fine white to yellowish setae. Middorsal area usually with some sort of stripe (figs. 395–398), but very rarely entirely black (fig. 399). Stripe varying from a few narrow bluish-white dashes to a slightly broken, middorsal bluish line that is often about same shade of blue as subdorsal area. Addorsal area varying from black to orange, but usually a mixture of both, with the black sometimes reduced to only a black spot around setal group D1 as in figure 395, but never entirely absent. Area around setal group D2 often visible as a small black spot (fig. 395). Subdorsal area bluish, speckled with fine black dots around bases of secondary setae. Subdorsal line, if present, consisting of only a pale yellowish mark on each segment immediately ventral to a variable black area surrounding setal group SD. Specimens have never been seen with a vertical black bar connecting setal groups D1 and SD, as is often the case in many populations of *M. californicum.* Supraspiracular area usually slightly darker, more grayish-blue than subdorsal area, and also speckled with black dots around bases of secondary setae. Subspiracular area various shades of pale bluish-gray white. Ventral area blackish, often mottled with gray-white, and generally with a black median spot or band on each segment, which is most conspicuous on lighter specimens. Primary dorsal setae yellowish to whitish to orange; secondary dorsal setae orange. Primary and secondary lateral setae usually white, occasionally somewhat yellowish, rarely the primary setae are somewhat dark. Lateral setae not tufted or only slightly so.

LARVAL DIAGNOSIS.—Larvae are difficult to separate from those of *M. californicum fragile* and other populations of *M. californicum.* There are no good characters which will positively identify them, but locality and host data will help, since *i. discoloratum* seems to show a decided preference for cottonwood while *californicum fragile* and *californicum* prefer various shrubs. Some *californicum* larvae have a vertical black bar which *i. discoloratum* does not have, but *c. fragile* does not have one in the areas where it occurs with *i. discoloratum. Fragile* larvae, however, usually have a distinct, black, dorsal, longitudinal band (figs. 380–382) which contains a few inconspicuous orange markings at the most, and *c. fragile* almost always has a conspicuous middorsal broken blue-white line. Larvae of *i. discoloratum* generally have some dorsal black, which may be reduced to a black spot around setal group D1, but they usually have more conspicuous orange markings, and a less prominent bluish to blue-white middorsal stripe which is often about the same color as the subdorsal area.

Possibly the best way to separate *i. discoloratum* larvae from *c. fragile* larvae in the southwestern Utah area is by the color of setae SD1 and SD2. They are usually black on *c. fragile* and white on *i. discoloratum*. This difference, however, cannot be relied on as a general character for separating all *i. discoloratum* from all populations of *M. californicum*, since setal color may vary within or between populations found in different areas. For example, this same difference holds for populations of *californicum* and *i. discoloratum* found at Buckhorn Wash, Emery County, but at the base of the La Sal Mountains in San Juan County, specimens of *californicum* collected on *Cercocarpus montanus* had white SD setae instead of black. Only two tents were found, and no egg masses were located, but the spumaline of reared females contained specks, and confirms the identification of the *C. montanus* population as *M. californicum*. Also, the adults which were reared from the *C. montanus* are typical of *californicum* found in that part of Utah. The adults reared from the cottonwood are typical *i. discoloratum*, and the spumaline did not contain any specks. Therefore, the white SD setae on the *C. montanus* population is just another example of the great variation in characters that is found throughout the range of *M. californicum*. See the introductory section on "The Western Tentbuilders" (page 118) for a more complete discussion of the differences between *M. incurvum discoloratum* and *M. californicum* and *M. californicum fragile*.

EGG MASSES.—The eggs are laid as a flat clasping mass, covered with a relatively tough spumaline which contains many small, fairly uniformly sized bubbles. The spumaline is very light colored, being white or nearly so as in figure 117, and without specks. Egg masses of *c. fragile* are covered with a gray or gray-brown spumaline which has many small specks, and egg masses of other populations of *M. californicum* are covered with gray-brown or brownish spumaline which may contain specks. See the introductory section on egg masses for a discussion of the specks (page 20).

TENTS.—Tents are large and essentially the same as those built by *M. californicum* and *M. americanum*, and cannot be distinguished from them. At several places along the Virgin River in Utah penultimate instar larvae were observed clustering on large branches and trunks of cottonwood trees in a fashion similar to *M. disstria*. All of these trees, however, had been almost completely stripped of their foliage, and the larvae probably were in the process of abandoning the trees in their search for additional food.

COCOONS.—Cocoons are fairly tightly constructed, usually without an outer envelope of silk, and dusted with a whitish powder.

FOOD PLANTS.—Egg masses were found on the following hosts: *Populus fremontii*, *Populus alba*, *Populus angustifolia*, *Salix* sp., and apricot.

TYPE.—Lectotype, here designated, a male in the United States National Museum. USNM Type No. 33661. Size: 30 mm. wingspread. Damaged by dermestids, resulting in a hole in the right side of abdomen. Data: *Clisiocampa mus* v. *discolorata*, B. Neumoegen, Type; typicum specimen; S. W. Utah, C. I. Weidt; Lectotype, *Malacosoma mus* v. *discoloratum* (Neumoegen), male, F. W. Stehr 1963. Genitalia in microvial labeled: Lectotype, *Malacosoma mus* v. *discoloratum* (Neumoegen), male genitalia, F. W. Stehr 1963.

TYPE LOCALITY.—The original description lists the localities as SW. Utah, and one female from Prescott, Arizona. This female from Prescott is in the USNM and is actually a female *M. californicum fragile*. The locality "S. W. Utah" most likely refers to the area near St. George along the Santa Clara and Virgin Rivers in Washington Co., Utah. In the original description Neumoegen says, "raised out of a lot of about 50 typical *mus* by Mr. Chr. I. Weidt. It seems to be rare." The name "*mus*" is a synonym of "*fragile*." It seems apparent that Mr. Weidt collected a bunch of *c. fragile* larvae on the brush, and in doing so picked up a few *i. discoloratum* larvae which had probably fallen from a nearby cottonwood, and which are quite similar in appearance to *c. fragile* larvae. The lectotype falls within the range of variation of specimens of *i. discoloratum* reared from cottonwoods growing near St. George, so the type locality is restricted to St. George, Washington Co., Utah.

PARALECTOTYPES.—There should be several females from SW. Utah according to the original description, but these are not in the USNM. The female from Prescott, Arizona, is *M. californicum fragile*.

DISTRIBUTION.—As far as is known at the present time, *i. discoloratum* seems to be restricted to the watercourses of the Colorado River and its tributaries in the Canyonland area of Utah, extreme western Colorado, and southeastern Nevada. It probably also occurs in northwestern New Mexico along the San Juan and Chico rivers and along the Colorado River in northern Arizona, but no specimens have been collected or seen from these areas. Most likely it occurs along the Colorado River in the Grand Canyon, but no tents were located on cottonwoods along the Havasu River in the Havasupai Indian Reservation or in the area near Hoover Dam, although it was collected at Mesquite, Nevada. Reports of tent caterpillars on cottonwoods in the

Moapa Valley, Nevada, are most likely *i. discoloratum*. No tents of any kind were located on cottonwoods along the Colorado River and the reservoirs from Boulder City to Yuma, Arizona, despite several days spent searching the area around Davis Dam, Needles, Topock, Parker Dam, Parker, Blythe, Yuma, and San Luis. Some form of *M. incurvum* should be found on cottonwoods along the river in these areas since adults have been seen from Yuma. Also some form of *M. californicum* probably occurs in the hills along the river, but none has been seen to date, except for a single male from Cibola, Yuma County, Arizona.

COMMENTS.—This subspecies is recognized because it seems to be quite well separated geographically from *M. incurvum incurvum*, and because most of the larvae are easily separated from *i. incurvum* (figs. 390–394) by the presence of a dorsal stripe on most of them, and by the lack of conspicuous tufting of the lateral setae. Larvae of *i. incurvum* almost never have a dorsal stripe, and the lateral setae are usually conspicuously tufted. There are less consistent differences in the color of the adults and larvae, too, but in other respects such as hosts, egg masses, color of spumaline, tents, etc., they are virtually identical.

M. incurvum discoloratum may be related to the aspen populations of *M. californicum* in a way similar to that suggested in the section on "The Western Tentbuilders" (page 118). An example of a population that may be a connecting link is Collection No. 305 which was similar to the aspen populations of *M. californicum* in most respects, the greatest differences being the fact that it was on *Populus angustifolia* which is sometimes a host of *i. discoloratum*, and that it occurred at an elevation of 6100 feet (below the aspen zone, but lower than the highest elevation where *i. discoloratum* has been found—6700 feet, Coll. No. 313).

Some connecting populations between *i. discoloratum* and other populations of *M. californicum* which do not have specks in their spumaline may also exist, but none were found during this study, although some adult males of Collection Nos. 313 and 284 (fig. 303) had a browner median area on the forewing than "normal" *i. discoloratum* males. This could be due to some introgression of genes from *M. californicum* populations which normally have a dark median area.

SPECIMENS EXAMINED.—624 (Museum specimens—51 males, 13 females, 49 larvae; reared specimens—265 males, 246 females, plus numerous larvae and egg masses). See Appendix I for collections made during this study (page 290).

UNITED STATES.—ARIZONA: Mohave Co. NEVADA: Clark Co.; Mesquite; "S. Nevada." UTAH: Bellevue (Washington Co.); Bluff; Capitol Reef Nat. Mon.; Moab; Santa Clara; St. George; Entrance, Zion National Park; Zion National Park; Zion Canyon; "Utah."

Malacosoma incurvum aztecum (Neumoegen), new combination

Clisiocampa azteca Neumoegen, 1893, p. 5.—Ancona, 1930, pp. 215–225.
Clisiocampa luteimargo Dyar, 1907, p. 232. Type: Holotype, male, United States National Museum Type No. 10447.
Malacosoma fragilis azteca (Neumoegen), Dyar, 1928, p. 623, pl. 86b.—Collier, 1936, p. 114.
Malacosoma luteimargo (Dyar), 1928, p. 623, pl. 86b.—Collier, 1936, p. 119.

Very few specimens have been available for study, but among these there is no great variation except for a few pale yellowish ones (both males and females) which were described by Dyar in 1907 as *Clisiocampa luteimargo*. However, Ancona (1930) indicated that the color of *aztecum* may vary from being uniform brown to light yellow, with many intermediate combinations.

ADULT MALES (figs. 285–287).—Color variable, ranging from pale yellow to dark blackish-brown, darker specimens lightly dusted with pale scales. Lines on forewings dark on yellowish specimens; lines on darker specimens appearing light or dark, depending on the background color. Lines often with a few small indentations along the veins, but not deep enough so they meet to cut off "islands." Median, inner, and outer areas about same color; median area sometimes slightly darker, inner area sometimes slightly lighter. Hindwings about same color as median band on forewing, usually unmarked, but occasionally crossed with a faint, contrasting line. Lower surface of both forewings and hindwings about same color as upper surface; both forewings and hindwings crossed by a single contrasting line which may be faint; pale specimens may have the region inside this line darker than the outside region.

MALE TERMINALIA (figs. 18, 43, and 63).—As described for *M. incurvum* (page 170), and indistinguishable from those of *M. californicum*.

ADULT FEMALES (figs. 288, 289).—Color varying from yellowish to medium brown to dark chocolate-brown. Lines on forewings light or dark, usually with some small light indentations, but not indented sufficiently to cut off "islands"; veins sometimes covered with darker scales than surrounding area. Median area usually same color as inner and outer areas, but sometimes darker. Hindwing about same color as median area of forewing. Lower surface of both forewings and hindwings same color as upper surface. Both forewings and hindwings crossed by a single contrasting line, with the region inside the line sometimes darker than outside region, especially on light specimens.

FEMALE TERMINALIA (fig. 96).—As described for *M. incurvum* (page 170), and indistinguishable from those of *M. californicum*.

ADULT DIAGNOSIS.—At the present time this is the only large tentbuilder recorded from Mexico, but *M. californicum* most certainly occurs in parts of Mexico. There are no known structural characters which will separate *M. incurvum aztecum* from *M. californicum*, and any differences in color patterns are as yet unknown since no specimens of *californicum* have been collected in Mexico. The only other species of *Malacosoma* known to occur in Mexico (outside of Baja California where *M. constrictum austrinum* must occur) is *M. tigris* which is easily identified in all life stages by the characters given for it (page 102).

MATURE LARVAE.—Only a few preserved larvae have been available, so the following description cannot include all the variation that undoubtedly exists. The specimens available are most similar to figures 391 and 394. Head blue, mottled with black, sparsely covered with fine whitish to blackish setae. Middorsal area black, with only a few faint orange markings. A very faint, narrow, broken, bluish-white middorsal stripe may be present on some specimens. Addorsal area black on all specimens examined. Subdorsal area black. Posterior subdorsal spot sometimes present as a small blue-white mark. Subdorsal line absent, or present as a yellowish mark on each segment. Supraspiracular area black with a few faint, irregular, bluish-gray markings and some whitish-gray areas around the SV setal groups. Ventral area entirely black, but some specimens will no doubt be found with gray-white ventral areas and dark median spots. Both primary and secondary dorsal setae pale golden orange. Primary and secondary lateral setae white, or yellowish in some specimens, and tufted around setal group L2.

LARVAL DIAGNOSIS.—To date, the only species known to occur in the same area is *M. tigris* (page 105), which is identified by the characters given for it. (Larvae of *tigris* from Mexico have not been examined, but they should not be greatly different from those found in the United States.) All larvae of *i. aztecum* which have been examined to date are similar to the dark phase of *i. incurvum* (figs. 391 and 394) which is present to a certain extent in populations of *i. incurvum* found in southern Arizona. Ancona (1930) discusses some light-colored larvae which he observed with darker larvae, but neither his descriptions nor his illustrations are good enough to determine if they are similar to larvae found in southern Arizona.

EGG MASSES (fig. 114).—Only five egg masses have been examined, but all were laid as a basically flat, clasping mass, and all were covered with dark brown spumaline which contained no specks. They are virtually identical in color and other respects to a few egg masses with dark spumaline obtained from reared specimens of *i. incurvum* collected at Tucson, Arizona (Coll. No. 202). However, it would not be surprising to find egg masses covered with lighter colored spumaline in populations of *i. aztecum* because of the variability found in the spumaline of *i. incurvum* (page 172).

TENTS.—The only tent examined to date is a poor one in the United States National Museum, but it is large, and similar to those constructed by other populations of *M. incurvum*, and by *M. californicum* and *M. americanum*.

COCOONS.—Only a few cocoons have been examined. They are fairly tightly constructed, with little or no outer envelope of silk, and are dusted with a whitish powder. Ancona (1930) reported yellowish powder on the cocoons he examined.

FOOD PLANTS.—It has been collected from *Salix lasiolepis*, *Prunus capulis*, willow, trembling aspen and ocean spray (*Holodiscus* sp.). Ancona (1930) reported it from *Salix mexicana* and *Salix bomplanidiana*. In this respect *i. aztecum* is quite similar to *M. incurvum incurvum* which commonly occurs on both *Salix* and *Prunus* in southern Arizona, in addition to cottonwood. The records from willow, trembling aspen, and ocean spray are from an area 6–10 miles W. of El Salto, Durango.

TYPE.—Lectotype, here designated, a male in the United States National Museum. USNM Type No. 33657. Size: 27 mm. wingspread. Data: *Clisiocampa azteca* Neumoegen, male, Type; typicum specimen; City-Mexico; Lectotype, *Malacosoma aztecum* (Neumoegen), male, F. W. Stehr 1963. Genitalia in microvial labeled: Lectotype, *Malacosoma aztecum* (Neumoegen), male genitalia, F. W. Stehr 1963.

TYPE LOCALITY.—Mexico City, D. F., Mexico.

PARALECTOTYPES.—One male, two females in the USNM.

DISTRIBUTION.—It has been reported from several states in Mexico, including Tlaxcala, Puebla, Chihuahua, Durango, Vera Cruz, and the Distrito Federal. It undoubtedly occurs in many other places in the central Mexican plateau, but it remains to be seen whether some form of *M. californicum* will be found in the same areas, and how much intergradation or isolation is present.

COMMENTS.—In nearly every respect (hosts, egg masses, larvae, adults) *aztecum* is more similar to *M. incurvum* than to any known populations of *M. californicum*. Despite the great similarity to *incurvum*, the available egg masses, larvae, and adult males of *aztecum* differ from the majority of the egg masses, larvae, and adult male *incurvum incurvum* found in Arizona. Some populations of *incurvum incurvum* in southern Arizona, however, contain a variable percentage of individuals which are quite similar to corresponding life stages of *aztecum*. These include: (1) The egg masses which are covered with dark spumaline, similar to figure 114 (most egg masses of *i. incurvum* are covered with whitish spumaline similar to fig. 117). (2) The darker, blacker larvae similar to figures 391 and 394 (most larvae of *i. incurvum* are lighter and bluer as in figs. 390, 392, and 393). (3) The darker males similar to those in figures 291 and 295 (most males of *i. incurvum* are lighter as in figs. 292, 294, 297, and 298). Neumoegen's *aztecum* is regarded as conspecific with *incurvum* because of these similarities, as well as similarities between adult females and preferred hosts. It is regarded as a subspecies because of the differences in some life stages between it and the majority of specimens of *i. incurvum* found in Arizona, and because of the almost total lack of specimens or data from the large area lying between Mexico City and the United States border.

The only specimens available from this area (except for a single male from Chihuahua) are a group of 64 adults, 11 larvae, and 3 egg masses in the Canadian National Collection collected 6–10 miles west of El Salto, Durango, on ocean spray (*Holodiscus* sp.), willow, and trembling aspen. The adults are dark like those from Mexico City, and the larvae are very similar to larvae from the Mexico City area. The egg masses are covered with very dark spumaline containing no specks and cocoons have a whitish powder similar to that of *incurvum* cocoons from all areas. In every respect these specimens are more similar to specimens from the Mexico City area than most specimens from Arizona, so they are regarded as *M. incurvum aztecum*. Many more reared collections from Mexico are needed.

Adult *Malacosoma* from the vicinity of Mexico City can be segregated into a dark brownish group described as *Clisiocampa azteca* (figs. 287 and 289) by Neumoegen in 1893 (including uniform brown specimens called the variety *unicolor* by Hoffman, but apparently never published), and a light yellowish group described by Dyar in 1907 as *Clisiocampa luteimargo* (figs. 285 and 288). Both male and female *luteimargo* are identical to *aztecum* in every respect except color. Dyar indicated in the original description of *luteimargo* that it occurred with *aztecum*, and there is a note on one specimen of *luteimargo* in the USNM indicating that specimens like *luteimargo* make up about 2 percent of the specimens collected with typical *aztecum*.

Ancona (1930) regarded *luteimargo* as a variety of *aztecum*. He examined 280 adult specimens (apparently reared) and found the following percentages of color phases: Uniform light brown (variety *unicolor*)—8 percent; dark brown with a blackish band separated from the external margin of the forewing by a narrow lighter line (apparently similar to fig. 286)—54 percent; lighter brown with two whitish lines on the forewings (similar to "typical" *aztecum*, figs. 287 and 289)—33 percent; yellowish specimens with a dark band—4 percent; yellowish specimens with dark lines (similar to *luteimargo*, figs. 285 and 288)—2.5 percent.

He also noted that the variety *unicolor* had black eyes, the variety *luteimargo* had pale yellowish eyes, and the most abundant forms had brownish eyes, or were intermediate between the other extreme types. The eye color of pinned specimens which have been examined does not appear to be correlated with overall color, but the colors may have changed after death. Pale yellowish specimens of *M. tigris* (figs. 171 and 172) and *M. californicum* (figs. 213, 228, 233, 238, 243, and 248) have dark eyes, but the eye color of these was not checked when they were alive.

Ancona indicated that cocoons subjected to 28° C. produced abundant yellowish moths, but they were not as pale as the typical *luteimargo*. Some of the palest individuals may be true albinos, but many of them may be the result of temperature effects similar to those suggested by Ancona. Pale yellowish adults similar to those Dyar described as *luteimargo* were not obtained from any of the collections of *M. incurvum* reared during this study, and they were not present among museum specimens from areas other than the Mexico City area. Therefore, it seems most likely that the *luteimargo* type of adult is the phenotypic expression of gene combinations peculiar to the Mexico City area as far as presently known, and whose expression may be influenced by temperature or other factors. None of them appear to be true albinos, since there is some pigment in all of them. For the above reasons *luteimargo* is regarded as a color phase of *M. incurvum aztecum*.

SPECIMENS EXAMINED.—205 (Museum specimens—100 males, 50 females, 55 larvae, and 5 egg masses).

MEXICO.—DISTRITO FEDERAL: City Mexico; Mexico City; Tacubaya; Tacubaya, 653; Xochimilco; S. Angel; Tlalpam; San Pedro de los Pinos; Santa Maria. TLAXCALA: Huamantla. VERACRUZ: Jalapa. DURANGO: Durango; 10 mi. W. El Salto; 6 mi. W. El Salto. CHIHUAHUA.—Chihuahua. NO SPECIFIC LOCALITY.—"Mexique"; "Mexico"; "Mex."

The Palearctic Species and a Brief Comparison with the North American Species

A few adults and larvae of *M. neustrium* (L.), *M. castrensis* (L.), and *M. franconicum* Esper have been available for study. A detailed study of these species and their variability has not been possible, nor has a complete survey of the extensive European literature on *Malacosoma* been undertaken. Insufficient positively identified specimens of a fourth described European species of questionable status, *M. alpicola* (Staudinger), were available so it has not been included. It seems to be very close to *franconicum*, however. Specimens of *neustrium* and *castrensis* supposedly collected in North America have been seen among museum specimens, but the data on all of these specimens is questionable, or they have been reared from egg masses found on imported nursery stock.

The most interesting of these specimens are the more than 70 *M. neustrium* in the Illinois Natural History Survey Collection. They bear accession numbers indicating they were collected from three different localities in 1909. One collection was reared from larvae collected on apple leaves 24 April at New Burnside, Johnson County, Ill. by C. E. Sanborn. The second was reared from eggs found on rose at Chicago on 22 March by C. E. Sanborn. The third was reared from eggs found on mountain ash at Princeton, Bureau County, Ill., on 6 February by C. E. Sanborn. It is conceivable that all three collections could have come from imported nursery stock since they were all collected in the same year, but highly unlikely since the three localities are widely separated and three different hosts are involved. If the data are not suspect then it is possible that *M. neustrium* is established in the Midwest since *neustrium* tents and adults superficially resemble those of *M. americanum* and would most certainly not be regarded as different or unusual.

The following brief descriptions and diagnoses are included to make it easier to identify these species if they are found in North America, and to compare them with the North American species.

All three of these Palearctic species build large tents similar to those constructed by *M. americanum*, *M. californicum*, and *M. incurvum*, and all three feed on a wide variety of hosts, as do all of the Nearctic species except *M. tigris* and *M. constrictum* which are restricted to oaks. They are widely distributed in Europe, and at least one of them (*neustrium*) occurs throughout the Palearctic from England to Japan. The egg masses of all three apparently are laid as a helical band completely encircling small twigs or stems similar to the way *disstria*, *tigris*, and *constrictum* lay their eggs. The eggs are held in place by dark brown spumaline which may also thinly cover the eggs, but apparently the eggs are not covered with a thick layer of spumaline containing many bubbles as are the egg masses of all North American species except *tigris*. The spumaline of two egg masses of *neustrium* from Korea which have been examined did not contain any specks. The cocoons of all three species apparently are similar to those constructed by the North American species, and are dusted with a yellowish powder.

Larvae of all three species have color patterns different from any of the North American species, but they, too, show much variation. All three usually have a nearly continuous, narrow, middorsal whitish or bluish-white stripe which will immediately separate them from all North American species except *americanum* and a few rare individuals of *californicum*. Larvae of *neustrium* are separated easily from *americanum* by the presence of a conspicuous pair of black dorsal humps on abdominal segment eight. In addition, the average number of setae in setal group D1 is four and in setal group L2 is two on abdominal segments 3–6 for *neustrium*. *M. disstria* is the only North American species with setal counts like this. All other North American species average five setae in D1 and three in L2. Only a few inflated larvae of *castrensis* (six) and *franconicum* (one) have been available, but these specimens have mottled blue and black heads. This immediately distinguishes them from *americanum* which has a black head. The number of setae in setal group L2 averaged three for *castrensis* and *franconicum*, which is the same as all species except *disstria* and *neustrium*. The number in D1 was usually six for *castrensis* and five or six for *franconicum*, which is greater than the four or five found in other species.

Adults of both *neustrium* (figs. 321–323, 324, and 327) and *castrensis* (figs. 325 and 326) are reported to be as highly variable as the North American species, with colors ranging from pale yellow to dark reddish-brown, and with variable lines on the forewings, or rarely none at all. Adult *franconicum* (figs. 328 and 329) apparently are not as highly variable, and they are unusual in having somewhat transparent wings, with clearly outlined veins covered by dark scales, and in having no lines on the forewings or relatively indistinct ones.

Adult male *neustrium* easily can be identified by their large, distinctive epiphysis which is like that of North America's *disstria* (fig. 75). The epiphysis of male *castrensis* and *franconicum* is either small or absent. However, the male terminalia of *neustrium* (figs. 27, 52, and 72) are closer to those of *castrensis* (figs. 28, 53, and 73) and *franconicum* (figs. 29, 54, and 74) than they are to those of *disstria* (figs. 12, 37, and 57).

The few male *castrensis* which have been examined can be separated from male *franconicum* which have been examined by their small epiphysis (absent or minute on *franconicum*) or by genitalic differences (relatively slight and of unknown constancy), but they are most easily separated by the differences in wing scales which are more fully discussed in the next paragraphs on females.

The female terminalia of all three Palearctic species are quite similar. The genital plate is unsclerotized except for a narrow arch just anterior to the ostium. The ovipositors of all three species are virtually identical, and differ from all North American species by lacking a distinct ventral lobe in combination with a pronounced dorsal lobe (fig. 104). The ovipositor is relatively small when compared with those of North American species, and is closest to that of *M. tigris* (fig. 84) in size and shape.

Female *neustrium* can be easily separated from *castrensis* and *franconicum* by the length of the antennal rami. At a point halfway to the antennal tip, the rami of *neustrium* are approximately twice as long as the diameter of the flagellar segment from which they arise (fig. 55); those of *castrensis* and *franconicum* are approximately as long as the diameter of the flagellar segment from which they arise (fig. 56). No good characters for separating female *castrensis* from *franconicum* were found except for differences in the wing scales. Two basic kinds of scales are present on the wings of both species—long, hairlike ones and flattened, shinglelike ones. Both kinds are numerous on the wings of *castrensis*, and they completely obscure the wing membrane. On the wings of *franconicum* both kinds of scales are smaller and less numerous except along the veins, and the wing membrane is easily visible between the scales, especially near the center of the wing. This makes it appear somewhat transparent. In addition, many of the shinglelike scales are less heavily pigmented and stand at right angles to the wing membrane on *franconicum*, thereby increasing the transparency of the wing. These characteristics are even more striking in male *franconicum*.

From this short summary of differentiating characteristics and basic similarities, it can be seen that these three Palearctic species form a group of species which are more closely related to each other than any of them is to any of the North American species. This is particularly evident when it is pointed out that all three lay helical egg masses and build large tents—a combination that is not found in any North American species. In addition, the ovipositors of females are similar, but different from any North American species, and the male terminalia are more similar to each other than to any of the North American males. Perhaps *M. neustrium* is closest to the North American *M. disstria*, and *M. castrensis* and *M. franconicum* are closest to the North American *M. tigris*, but they are still very distant.

The Relationships Between the North American Species

When everything is considered, the North American species fall into two groups. One group is made up of *disstria*, *tigris*, and *constrictum*. The most important similarities are that all three lay helical egg masses, build little or nothing in the way of a tent, have their forewings crossed by lines which are darker than the background color, and have females with relatively small ovipositors. Within this group *disstria* is alone in building no tent at all, having a large, distinctive epiphysis (especially males), having females with a distinctive, sclerotized genital plate, and in feeding on many different hosts. The most important similarities between the two other species, *tigris* and *constrictum*, are their restriction to oaks, construction of small tents each time they molt which are used only for attachment during molting, and having dark colored females and light males. As far as differences are concerned, they occur in different geographic areas, and differ in genitalic characters, but the biggest difference is in the egg masses, which are covered with bubbles of yellowish spumaline by *constrictum*, but which are essentially not covered with spumaline by *tigris*.

The second North American group is made up of *americanum*, *incurvum*, and *californicum*. All three lay clasping egg masses, construct large tents, usually have the forewings crossed by light lines (but sometimes the reverse is true in some individuals and populations of *californicum* and *incurvum*), and have females with relatively large ovipositors. Within this group *californicum* and *incurvum* are very closely related, and *americanum* stands alone, differing in the ways pointed out in the diagnoses (pages 112, 113).

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Illustrations

Figure 1

Distribution of *M. disstria* and *M. tigris*. Individual localities for *disstria* have not been plotted for the eastern states solidly covered with circles, but it should be found throughout all of them.

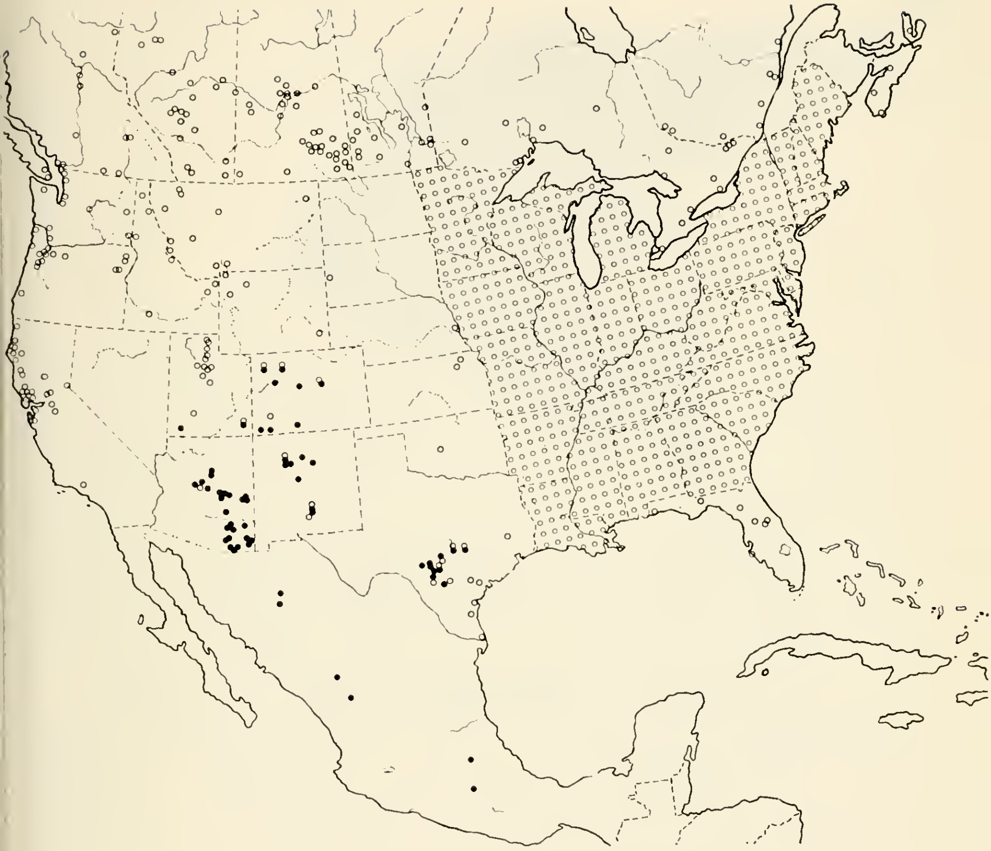


Fig. 1

○ *Malacosoma disstria*

● *Malacosoma tigris*

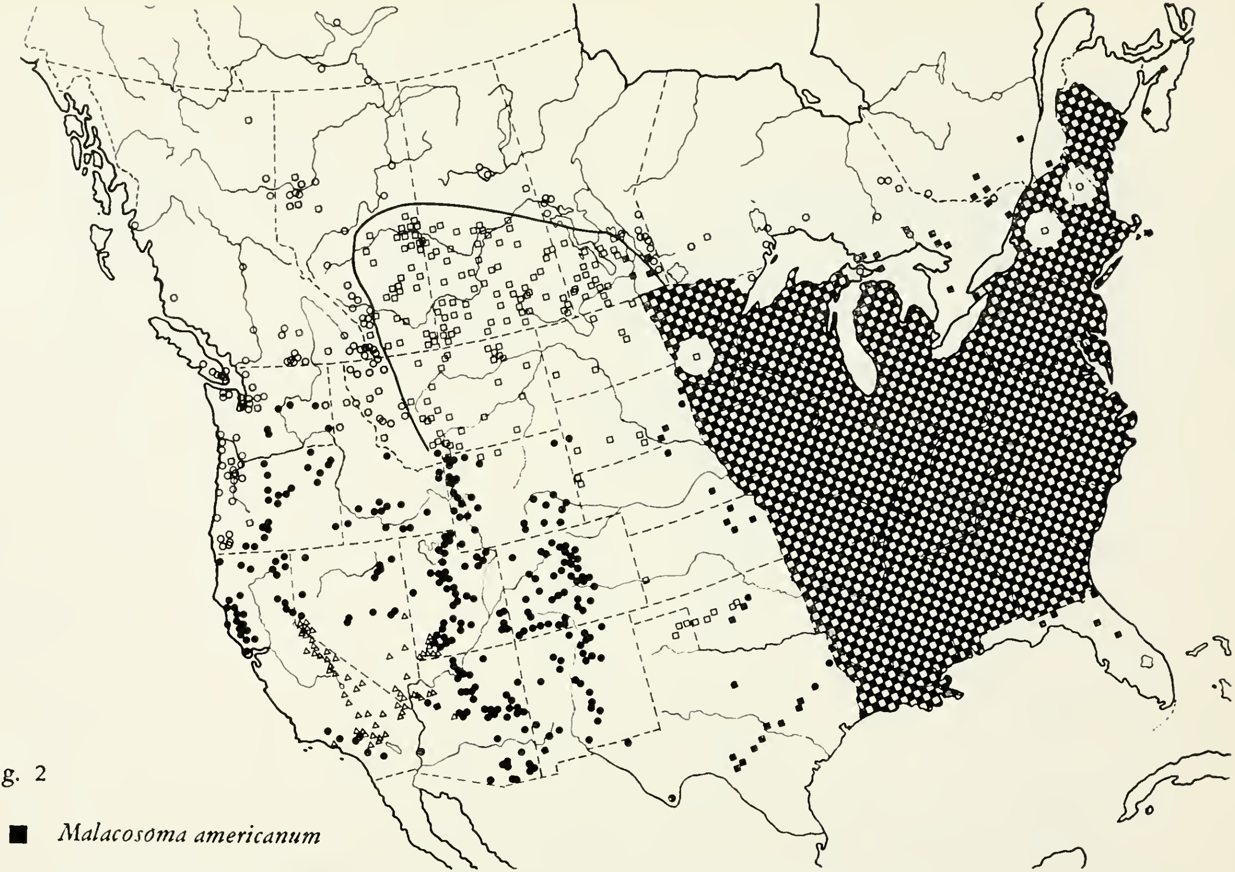


Fig. 2

■ *Malacosoma americanum*

○ *Malacosoma californicum pluviale*

□ *Malacosoma californicum lutescens*

△ *Malacosoma californicum fragile*

● *Malacosoma californicum* - central populations

Figure 2

Distribution of *M. americanum*, *M. californicum* (central populations), *M. californicum pluviale*, *M. californicum lutescens*, and *M. califoricum fragile.*

See figure 3 for the distributions of *M. californicum californicum*, *M. californicum ambisimile*, and *M. californicum recenseo.*

Individual localities for *americanum* have not been plotted for the eastern states which are solidly checkered, but it should be found throughout all of them.

Note the collections of *M. californicum pluviale* in New Hampshire, New York, the Upper Peninsula of Michigan, and northeastern Minnesota, and of *M. californicum lutescens* in west-central Minnesota.

Figure 3

Distribution in California of *M. californicum* and the subspecies *M. californicum californicum*, *M. californicum ambisimile*, *M. californicum recenseo*, and *M. californicum fragile*.

See figure 6 for a more detailed map of part of the distribution of *M. californicum californicum* and *M. californicum ambisimile*.

lg. 3

● *Malacosoma californicum* - central populations

☐ *Malacosoma californicum californicum* ○ *Malacosoma californicum recenseo*

■ *Malacosoma californicum ambisimile* ▲ *Malacosoma californicum fragile*

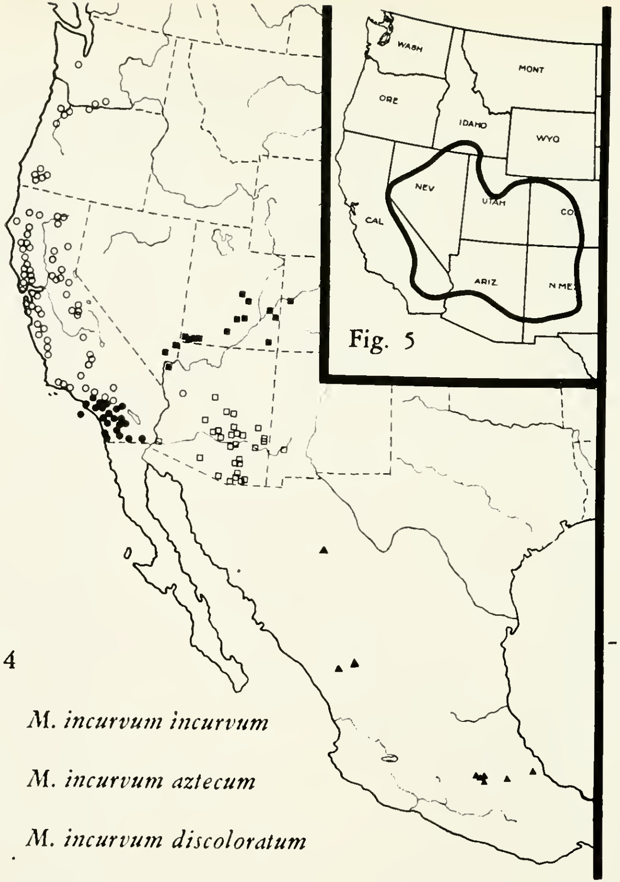


Fig. 4

☐ *M. incurvum incurvum*

▲ *M. incurvum aztecum*

■ *M. incurvum discoloratum*

○ *M. constrictum constrictum*

● *M. constrictum austrinum*

Fig. 5

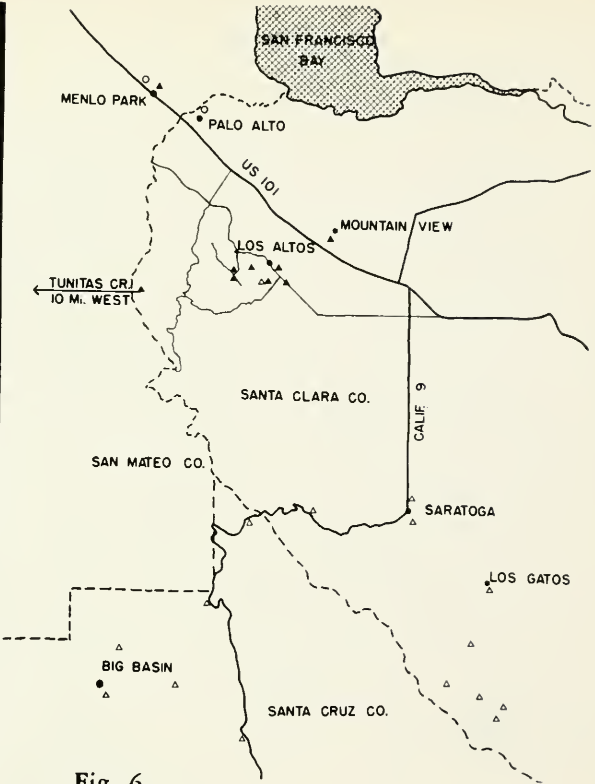


Fig. 6

○ *M. californicum californicum*

△ *M. californicum ambisimile*

▲ Colonies intermediate between *M. c. californicum* and *M. c. ambisimile*

Figures 4–6

4. Distribution of *M. constrictum constrictum*, *M. constrictum austrinum*, *M. incurvum incurvum*, *M. incurvum discoloratum*, and *M. incurvum aztecum*.

5. The heavy black line outlines the area within which populations of *M. californicum* have been found which have specks in the spumaline. See the introductory section on egg masses for a discussion of the specks (page 20).

6. Detailed map of larval collections of *M. californicum californicum*, *M. californicum ambisimile*, and intermediate populations where their ranges meet in California. See discussion of *M. californicum ambisimile* (page 144).

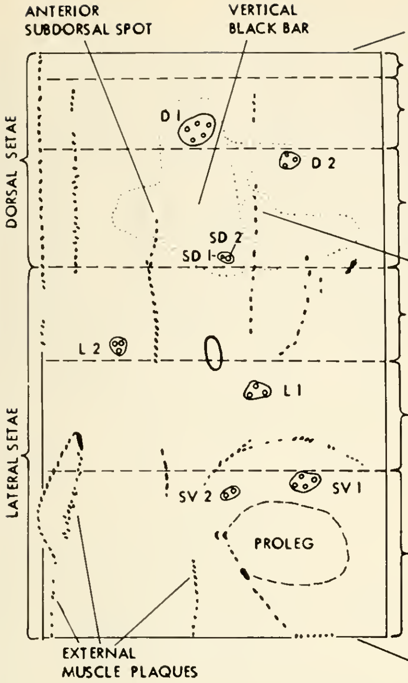
Figures 7–11

7, 8. Generalized setal map of third abdominal segment of *Malacosoma*. See discussion of larvae in text (page 39) and figure 9.

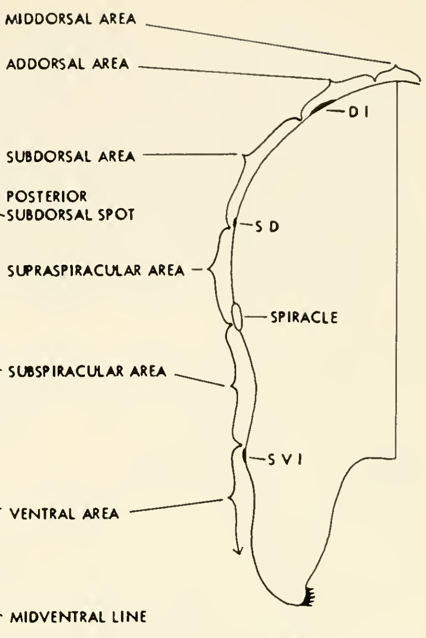
9. The "torso" mark found in some populations of *M. californicum*, especially *M. californicum pluviale*. Compare with figure 7 and figures 358, 364, 365, 370–372.

10. Wing venation of *Malacosoma*, showing terminology and other features.

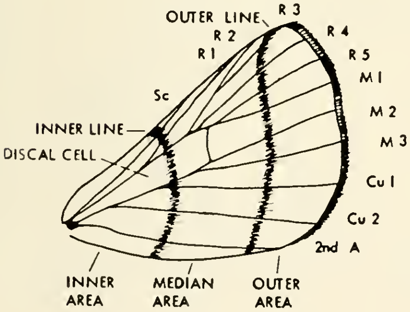
11. Diagrammatic representation of the relationships of the components which make up the larval color pattern. See discussion of larval color pattern in text (page 41).

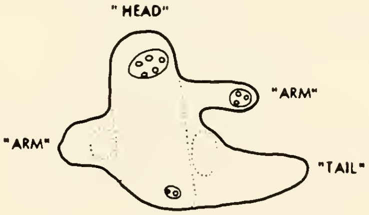

ANTERIOR SUBDORSAL SPOT
VERTICAL BLACK BAR
MIDLINE
DORSAL SETAE
D 1
D 2
SD 2
SD 1
POSTERIOR SUBDORSAL SPOT
L 2
L 1
LATERAL SETAE
SV 2
SV 1
PROLEG
EXTERNAL MUSCLE PLAQUES
MIDVENTRAL LINE

7

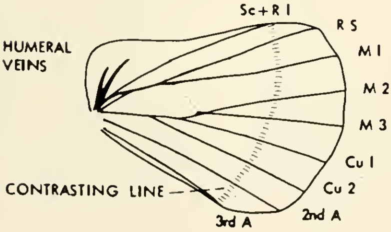

MIDDORSAL AREA
ADDORSAL AREA
D 1
SUBDORSAL AREA
S D
SUPRASPIRACULAR AREA
SPIRACLE
SUBSPIRACULAR AREA
S V 1
VENTRAL AREA

8

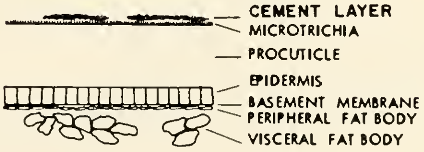

OUTER LINE
R 3
R 2
R 4
R 1
R 5
M 1
Sc
M 2
INNER LINE
M 3
DISCAL CELL
Cu 1
Cu 2
2nd A
INNER AREA
MEDIAN AREA
OUTER AREA


"HEAD"
"ARM"
"ARM"
"TAIL"

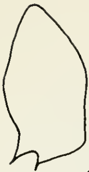
9


Sc+R 1
R S
HUMERAL VEINS
M 1
M 2
M 3
Cu 1
CONTRASTING LINE
Cu 2
3rd A
2nd A

10


CEMENT LAYER
MICROTRICHIA
PROCUTICLE
EPIDERMIS
BASEMENT MEMBRANE
PERIPHERAL FAT BODY
VISCERAL FAT BODY

11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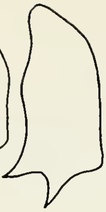
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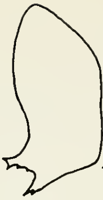
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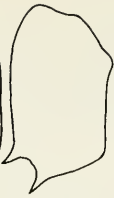
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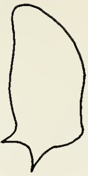
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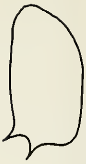
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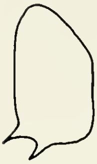
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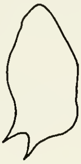
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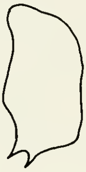
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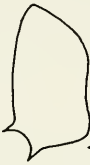
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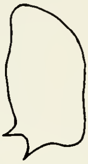
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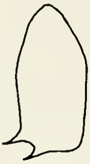
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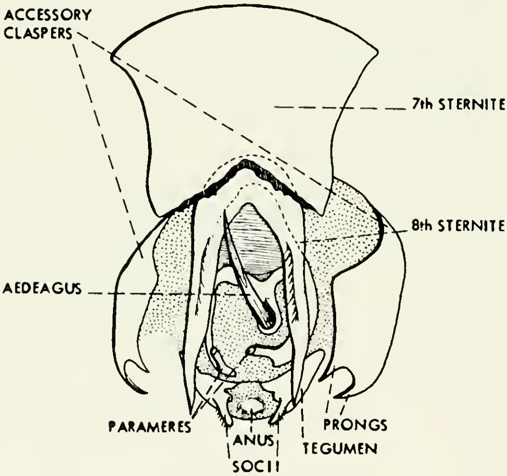

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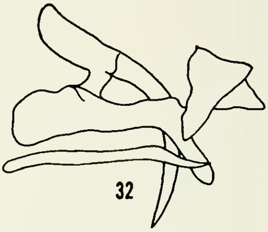
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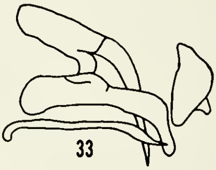
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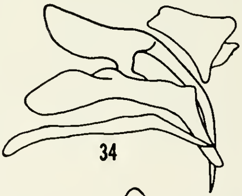
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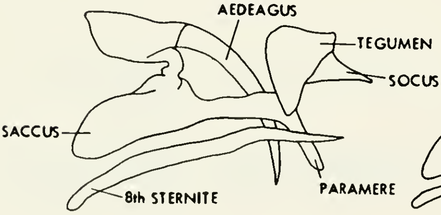

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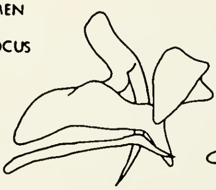
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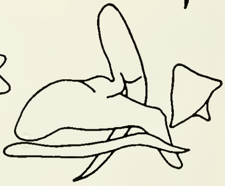

36

Figures 12–36

12–29. Right accessory claspers of males, all drawn to the same scale from males with wingspread of 25–27 mm., except figures 27–29 (27 was 31 mm., 28 was 28 mm., 29 was 21 mm.). The left accessory claspers are similar. There is considerable variability in the accessory claspers of a species or even subspecies. For example, some specimens of *M. tigris* may have evenly tapered prongs rather than the more common jagged type (fig. 14). Note, however, the great overall similarity between figures 16–26 (the closely related species *M. incurvum* and *M. californicum*) and figures 27–29 (Palearctic species) when compared with figures 12, 13, 14, and 15 (other distinct North American species). See also figures 37–54 and 57–74 for a comparison of other genitalic structures from the same specimens.

12. *M. disstria.*
13. *M. constrictum constrictum.*
14. *M. tigris.*
15. *M. americanum.*
16. *M. incurvum incurvum.*
17. *M. incurvum discoloratum.*
18. *M. incurvum aztecum.*
19. *M. californicum californicum.*
20. *M. californicum ambisimile.*
21. *M. californicum recenseo.*
22. *M. californicum pluviale*, Seattle, Washington.
23. *M. californicum pluviale*, Alberta (bog population).
24. *M. californicum lutescens*, Saskatchewan.
25. *M. californicum lutescens*, Oklahoma.
26. *M. californicum fragile.*
27. *M. neustrium.*
28. *M. castrensis.*
29. *M. franconicum.*
30. Male terminalia, *M. americanum*, ventral aspect, showing the relationships of the individual structures.

31–36. Male genitalia, lateral aspect, all drawn to the same scale from males with a wingspread of 25–27 mm. The very lightly sclerotized and membranous areas which connect the parts are not shown.

31. *M. americanum.*
32. *M. tigris.*
33. *M. disstria.*
34. *M. constrictum.*
35. *M. incurvum.*
36. *M. californicum.*

Note the large size of *americanum* compared with *incurvum* and *californicum*, and the small size of *disstria* compared with the others.

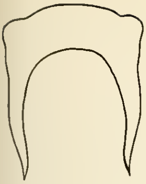
Figures 37–56

37–54. Eighth sternites of male genitalia, ventral aspect, all drawn to the same scale from males with wingspread of 25–27 mm., except figures 52–54 (52 was 31 mm., 53 was 28 mm., 54 was 21 mm.). Note the distinctive shape and/or size of *disstria*, *constrictum constrictum*, *tigris*, and *americanum*, and the minor variations on a single basic shape shown by *incurvum* (figs. 41–43) and *californicum* (figs. 44–51). Variations as great as these may be found within a subspecies, so the eighth sternite (and other genitalic structures) cannot be used for identification of infraspecific taxa. See also figures 12–29 and 57–74 for a comparison of other genitalic structures from the same specimens.

37. *M. disstria.*
38. *M. constrictum constrictum.*
39. *M. tigris.*
40. *M. americanum.*
41. *M. incurvum incurvum.*
42. *M. incurvum discoloratum.*
43. *M. incurvum aztecum.*
44. *M. californicum californicum.*
45. *M. californicum ambisimile.*
46. *M. californicum recenseo.*
47. *M. californicum pluviale*, Seattle, Washington.
48. *M. californicum pluviale*, Alberta (bog population).
49. *M. californicum lutescens*, Saskatchewan.
50. *M. californicum lutescens*, Oklahoma.
51. *M. californicum fragile.*
52. *M. neustrium.*
53. *M. castrensis.*
54. *M. franconicum.*

Note the greater similarity of *franconicum* to *castrensis* than to *neustrium* (except for size).

55. Median antennal segments of female *neustrium.*
56. Median antennal segments of female *castrensis.* Female *franconicum* are similar.



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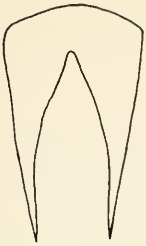

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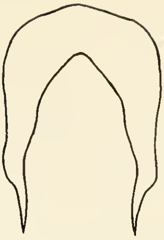

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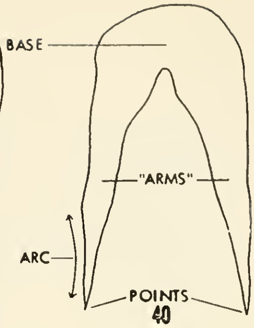

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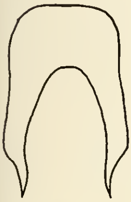

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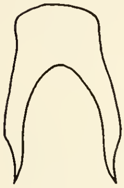

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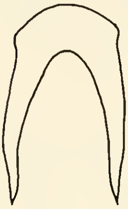

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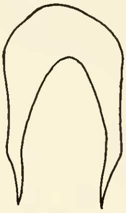

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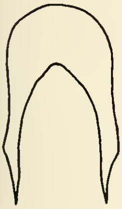

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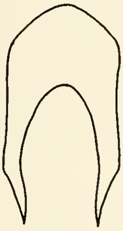

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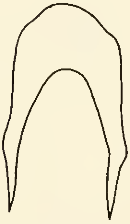

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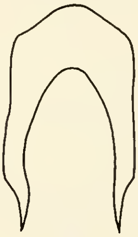

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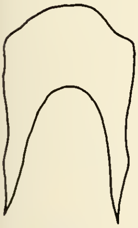

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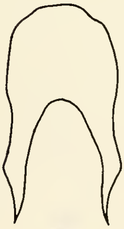

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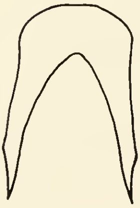

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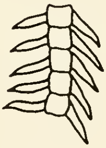

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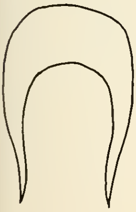

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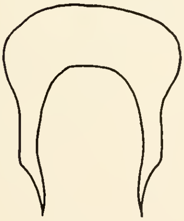

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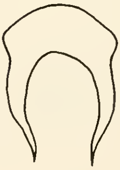

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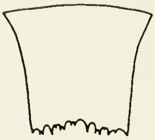
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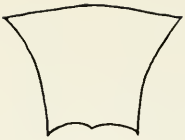
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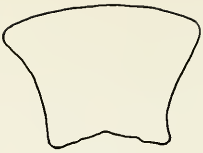
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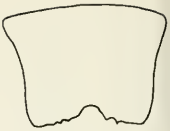
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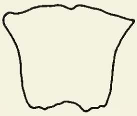
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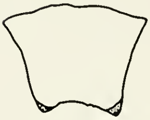
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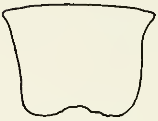
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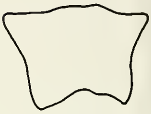
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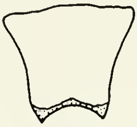
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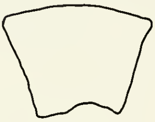
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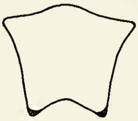
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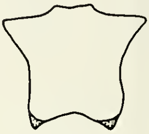
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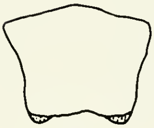
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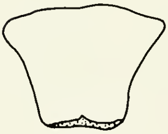
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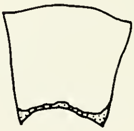
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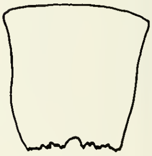
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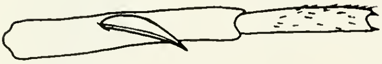
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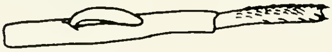
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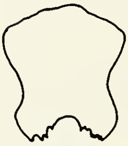
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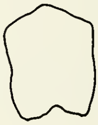
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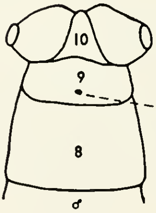

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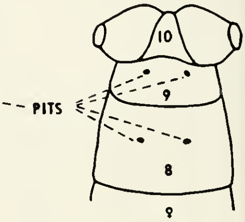

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Figures 57–80

57–74. Seventh sternites of male genitalia, ventral aspect, all drawn to the same scale from males with wingspread of 25–27 mm., except for figures 72–74 (72 was 31 mm., 73 was 28 mm., 74 was 21 mm.). The stippled areas near the lower edge of figures 61–71 represent areas which are incompletely sclerotized. This trait may often be found in all populations of *incurvum* and *californicum*, but is rarely found in other species.

57. *M. disstria.*
58. *M. constrictum constrictum.*
59. *M. tigris.*
60. *M. americanum.*
61. *M. incurvum incurvum.*
62. *M. incurvum discoloratum.*
63. *M. incurvum aztecum.*
64. *M. californicum californicum.*
65. *M. californicum ambisimile.*
66. *M. californicum recenseo.*
67. *M. californicum pluviale*, Seattle, Washington.
68. *M. californicum pluviale*, Alberta (bog population).
69. *M. californicum lutescens*, Saskatchewan.
70. *M. californicum lutescens*, Oklahoma.
71. *M. californicum fragile.*
72. *M. neustrium.*
73. *M. castrensis.*
74. *M. franconicum.*

75–78. Tibia and first tarsal segment of left foreleg.

75. Male *M. disstria*, showing characteristically shaped epiphysis which is always present. Male *M. neustrium* have a similarly shaped epiphysis.

76. Female *M. disstria*, showing characteristically shaped epiphysis which is usually present, but may be reduced or absent.

77. Male *M. incurvum incurvum*, showing an unusually large epiphysis for this species. It may be smaller or even absent.

78. Male *M. americanum*, showing the normal epiphysis.

79–80. Diagrammatic representation of the location of the pits used in sexing larvae, showing ventral aspect of terminal abdominal segments.

79. Male.
80. Female.

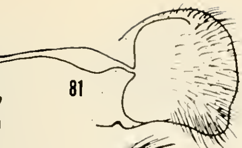
Figures 81–104

83, 90, 95, 102—female genital plates.
82, 85, 87, 89, 92, 94—caudal aspect of ovipositors (setae not shown).
All other figures—lateral aspect of ovipositors.

All drawings are to the same scale from females having a wingspread of 34–37 mm.

Note that the ovipositors of *incurvum* and *californicum* are much more similar to *americanum* than to any of the other species.

81. *M. disstria.*
82. *M. disstria*, caudal aspect.
83. *M. disstria*, genital plate. Note that ostium is centrally located.
84. *M. tigris.*
85. *M. tigris*, caudal aspect.
86. *M. constrictum constrictum.*
87. *M. constrictum constrictum*, caudal aspect.
88. *M. americanum.*
89. *M. americanum*, caudal aspect.
90. *M. americanum*, genital plate. Note that ostium is near the edge.
91. *M. californicum californicum.*
92. *M. californicum californicum*, caudal aspect.
93. *M. incurvum incurvum.*
94. *M. incurvum incurvum*, caudal aspect.
95. *M. incurvum incurvum*, genital plate, which varies from being heavily sclerotized to almost completely unsclerotized.
96. *M. incurvum aztecum.*
97. *M. californicum ambisimile.*
98. *M. californicum pluviale.*
99. *M. californicum recenseo.*
100. *M. californicum fragile.*
101. *M. californium lutescens.*
102. *M. californicum*, genital plate. In various populations of *californicum*, the genital plate may vary from being heavily sclerotized to completely unsclerotized.
103. *M. incurvum discoloratum.*
104. *M. neustrium.* Note the pronounced dorsal lobe and lack of a distinct ventral lobe. The ovipositors of both *M. castrensis* and *M. franconicum* are similar to *neustrium.*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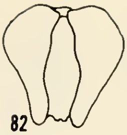
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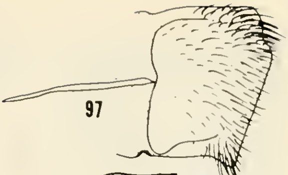
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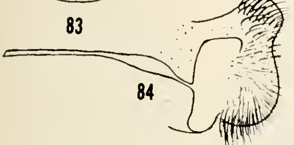
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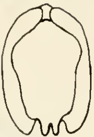
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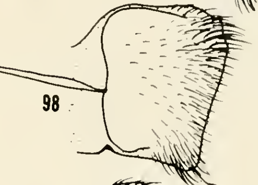
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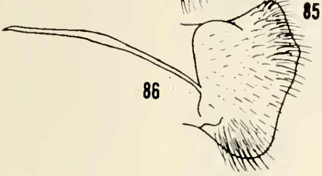
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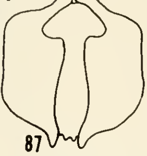
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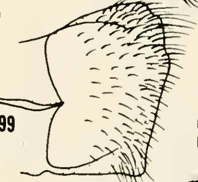
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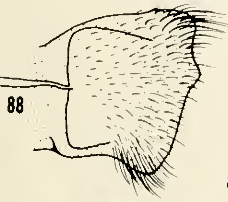
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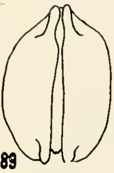
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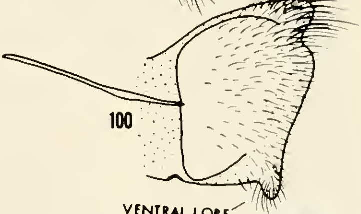

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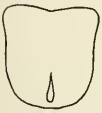
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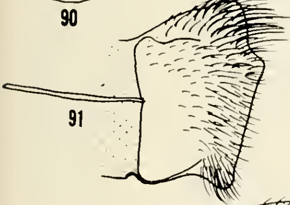
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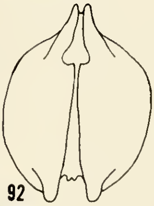
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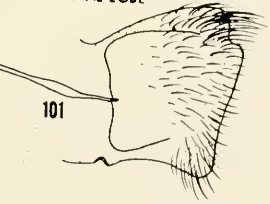
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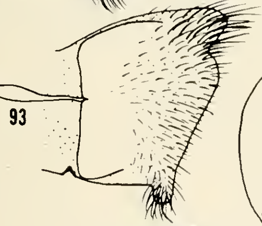
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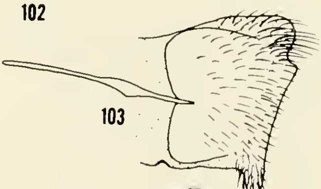
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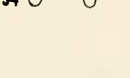
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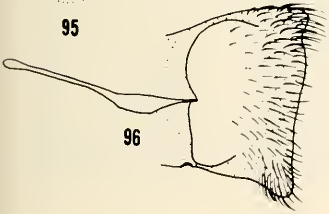
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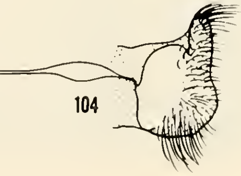
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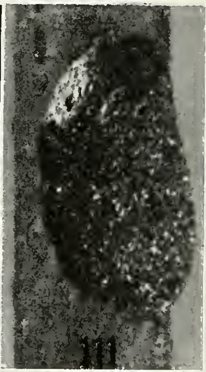
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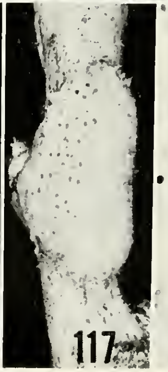
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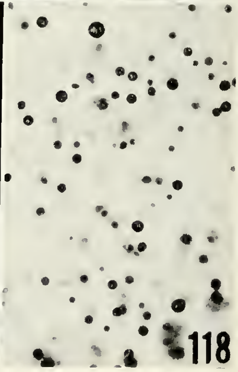

118

Figures 105–118

105. Two unhatched egg masses of *M. californicum pluviale* laid near base of trunk of a small tree. Brown spumaline. 2.5×.

106. Hatched egg mass of *M. tigris.* Note the lack of spumaline covering the eggs. 3.5×.

107. Unhatched egg mass of *M. constrictum austrinum*, somewhat smaller than normal. Top egg mass with spumaline removed. Note that the eggs are visible beneath the clear, yellowish spumaline. 2.5×.

108. Unhatched, abnormal egg mass of *M. disstria* with dark brown spumaline removed to show how the eggs are laid as a helical band. 4×. See figure 113.

109. Unhatched egg mass of *M. americanum* laid on a small twig, with dark brown spumaline partially removed to show the distinct beginning and end of the egg mass (on either side of the dark streak at the left side). The spumaline normally would obscure the beginning and end of an egg mass laid on a twig this small. Near Green Bay, Wisconsin. 1.5×.

110. Hatched egg mass of *M. americanum* laid on a larger branch, and clearly showing the beginning and end. The spumaline normally would not obscure completely the beginning and end of such an egg mass. Also note the much lighter color of the eggs when compared with figure 109, after at least one year of exposure under field conditions. Near Fredericksburg, Texas. 2.5×.

111. A nearly flat, unhatched egg mass of *M. americanum* laid near the base of the trunk of a small tree. The beginning and end are clearly visible. Near Grantsburg, Wisconsin. 2×.

112. Unhatched egg mass of *M. californicum* laid relatively flat on a large branch. Near Salt Lake City, Utah. 2×.

113. Normal, unhatched egg mass of *M. disstria.* 2.5×. See figure 108.

114. Unhatched egg mass of *M. incurvum aztecum* covered with the very dark brownish-black spumaline that also is found occasionally on egg masses of *M. incurvum incurvum* from southern Arizona. 2×. See figure 117.

115. Hatched egg mass of *M. californicum californicum* from near San Francisco Bay, California, showing individual emergence holes through the relatively collapsed, brown spumaline that frequently is found in Pacific Coast populations of *M. californicum.* 2×. See figure 116.

116. Hatched egg mass of *M. californicum* from central Nevada showing the lack of individual emergence holes in the spumaline. This situation is usually found in populations of *M. californicum* other than those from the Pacific coast. Some spumaline removed at left center. 2×. See figure 115.

117. Hatched egg mass of *M. incurvum incurvum* showing the pale, nearly white spumaline usually found on egg masses of *incurvum* in the United States. 2×. See figure 114.

118. Photomicrograph of hand-cut section of the spumaline contained in the reservoirs of the accessory glands of a preserved female *M. californicum fragile* from Morongo Valley, California, showing the specks. Note the variable size of those specks which are reasonably sharp, indicating the size is not constant. 320×.

Figures 119–139

All figures life size.

119–139. *M. disstria.*

119–127. All field-collected males from Lac Mondor, Ste. Flore, Quebec, showing the variation that may be found in a single population.

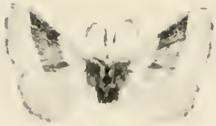
128, 129, 131, 132, 134, 135, 137. Other variations that may be found among males. Males similar to figures 123, 131, and 137 are most common, but males similar to figures 128, 134, and 135 are more common in the West than the East.

130, 133, 136, 138, 139. All females. Females similar to figures 130, 138, and 139 are most common in both East and West.

128. Male, 4 mi. N. St. Helena, Napa Co., California.
129. Male, Lethbridge, Alberta.
130. Female, Beaver, Utah.
131. Male, Forestville, Quebec.
132. Male, no data.
133. Female, Geraldton, Ontario.
134. Male, Corvallis, Oregon.
135. Male, Smokey Falls, Mattagami R., Ontario.
136. Female, Lac Mondor, Ste. Flore, Quebec.
137. Male, Lethbridge, Alberta.
138. Female, Medicine Hat, Alberta.
139. Female, Lac Mondor, Ste. Flore, Quebec.

Most of the illustrated specimens are from Canada because many more specimens were available from Canada than the United States, resulting in a greater chance of finding extremes in color pattern among them. Similar extremes, however, should be found in most populations in both the United States and Canada.


119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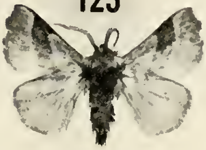
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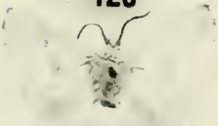
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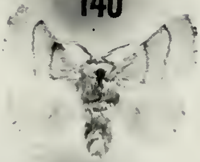
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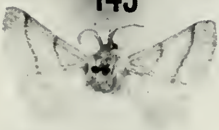
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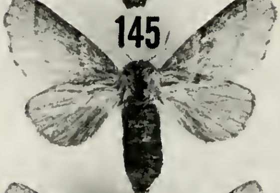
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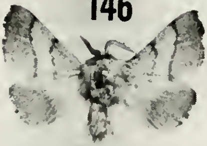
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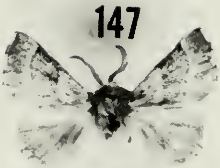
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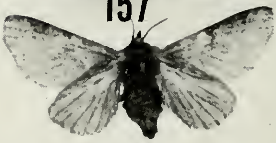
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Figures 140–160

All figures are life size.

140–151. *Malacosoma constrictum constrictum*, showing the variation that may be found. Specimens similar to figures 140, 141, 142, 143, and 148 are most common.

140. Male, Pacheco Pass, Santa Clara Co., California (Coll. 42).
141. Male, Eel R., Mendocino Co., California.
142. Female, Trinity Co., California.
143. Male, near Guerneville, California.
144. Male, Pacheco Pass, Santa Clara Co., California (Coll. 42).
145. Female, near Woodlake, Tulare Co., California (Coll. 111).
146. Male, Berkeley, California.
147. Male, Salem, Oregon.
148. Female, Paso Robles, California.
149. Male, Summerland, Santa Barbara Co., California.
150. Male, Paso Robles, California.
151. Female, near Guerneville, California.

152–160. *Malacosoma constrictum austrinum*, showing the variation that may be found. Specimens as light as figure 158 are rare.

152. Male, paratype, near Santa Ysabel, California (Coll. 26).
153. Male, paratype, near Santa Ysabel, California (Coll. 26).
154. Female, paratype, near Santa Ysabel, California (Coll. 26). Specimens 152–154 are slightly smaller than normal due to poor quality foliage used during part of rearing.
155. Male, Perris, California.
156. Male, Perris, California.
157. Female, Claremont, California.
158. Male, Perris, California.
159. Male, Warner's, California.
160. Female, Warner's, California.

Figures 161–181

All figures life size.

161–175. *M. tigris*, showing the extremes of variation that may be found. Specimens similar to figures 161, 162, 164, 166, 174, and 175 are most common.

161. Male, Madera Canyon, Santa Rita Mountains, Arizona.

162. Male, Glenwood Springs, Colorado.

163. Female, near Silver City, New Mexico.

164. Male, Rock Creek Canyon, Colorado.

165. Male, Guerrero Mill, Hidalgo, Mexico.

166. Female, no data.

167. Male, Matachic, Chihuahua, Mexico.

168. Male, Palos Colorados, Durango, Mexico.

169. Female, near Garner St. Park, Uvalde Co., Texas (Coll. 223).

170. Male, near Pine, Gila Co., Arizona.

171. Male, 20 mi. N. Leakey, Real Co., Texas (Coll. 226). A pale yellow, almost totally unmarked moth reared along with normally colored moths (figs. 174, 175). Slightly smaller than normal.

172. Female, same as 171.

173. Male, Mesa Verde Nat. Park, Colorado.

174. Male, 20 mi. N. Leakey, Real Co., Texas (Coll. 226). A normally colored male. See figures 171 and 172. Slightly smaller than normal.

175. Female, same as 174.

176–181. *M. californicum californicum*, showing common variations in color pattern. Specimens similar to figures 177 and 180 are most common.

176. Male, Concord, California.

177. Male, Concord, California.

178. Male, 10 mi. N. San Jose, California (Coll. 74).

179. Female, Mill Valley, California.

180. Female, near Martinez, California (Coll. 5).

181. Female, Belmont, California (Coll. 8).


161


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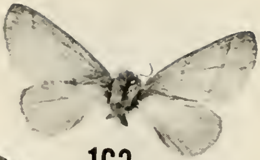
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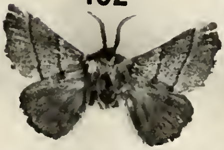
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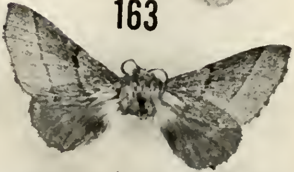
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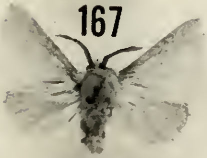
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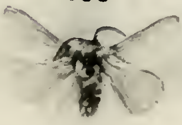
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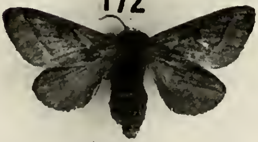
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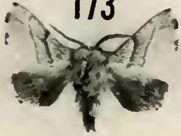
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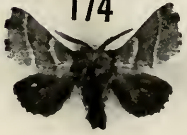
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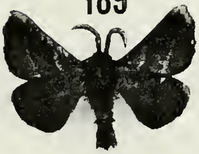
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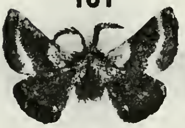
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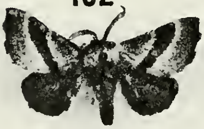
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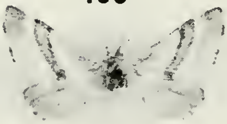
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Figures 182–202

All figures life size.

182–187. *M. californicum ambisimile*, showing variations in color pattern. Specimens similar to figures 183, 184, 186, and 187 are most common.

182. Male, Morgan Hill, California (Coll. 40).
183. Male, 5 mi. W. Saratoga, California.
184. Male, 3 mi. SE. Big Basin, California.
185. Female, 3 mi. SE. Big Basin, California.
186. Female, Morgan Hill, California (Coll. 40).
187. Female, Morgan Hill, California (Coll. 40).

188–190. *M. californicum recenseo*. Specimens similar to figures 188 and 190 are most common.

188. Male, Blue Canyon Airport, Placer Co., California (Coll. 17A).
189. Male, near Mt. Shasta, California (Coll. 120A).
190. Female, Blue Canyon Airport, Placer Co., California (Coll. 17A).

191–202. *M. californicum pluviale*, showing variations that may be found in this subspecies. Specimens similar to figures 191, 192, 197, 200, and 201 are most common.

191. Male, Seattle, Washington.
192. Male, NW. Calgary, Alberta (bog population, Coll. 180).
193. Male, Corvallis, Oregon.
194. Male, McMurray, Alberta.
195. Male, near Eugene, Oregon (Coll. 122).
196. Male, near Spokane, Washington (Coll. 343).
197. Female, Victoria, British Columbia.
198. Female, near Eugene, Oregon (Coll. 122).
199. Female, Laniel, Quebec.
200. Female, NW. Calgary, Alberta (bog population, Coll. 180).
201. Female, Rolla, British Columbia.
202. Female, Lemolo, Kitsap Co., Washington.

Figures 203–223

All figures life size.

203. Normal female *M. californicum californicum.*

204. Gynandromorph, *M. californicum californicum*, F_1, Belmont, California.

205. Normal light male *M. californicum californicum.*

206. Normal male, *M. americanum.*

207. Gynandromorph, *M. americanum*, Fredericksburg, Texas.

208. Normal female, *M. americanum.*

209–223. *M. californicum lutescens*, showing variations that may be found in this subspecies. Specimens similar to figures 209, 210, 211, 216, 218, 219, 220, and 222 are most common.

209. Male, Armley, Saskatchewan.

210. Male, Gainsboro, Saskatchewan.

211. Male, near Guthrie, Oklahoma (Coll. 423).

212. Male, near Guthrie, Oklahoma (Coll. 423).

213. Male, near Guthrie, Oklahoma (Coll. 423).

214. Male, Rutland, Saskatchewan.

215. Male, Attons Lake, Cutknife, Saskatchewan.

216. Female, Neepawa, Manitoba.

217. Female, Rosetown, Saskatchewan.

218. Male, near Ft. Benton, Montana (Coll. 335).

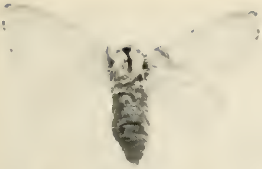
219. Female, Harlan, Saskatchewan.

220. Female, near Miami, Texas (Coll. 416).

221. Male, near Beauvallon, Alberta (Coll. 173).

222. Female, Manyberries, Alberta.

223. Female, near Guthrie, Oklahoma (Coll. 421).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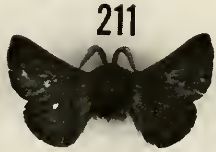
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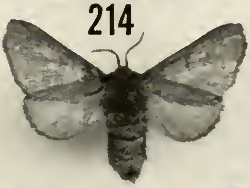
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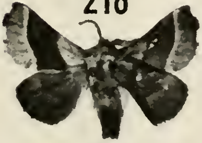
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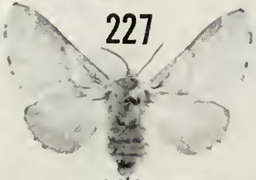

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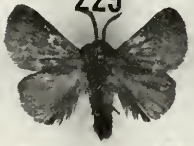

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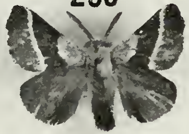

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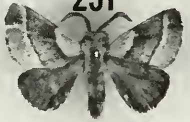

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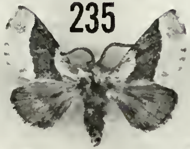

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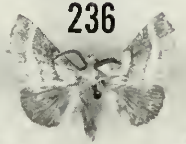

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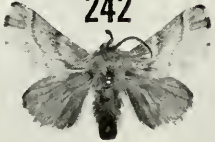

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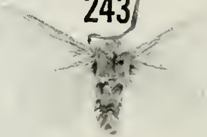

248

Figures 224–248

All figures life size.

224–248. *Malacosoma californicum* (central populations), showing four examples of variations in males and females that may be found in specimens from a single local population. This much variation, however, in specimens reared from single colonies is almost never found. Males are generally more variable than females. Specimens similar to those in columns 2, 3, and 4 are much more common than those in columns 1 and 5 (except fig. 239).

224–228. Males, Lamoille Canyon, Ruby Mountains, Nevada.

229–233. Females, Lamoille Canyon, Ruby Mountains, Nevada.

234–238. Males, Sacajawea Camp, 24 mi. W. Big Piney, Sublette Co., Wyoming.

239–243. Males, Todd's Lodge, Oak Creek Canyon, Arizona.

244–248. Males, Big Springs Ranch, Florissant, Teller Co., Colorado.

Note the large size of the males from Big Springs Ranch, Colorado, compared with the other males. All specimens are field collected, so the larvae from which these moths developed probably had adequate food in good condition. This suggests that in *Malacosoma*, as in other organisms, local populations of the same species may evolve different body sizes.

Figures 249–269

All figures life size.

249–251. Male *M. californicum* (central populations), from 7 mi. E. Cane Springs, Arizona (Coll. 209), showing extremes in variation from a single collection.

252–254. Female *M. californicum* (central populations), from near Grantsville, Utah, showing extremes in variation.

255–259. Male *M. californicum* (aspen populations), from near Cape Royal, Grand Canyon Nat. Park, Arizona (Coll. 446), showing variations. Specimens similar to figures 257–259 are most common.

260. Female *M. californicum* (aspen populations), from near Cape Royal, Grand Canyon Nat. Park, Arizona (Coll. 446). There was very little variation in the light brown females.

261, 262. Male and female, respectively, from Bear Canyon, Santa Catalina Mtns., Arizona (Coll. 263). This collection was classified as *M. californicum*, although it showed some characteristics of *M. incurvum incurvum*.

263–269. Male *M. californicum* (central populations), showing other variations that may be found.

263. Male, Eureka, Utah.
264. Male, Bryce Canyon Nat. Park (Coll. 441).
265. Male, Bursum Camp, 18 mi. E. Alma, Catron Co., New Mexico.
266. Male, near Albuquerque, New Mexico (Coll. 258).
267. Male, Colorado Springs, Colorado.
268. Male, no data.
269. Male, Las Vegas HS, New Mexico.


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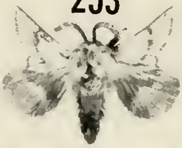
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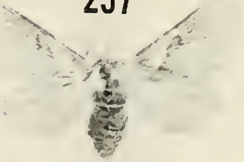
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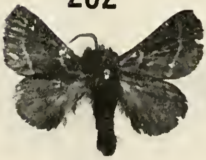
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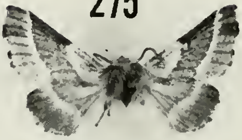

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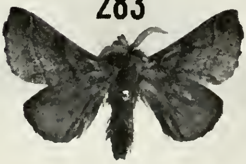

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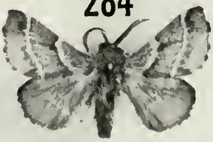

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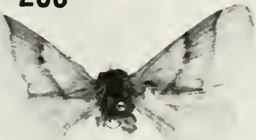

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Figures 270–289

All figures life size.

270-284. *M. californicum fragile*, showing variations that may be found in this subspecies. Specimens similar to figures 270, 271, 273, 274, 277, 282, 283, and 284 are most common.

270. Male, Providence Mountains, California.
271. Male, Split Rock Tank, Mojave Desert, California.
272. Male, near Kanarraville, Utah (Coll. 265).
273. Male, Valentine, Arizona (Coll. 218).
274. Male, near Shivwits, Utah (Coll. 234).
275. Male, Mammoth, California.
276. Male, Valentine, Arizona (Coll. 218).
277. Male, near Kingman, Arizona (Coll. 207).
278. Female, Valentine, Arizona (Coll. 218).
279. Female, near Kingman, Arizona (Coll. 207).
280. Female, near Kingman, Arizona (Coll. 207).
281. Female, near Shivwits, Utah (Coll. 234).
282. Female, Mitchell Caverns St. Park, California (Coll. 204).
283. Female, Morongo Valley, California (Coll. 27).
284. Female, near Shivwits, Utah (Coll. 234).

285–289. *M. incurvum aztecum*. Specimens similar to figures 286, 287, and 289 are more common.

285. Male, similar to males originally described as *luteimargo* from Mexico City.
286. Male, "Mex."
287. Male, Mexico City.
288. Female, similar to females originally described as *luteimargo* from Mexico City.
289. Female, Mexico City, Mexico.

Figures 291–311

All figures life size.

291–299. *M. incurvum incurvum*, showing variations that may be found. Specimens similar to figures 292, 293, 294, and 296 are most common.

291. Male, Tucson, Arizona (Coll. 202).
292. Male, Tucson, Arizona.
293. Female, Tucson, Arizona.
294. Male, near Phoenix, Arizona (Coll. 200).
295. Male, Winkelman, Arizona (Coll. 216).
296. Female, near Phoenix, Arizona (Coll. 200).
297. Male, Tucson, Arizona (Coll. 202).
298. Male, Miami, Arizona (Coll. 214).
299. Female, no data.

300–308. *M. incurvum discoloratum*, showing variations that may be found. Specimens similar to figures 300, 301, 302, 304, 305, and 307 are most common.

300. Male, near Shivwits, Utah (Coll. 233).
301. Male, near Shivwits, Utah (Coll. 233).
302. Female, near Moab, Utah (Coll. 283).
303. Male, La Sal Mtns., Utah (Coll. 284).
304. Male, Capitol Reef Nat. Mon., Utah.
305. Female, Boulder, Utah (Coll. 440).
306. Male, San Rafael R., Utah (Coll. 282).
307. Male, near Moab, Utah (Coll. 283).
308. Female, near Shivwits, Utah (Coll. 233).
309. Cocoon of *M. disstria* webbed in a leaf by the outer envelope of silk, and with more tightly spun inner cocoon in the center.
310. Cocoon of *M. californicum fragile* completely lacking the outer envelope of silk.
311. Male, *M. americanum*, lower surface, Warrendale, Pennsylvania.


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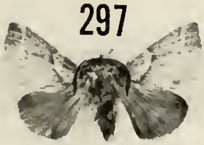
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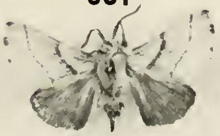
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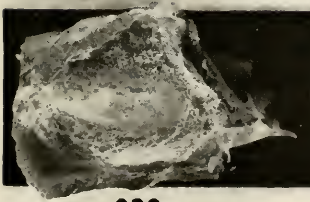
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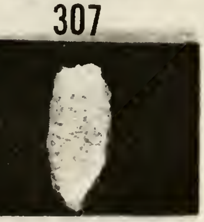
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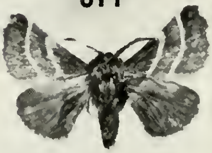
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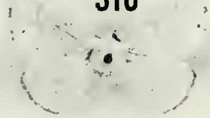
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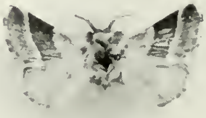
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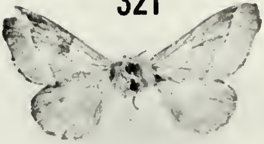
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Figures 312–329

All figures life size.

312–320. *M. americanum*, showing variations that may be found. Specimens similar to figures 312, 314, 315, 317, 318, and 320 are most common.
312. Male, New York City, New York (unusually large).
313. Male, Shawville, Clearfield Co., Pennsylvania.
314. Male, Lac Mondor, Ste. Flore, Quebec.
315. Female, no data (unusually large).
316. Male, Lac Mondor, Ste. Flore, Quebec.
317. Male, Dayton, Virginia.
318. Female, Mendham, New Jersey.
319. Male, Lakehurst, New Jersey.
320. Female, near Guthrie, Oklahoma (Coll. 422).
321–323. *M. neustrium*, showing some variations in the few males available.
321. Male, Kongans, Siberia.
322. Male, Si Gong Kong, near Tatsienlu (China).
323. Male, Paris, France.
324. Female, *M. neustrium*, Mitsukuri, Japan.
325. Male, *M. castrensis*, Hungary.
326. Female, *M. castrensis*, "Europe."
327. Female, *M. neustrium*, Paris, France.
328. Male, *M. franconicum*, Schwerin (E. Germany?).
329. Female, *M. franconicum*, Schwerin (E. Germany?).

Figures 330–332

330. Nearly complete defoliation of aspen by *M. disstria* in C.hippewa National Forest, near Cass Lake, Minnesota. (Photo courtesy U.S Forest Service).

331. Cocoons of *M. disstria* webbed together and between aspen leaves near Two Hills, Alberta. Larvae which pupated earliest webbed the leaves together before the tree was completely defoliated by slower maturing larvae. Anywhere from one to ten or more cocoons may be found in each clump.

332. Mature larvae of *M. disstria* resting on branches and trunks of aspen in Superior National Forest, near Grand Marais, Minnesota. (Photo courtesy U.S. Forest Service.)

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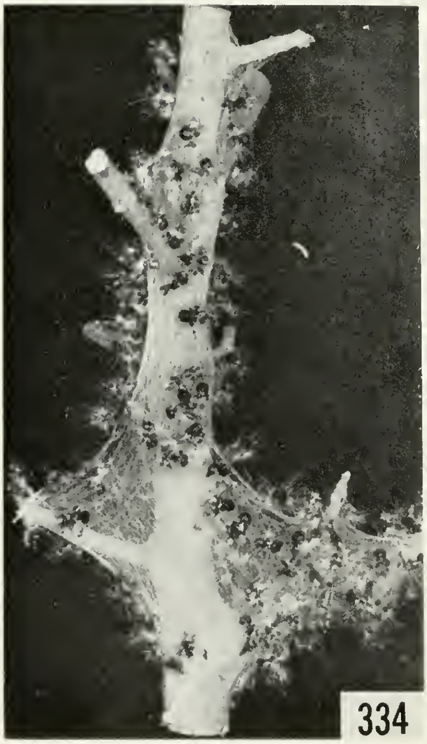
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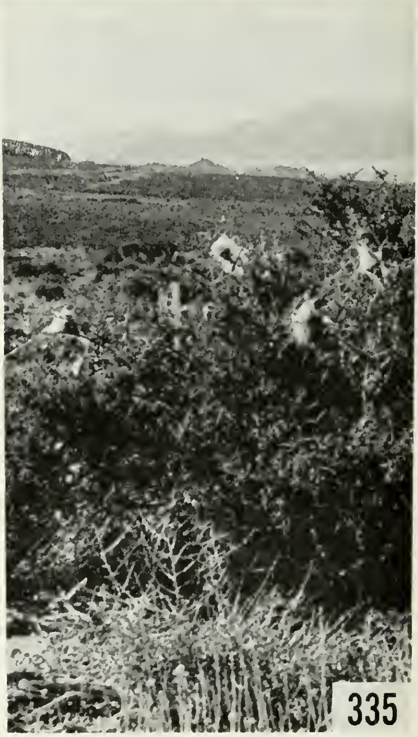
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Figures 333–335

333. Penultimate instar larvae of *M. californicum pluviale* sunning on tent near Corvallis, Oregon.

334. Molting tent of *M. tigris*, with attached penultimate instar exuviae. Note that the supporting branches are clearly visible inside the flimsy tent, and no exuviae or frass are inside. (There are a few old staminate flowers inside the tent on the lower right side near the main branch.) Slightly reduced; the length of the portion of the main branch visible in the photo was 120 mm. (4¾ inches). This is an unusually large tent.

335. Tents of *M. californicum fragile* approximately eight miles SE. of Lucerne Valley, San Bernardino Co., California, on *Prunus fasciculata*, the desert almond. The dark masses near the center of the tents are masses of caterpillars, frass, and exuviae inside the tents.

Figures 336–338

336. Insectary-trailer used during the field work. The flaps can be removed if direct sun on the cages is desired.

337. Cocoons and larvae of *M. californicum pluviale* (bog populations) showing the masses of cocoons that were found spun in grass and other vegetation at ground level (Coll. 180).

338. Third instar larvae of *M. constrictum constrictum* clustering on branch of *Quercus douglasii* at Pacheco Pass, Santa Clara Co., California (Coll. 42).

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Figures 339–369

All figures are last instar larvae, ¾ life size. Size variations are due to different degrees of maturity, disease, differing distention after death, etc. Figure 349 is ventral aspect. Figures 341, 343, 344, 347, 348, 351, 353, 355, 356, 357, 363, and 367 are lateral aspect. All others are dorsal aspect.

339. *M. disstria*, near St. Helena, California (Coll. 84A). Note tachinid egg on head.

340. *M. disstria*, near Garberville, California (Coll. 108).

341. *M. disstria*, near St. Helena, California (Coll. 84A).

342. *M. tigris*, near Garner St. Park, Texas (Coll. 223).

343. *M. tigris*, near Garner St. Park, Texas (Coll. 223).

344. *M. tigris*, near Anderson Jct., Utah (Coll. 264).

345. *M. constrictum constrictum*, near Bingen, Washington (Coll. 127).

346. *M. constrictum austrinum*, near Santa Isabel, California (Coll. 26), paratype.

347. *M. constrictum constrictum*, Los Altos, California (Coll. 19).

348. *M. constrictum austrinum*, near Santa Isabel, California (Coll. 26), paratype.

349. *Malacosoma* sp., ventral aspect, showing conspicuous median black area on each segment that may be found in all species.

350. *M. americanum*, near Leakey, Texas (Coll. 227).

351. *M. americanum*, near Leakey, Texas (Coll. 227).

352. *M. californicum californicum*, Petaluma, California (Coll. 13).

353. *M. californicum californicum*, Petaluma, California (Coll. 13).

354. *M. californicum ambisimile*, Morgan Hill, California (Coll. 40).

355. *M. californicum ambisimile*, Morgan Hill, California (Coll. 40).

356, 357. Intermediates between *M. californicum californicum* and *M. californicum ambisimile*, near Los Altos, California (figure 356, Coll. No. 30A; fig. 357, Coll. No. 20).

358–363. Variations of color pattern in the Mendocino-Trinity population of *M. californicum*.

358. Near Geyserville, California (Coll. 97). Note lack of blue-white mid-dorsal stripe. Compare with figure 370.

359. Near Geyserville, California (Coll. 97). Much darker than figure 358 and closer to figure 352.

360. Near Cloverdale, California (Coll. 62). Close to figures 364, 365.

361–363. Near Calpella, California (Coll. 103). Common color patterns found in Mendocino-Trinity population.

364. *M. californicum recenseo*, near Lake Tahoe, California (Coll. 149). Most common color pattern.

365. *M. californicum* (central populations), near Dufur, Oregon (Coll. 128). Most common color pattern in E. Oregon, SE. Washington, S. Idaho and N. Nevada. Note similarity to figure 364, but the adults are differently colored. Also note intermediate nature between figures 370, 371, and figures 383–389.

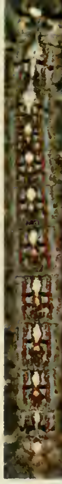
366–369. *M. californicum fragile*, showing variations which may be found. See also figures 380–382.

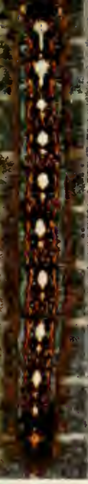
366. Near Tom's Place, California (Coll. 114). Note similarity to figure 362.

367. Near Tom's Place, California (Coll. 114).

368. Morongo Valley, California (Coll. 27).

369. Morongo Valley, California (Coll. 27).


339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Figures 370–399

All figures are last instar larvae, ¾ life size. Size variations are due to different degrees of maturity, disease, differing distention after death, etc. Figures 371, 393, 394, and 396 are lateral aspect. All others are dorsal aspect.

370. *M. californicum pluviale*, near Kalispell, Montana (Coll. 341). Note the white tachinid eggs on the head.

371. *M. californicum pluviale*, near Kalispell, Montana (Coll. 341).

372. *M. californicum pluviale*, NW. Calgary, Alberta (bog population) (Coll. 180).

373–375. *M. californicum lutescens*, near Derwent, Alberta (Coll. 179), showing some variations found at a single locality. See figure 376.

376. *M. californicum lutescens*, near Guthrie, Oklahoma (Coll. 421), showing the conspicuous vertical black bars invariably found in southern populations, and the conspicuous addorsal orange areas sometimes found in all populations.

377–379. Intermediates between *M. californicum lutescens* and *M. californicum pluviale*, near Helena, Montana (Coll. 356), showing extremes of variation.

380–382. *M. californicum fragile*, near Shivwits, Utah (Coll. 234), showing variations that are often found. Also see figures 366–369.

383–387. *M. californicum* (central populations), showing variations that may be found throughout much of the Great Basin and Rocky Mountain area.

383, 384. Near Austin, Nevada (Coll. 300).

385, 386. Near Hot Springs, Utah (Coll. 271).

387. Near Monticello, Utah (Coll. 287).

388, 389. *M. californicum* (aspen populations), near Jacob Lake, Arizona (Coll. 308), showing the two most common color patterns found in the Arizona-Utah area.

390–394. *M. incurvum incurvum*, near Phoenix, Arizona (Coll. 200), showing common variations found in Arizona. Larvae ready to pupate. Figures 390 and 392 are most common near Phoenix. Figure 393, lateral aspect of figure 390. Figure 391 is rare near Phoenix, and more common near Tucson. Larvae of *M. incurvum aztecum* from near Mexico City which have been seen are similar to figure 391. Figure 394, lateral aspect of figure 391.

395–399. *M. incurvum discoloratum*, from Utah, showing variations. Larvae in early last instar.

395. Near Shivwits, Utah (Coll. 233), most common form.

396. Near Shivwits, Utah (Coll. 233).

397. Near Shivwits, Utah (Coll. 233), less common form.

398. San Rafael R., Utah (Coll. 282), middorsal stripe is less distinct on the most common form found here.

399. San Rafael R., Utah (Coll. 282), rare form with no middorsal stripe.

279-280—68——Tip in

APPENDIX I

Collection Data

The data for collections made during this study are presented in the following list. Entries are arranged chronologically under each species, subspecies, or intermediate. References to these collections in the text are made by collection numbers, but it should be evident from the context which species, subspecies, or intermediate in this list should be examined to find a given collection. The Mendocino-Trinity and Aspen populations of *M. californicum* are included under *M. californicum.* Where subspecies are involved, most collections were classified as the subspecies which the majority of the specimens most closely resembled, rather than as intermediates, since the fact that they are regarded as subspecies implies the existence of intermediates in most continental situations. Intermediate populations occur in all boundary areas unless it is specifically mentioned in the comments or distribution under each subspecies that they were not found.

Following the date the letters "E" (eggs), "L" (larvae), "P" (pupae) or "A" (adults) may be found. These indicate which life stages were collected and/or reared. The number in parentheses after the "E" indicates how many egg masses were collected in the immediate vicinity on one or more hosts. The available information about *Malacosoma* egg masses indicated they were laid in a characteristic way for some species (see the section on egg masses, page 20). Therefore, an effort was made to find several egg masses at each locality (on one or more hosts) in order to obtain this information for each population, and to obtain some idea of the variability that could be expected in such populations. If the number is divided (4/2) it means that 4 egg masses were found which did not have any specks in the spumaline, and 2 were found which contained specks. An asterisk (4/2*) indicates that part of the egg masses which contained specks had relatively few. Undivided numbers (4) mean none of the egg masses had specks in the spumaline. A "P" indicates that some cocoons were found in the area.

After the "L" the numbers 1, 2, 3, 4, or 5 may be found. These numbers indicate the instar(s) which were present on the date the collection was made (ignoring the possibility that six instars may sometimes occur). This does not mean that all of the listed instars were found in a single colony; it merely indicates which instars were found in the one or more colonies that were examined. This information should make it possible for anyone interested in studying *Malacosoma* to estimate the dates that larvae could be found in a given area (keeping in mind the fact that the date of hatching may vary as much as a month from one year to another, depending on local weather conditions). It may also be of value in planning the timing of other studies which have to be carried out at a certain stage in seasonal advance, since the hatching of tent caterpillars is closely correlated with other phenological events such as the appearance of the first leaves of their host plants. (See the section on life cycle, page 13.)

The first host listed is the one on which the egg mass and/or specimens which were reared were found, or the one most commonly attacked in collections where they were not reared. Additional hosts are those on which colonies or egg masses were found in the same vicinity. Those marked with an asterisk (*) are hosts on which colonies or egg masses were found, but which are not considered to be normal hosts for oviposition.

The scientific names of host plants are those used in Abrams and Ferris (1940–1960), "Illustrated Flora of the Pacific States," with the exception of chokecherry, for which *Prunus virginiana* has been used throughout. Scientific names of species not found in the Pacific states have been taken from the following floras which are listed in descending order of use: Kearney and Peebles (1951), "Arizona Flora"; Shinners (1958), "Spring Flora of the Dallas-Fort Worth area, Texas"; Moss (1959), "Flora of Alberta"; and Harrington (1954), "Manual of the Plants of Colorado."

Elevations are usually accurate within + or − 100 feet. Those given more precisely than 100-foot intervals were either taken from maps or estimated from known elevations nearby.

The collection data are arranged in the following order:

Malacosoma disstria Hübner

84A) 2.5 mi. N. St. Helena (sec. rd.)
Napa Co , Calif., El. 250
28 Apr. 1960 L(5) A
prune

91F) 8 mi. W. Calistoga (sec. rd.)
Sonoma Co , Calif., El. 500
28 Apr. 1960 L(4)
Salix sp.

108) 9 mi. N. Garberville, US 101
Humboldt Co., Calif., El. 500
3 May 1960 L(5)
Quercus garryana

176) 2 mi. E. Beauvallon, Alta. 45
Alberta El. 2000
29 June 1960 L(5) A
Populus tremuloides
For Biol. Lab. No. 60A-633

178) 8 mi. E. Two Hills, Alta. 45
Alberta, El. 2300
8 July 1960 L(5) P, A
Populus tremuloides

224) 1 mi. S. Garner State Park
Uvalde Co., Tex., El. 1500
5 Apr. 1961 L(5)
Quercus virginiana

334) Great Falls
Cascade Co., Mont., El. 3330
10 June 1961 L(4)
Populus alba

406) Just W. of Georgetown
Williamson Co., Tex.
17 Apr. 1962 E(10)L(5) A
Quercus virginiana

410) Inks Lake State Park
Burnet Co., Tex.
18 Apr 1962 E, L(5)
Quercus virginiana,
Quercus sp.

411A) 14 mi. N. Fredericksburg
Gillespie Co., Tex.
18 Apr. 1962 L(5)
Quercus marilandica

412A) 1 mi. S. Kerrville
Kerr Co., Tex.
19 Apr. 1962 L(5)
Quercus sp. (red oak group)

468) 10 mi. S. Cowan on Man. 10
Manitoba
1 July 1962 L(5) P, A
Populus tremuloides

Malacosoma constrictum constrictum (Henry Edwards)

19) 1325 Fremont Ave., Los Altos,
Santa Clara Co., Calif., El. 200
24 Mar. 1960 E(1)L(2, 3) A
Quercus agrifolia

29A) Vets. Hosp., Menlo Park
San Mateo Co., Calif., El. 25
8 Apr. 1960 L(5)
Quercus agrifolia

Malacosoma constrictum constrictum—Continued

42) Pacheco Pass, Calif. Hy. 150
Santa Clara Co., Calif., El. 1200
12 Apr. 1960 E(13)L(3, 4) A
Quercus douglasii

49A) 8 mi. N. Sonoma on Cal. Hy. 12
Sonoma Co., Calif., El. 150
14 Apr. 1960 E(2)L(3, 4)
Quercus agrifolia

63A) Sonoma-Mend. Co. line on US 101
Mendocino Co., Calif., El. 400
14 Apr. 1960 L(3)
Quercus garryana

65A) 8 mi. E. Hopland
Mendocino Co., Calif., El. 800
15 Apr. 1960 E(1)L(3)
Quercus garryana

70) Orangevale, Sacramento Co., Calif., El. 100
17 Apr. 1960 L(4, 5)
Quercus wislizenii

71) ½ mi. SE. San Andreas on Cal. 49
Calaveras Co., Calif., El. 1050
18 Apr. 1960 E(1)L(4)
Quercus douglasii

72) 2 mi. W. Mariposa on Cal. 49
Mariposa Co., Calif., El. 2300
18 Apr. 1960 E(1)
Quercus wislizenii

76B) 9 mi. W. Saratoga on Cal. 17
Santa Cruz Co., Calif., El. 2000
21 Apr. 1960 L(3)
Quercus agrifolia

82) 5 mi. S. Clear Lake on Cal. 53
Lake Co., Calif., El. 1300
24 Apr. 1960 L(5)
Quercus garryana

85) 6 mi. N. St. Helena (sec. rd.)
Napa Co., Calif., El. 250
28 Apr. 1960 L(4, 5)
Quercus agrifolia

90A) 3 mi. W. Calistoga (sec. rd.)
Sonoma Co., Calif., El. 1000
28 Apr. 1960 E(1)L(4, 5)
Quercus agrifolia

91C) 8 mi. W. Calistoga (sec. rd.)
Sonoma Co., Calif., El. 500
28 Apr. 1960 L(4, 5)
Quercus agrifolia, *Q. durata*,
Q. garryana

92A) 5 mi. N. Santa Rosa (sec. rd.)
Sonoma Co., Calif., El. 350
28 Apr. 1960 L(4, 5)
Quercus kelloggii,
Q. agrifolia

97A) 9 mi. E. Geyserville (sec. rd.)
Sonoma Co., Calif., El. 800
29 Apr. 1960 L(5)
Quercus agrifolia

110) 4 mi. E. Priest Valley, Cal. 198
Monterey Co., Calif., El. 2500
5 May 1960 E(1)L(5) A
Quercus douglasii

111) 18 mi. N. Woodlake on Cal. 85
Tulare Co., Calif., El. 2200
6 May 1960 E(1)L(5) P, A
Quercus douglasii

121B) 10 mi. N. Grants Pass on US 99
Josephine Co., Ore., El. 1650
17 May 1960 E(1)L(5)
Quercus garryana,
Q. kelloggii

127) 8 mi. E. Bingen on US 830
Klickitat Co., Wash., El. 100
20 May 1960 E(1)L(5) A
Quercus garryana, *Quercus* sp.

Malacosoma constrictum constrictum—Continued

152) 12 mi. E. Covelo (sec. rd.)
Mendocino Co., Calif.
31 May 1960 L(5)
Quercus agrifolia
J. DeMars, collector

Malacosoma constrictum austrinum Stehr

1) Just E. Guatay, U.S. 80
San Diego Co., Calif., El. 3950
23 Feb. 1960 E(47)
Quercus dumosa, *Q. agrifolia*,
Q. engelmanii, *Ceanothus* sp.*

26) ¼ mi. E. Santa Ysabel
San Diego Co., Calif., El. 3000
2 April 1960 E(30)L(1, 2, 3) A
Quercus dumosa

221) 7 mi. E. Temecula on Calif. 71
Riverside Co., Calif., El. 1300
26 March 1961 E(2)L(3) A
Quercus sp.

Malacosoma tigris (Dyar)

223) 1 mi. S. Garner State Park
Uvalde Co , Tex., El. 1500
5 Apr. 1961 E(1)L(3, 4, 5) A
Quercus virginiana

226) 20 mi. N. Leakey on US 83
Real Co., Tex., El. 2400
5 Apr. 1961 E(1)L(4, 5) A
Quercus virginiana

228) 26 mi. N. Leakey on US 83
Real Co., Tex., El. 2300
5 Apr. 1961 E(1)L(4)
Quercus sp.

257) 1 mi. W. Tijeras on US 66
Bernalillo Co., N. Mex., El. 6200
3 May 1961 E(1)L(3)
Quercus undulata

264) Anderson Junction
Washington Co., Utah El. 4100
9 May 1961 E(1)L(4)
Quercus turbinella

405) Just W. of Georgetown
Williamson Co., Tex.
17 Apr. 1962 E L(5) A
Quercus virginiana

409) Inks Lake State Park
Burnet Co., Tex.
18 Apr. 1962 E(25)L(5)
Quercus virginiana,
Q. stellata

411B) 14 mi. N. Fredericksburg
Gillespie Co., Tex.
18 Apr. 1962 L(5)
Quercus marilandica,
Q. macrocarpa

412B) 1 mi. S. Kerrville
Kerr Co., Tex.
19 Apr. 1962 L(5)
Quercus sp. (red oak group)

414A) 5 mi. SE. Rocksprings on Tex. 55
Edwards Co., Tex., El. 2300
19 Apr. 1962 L(5)
Quercus sp.

435) 6 mi. E. Durango on US 160
LaPlata Co., Colo.
6 June 1962 L(4)
Quercus gambelii

Malacosoma americanum (Fabricius)

225) 10 mi. N. Leakey on US 83
Real Co., Tex., El. 2000
5 Apr. 1961 E(3)L(4, 5) A
Prunus serotina

Malacosoma americanum—Con.

227) 25 mi. N. Leakey on US 83
Real Co., Tex., El. 2500
5 Apr. 1961 E(6)L(5) A
Prunus spp.

400) 8 mi. N. Blue Eye on Mo. 13
Stone Co., Mo., El. 900
15 Apr. 1962 E(3)L(2, 3)
Prunus serotina

401) 1 mi. N. Dover on Ark. 1
Pope Co., Ark.
15 Apr. 1962 E(4)L(4)
Prunus serotina

402) 1 mi. N. Randolf on US 167
Union Co., La.
16 Apr. 1962 E(1)L(5) P
wild plum

403) 4 mi. E. Ratcliff on Tex. 7
Houston Co., Tex.
17 Apr. 1962 E(1) P, A
Crataegus sp.

404) Thorndale, Milam Co., Tex.
17 Apr. 1962 E(1)L(5)
Crataegus sp.

407) 5 mi. W. Georgetown on Tex. 29
Williamson Co., Tex.
17 Apr. 1962 E(3)L(5) P, A
wild plum

408) Inks Lake State Park
Burnet Co , Tex.
18 Apr. 1962 E(1)L(5)
Prunus sp. (plum)

411) 14 mi. N. Fredericksburg
Gillespie Co., Tex.
18 Apr. 1962 E(5)L(5) A
wild plum

412) 1 mi. S. Kerrville on Tex. 16
Kerr Co., Tex.
19 Apr. 1962 E(8)L(5)
wild plum, *Quercus* sp.—red oak group*

413) 9 mi. E. Camp Wood
Real Co., Tex.
19 Apr. 1962 E L(5)
Prunus serotina

414) 5 mi. SE. Rocksprings on Tex. 55
Edwards Co., Tex., El. 2300
19 Apr. 1962 E(5)L(5) P, A
wild plum

422) 6 mi. E. Guthrie on Okla. 33
Logan Co., Okla., El. 1100
25 Apr. 1962 E(1)L(4) A
wild plum

424A) 2 mi. E. Coyle on Okla. 33
Payne Co , Okla., El. 1000
25 Apr. 1962 E(1)L(5)
wild plum

Many collections between Guthrie and Drumright, Okla. on wild plum 25Apr.1962

425) 8 mi. S. Alma on Kan. 99
Waubunsee Co., Kan., El. 1500
26 Apr. 1962 E(1)L(3)
wild plum

426) 5 mi. S. Corning on Kan. 63
Nemaha Co., Kan., El. 1500
26 Apr. 1962 E(3)L(2, 3)
Prunus virginiana

427) 5 mi. W. Jct US 18 & SD 37
Hutchinson Co , S. Dak.
26 May 1962 E(5)L(4, 5) A
wild plum

428) 1 mi. NW. Pickstown (sec. rd.)
Charles Mix Co., S. Dak.
27 May 1962 E(1)L(5)
wild plum

Malacosoma americanum—Con.

431) 8 mi. E. Turnerville on US 212
Deuel Co., S. Dak.
27 May 1962 E(2)L(3, 4)
wild plum

464) 3 mi. N. Thief River Falls
Pennington Co., Minn.
30 June 1962 E(1)L(5) P
Prunus virginiana

Malacosoma californicum (Packard)

14) 2 mi. NW. Healdsburg (sec. rd.)
Sonoma Co., Calif., El. 100
20 Mar. 1960 E(1)L(1) A
Quercus agrifolia, plum

48) 2 mi. N. Sonoma (sec. rd.)
Sonoma Co., Calif.
14 Apr. 1960 E(1)L(4, 5)
prune, *Q. agrifolia*, plum

49) 8 mi. N. Sonoma on Cal. 12
Sonoma Co., Calif., El. 150
14 Apr. 1960 E(1)L(4)
Quercus agrifolia

50) 1 mi. N. Kenwood on Cal. 12
Sonoma Co., Calif., El. 475
14 Apr. 1960 E(3)L(3, 4, 5)
prune, apple

51) 2½ mi. E. Santa Rosa on Cal. 12
Sonoma Co., Calif., El. 250
14 Apr. 1960 L(5)
prune

52) 1 mi. W. Santa Rosa (sec. rd.)
Sonoma Co., Calif., El. 200
14 Apr. 1960 E(1)L(4) A
prune

53) ½ mi. W. Forestville on Cal. 12
Sonoma Co., Calif., El. 350
14 Apr. 1960 L(3)
prune

54) 1 mi. W. Guerneville (sec. rd.)
Sonoma Co., Calif., El. 100
14 Apr. 1960 L(3, 4)
apple

55) 2.5 mi. E. Guerneville (sec. rd.)
Sonoma Co., Calif., El. 125
14 Apr. 1960 E(1)L(4) A
apple

56) 7.5 mi. E. Guerneville (sec. rd.)
Sonoma Co., Calif., El. 150
14 Apr. 1960 L(4)
prune

57) 9 mi. E. Guerneville (sec. rd.)
Sonoma Co., Calif., El. 175
14 Apr. 1960 E(1)L(3, 4, 5)
Salix sp.

58) 9.5 mi. E. Guerneville (sec. rd.)
Sonoma Co., Calif., El. 175
14 Apr. 1960 E(1)L(3, 4, 5)
Quercus agrifolia

59) 3 mi. SW. Healdsburg (sec. rd.)
Sonoma Co., Calif., El. 200
14 Apr. 1960 E(1)L(3, 4)
prune, *Q. agrifolia*

60) 1 mi. N. Healdsburg on US 101
Sonoma Co., Calif., El. 100
14 Apr. 1960 L(4, 5) A
prune, *Q. agrifolia*

61) 1 mi. S. Geyersville on US 101
Sonoma Co., Calif., El. 150
14 Apr. 1960 E(2)L(4, 5)
prune

62) 1 mi. S. Cloverdale on US 101
Sonoma Co., Calif., El. 300
14 Apr. 1960 L(3, 4, 5) A
prune

63) Sonoma-Mend. Co. line, US 101
Mendocino Co., Calif., El. 400
14 Apr. 1960 E(2)L(2, 3, 4)
Cercocarpus betuloides

Malacosoma californicum—Con.

64) Mend.-Lake Co. line, E. of Hopland
Lake Co., Calif., El. 2300
15 Apr. 1960 E(1)L(1, 2, 3)
Cercocarpus betuloides

65) 8 mi. E. of Hopland,
Mendocino Co., Calif., El. 800
15 Apr. 1960. E(10)L(3, 4, 5) A
Salix sp., *Cercocarpus betuloides*

66) 1 mi. N. Ukiah on US 101
Mendocino Co., Calif., El. 625
15 Apr. 1960 E(1)L(2, 3)
prune, *Rosa* sp.

66B) Same data as 66, but collected
29 Apr. 1960, prune L(4, 5) A

67) 1 mi. W. Willits on Cal. 20
Mendocino Co., Calif., El. 1350
15 Apr. 1960 E(1)L(2, 3)
Prunus virginiana, *Salix* sp.

68) 13 mi. W. Willits on Cal. 20
Mendocino Co., Calif., El. 400
15 Apr. 1960 E(2)L(1, 2)
Ceanothus thyrsiflorus

69) 10 mi. N. Pt. Arena on Cal. 1
Mendocino Co., Calif., El. 50
15 Apr. 1960 E(1)L(1)
Ceanothus thyrsiflorus

83) 1.5 mi. N. St. Helena (sec. rd.)
Napa Co., Calif., El. 250
28 Apr. 1960 E(3)L(4, 5) A
apple

84) 2.5 mi. N. St. Helena (sec. rd.)
Napa Co., Calif., El. 250
28 Apr. 1960 E(1)L(4, 5) A
prune

86) 6.5 mi. N. St. Helena (sec. rd.)
Napa Co., Calif., El. 375
28 Apr. 1960 L(5) A
prune

86A and 86B—Same data as 86

87) 7 mi. N. St. Helena (sec. rd.)
Napa Co., Calif., El. 350
28 Apr. 1960 L(5) A
prune

87A) Same data as 87

88) 1 mi. W. Calistoga (sec. rd.)
Napa Co., Calif., El. 375
28 Apr. 1960 E(2)L(4, 5) A
Salix spp., *Rosa* sp.

89) 2.5 mi. W. Calistoga (sec. rd.)
Sonoma Co., Calif., El. 1100
28 Apr. 1960 E(1)L(5) A
prune

90) 3 mi. W. Calistoga (sec. rd.)
Sonoma Co., Calif., El. 1000
28 Apr. 1960 E(1)L(4, 5) A
Quercus agrifolia

91) 8 mi. W. Calistoga (sec. rd.)
Sonoma Co., Calif., El. 500
28 Apr. 1960 E(1)L(4, 5)
Cercocarpus betuloides

91A, B, E: Same data as 91
91A, *Q. agrifolia* L(4, 5)
91B *Salix* sp. L(4, 5)
91E, *C. betuloides* L(4, 5)

92) 5 mi. N. Santa Rosa (sec. rd.)
Sonoma Co., Calif., El. 350
28 Apr. 1960 E(1)L(4, 5)
Quercus kelloggii, *Q. agrifolia*

93) 1.5 mi. S. Healdsburg on US 101
Sonoma Co., Calif., El. 100
29 Apr. 1960 L(5) A
prune

Malacosoma californicum—Con.

94) 1 mi. E. Geyserville on Cal. 128
Sonoma Co., Calif., El. 200
29 Apr. 1960 E(1)L(5) A
prune

95) 5 mi. SE. Geyserville (sec. rd.)
Sonoma Co., Calif., El. 225
29 Apr. 1960 L(5)
apple

96) 6.5 mi. E. Geyserville (sec. rd.)
Sonoma Co., Calif., El. 600
29 Apr. 1960 E(1)L(5)
Quercus agrifolia

97) 9 mi. E. Geyserville (sec. rd.)
Sonoma Co., Calif., El. 800
29 Apr. 1960 L(5) A
Quercus agrifolia

98) 13 mi. E. Geyserville (sec. rd.)
Sonoma Co., Calif., El. 2000
29 Apr. 1960 L(4)
Cercocarpus betuloides

99) 16 mi. E. Geyserville (sec. rd.)
Sonoma Co., Calif., El. 2500
29 Apr. 1960 E(1)L(3, 4, 5) A
Cercocarpus betuloides

100) 4.5 mi. E. Cloverdale (sec. rd.)
Sonoma Co , Calif., El. 700
29 Apr. 1960 L(5) A
Cercocarpus betuloides, Salix sp.

101) 14 mi. W. Cloverdale on Cal. 128
Mendocino Co., Calif., El. 1000
29 Apr. 1960 E(1)L(3, 4, 5)
Cercocarpus betuloides

102) 9 mi. W. Ukiah (sec. rd.)
Mendocino Co., Calif., El. 2100
29 Apr. 1960 E(1)L(4, 5)
Cercocarpus betuloides

103) 9 mi. E. Calpella on Cal. 20
Mendocino Co., Calif., El. 900
29 Apr. 1960 E(1)L(4, 5)
prune, *Cercocarpus betuloides*

104) 2 mi. E. Clear Lake (sec. rd.)
Lake Co., Calif., El. 2200
29 Apr. 1960 E(1)L(3)
Cercocarpus betuloides

105) 3.5 mi. N. Willits on US 101
Mendocino Co., Calif., El. 1500
2 May 1960 E(2)L(3, 4)
Ceanothus integerrimus

106) 1.5 mi. S. Laytonville on US 101
Mendocino Co., Calif., El. 1600
2 May 1960 L(3, 4, 5)
Cercocarpus betuloides, prune

107) 11 mi. N. Laytonville on US 101
Mendocino Co., Calif., El. 1500
2 May 1960 E(1)L(2, 3)
Ceanothus integerrimus,
Cercocarpus betuloides

109) 1.5 mi. N. Cummings on US 101
Mendocino Co., Calif., El. 1400
3 May 1960 L(3)
Ceanothus incanus

128) 7 mi. S. Dufur on US 197
Wasco Co., Ore., El. 2300
20 May 1960 E(1)L(4, 5) A
Rosa sp.

129) 2 mi. N. Criterion Pass, US 197
Wasco Co., Ore., El. 3100
20 May 1960 E(1)L(4)
Rosa sp.

130) 15 mi. N. Redmond on US 97
Jefferson Co., Ore., El. 3100
20 May 1960 E(1)L(3, 4) A
Purshia tridentata

Malacosoma californicum—Con.

131) 21 mi. S. Chemult on US 97
Klamath Co., Ore., El. 4600
20 May 1960 E(1)(L2)
Purshia tridentata

132) 1.5 mi. W. Nubieber on US 299
Lassen Co., Calif., El. 4300
24 May 1960 E(5)L(3, 4, 5) A
Prunus subcordata, *Purshia tridentata*, *Prunus virginiana*

133) 2 mi. N. Milford on US 395
Lassen Co., Calif., El. 4600
24 May 1960 E(1)L(gone)
Purshia tridentata, *Prunus virginiana*, *Rosa* sp.

134) 3 mi. N. Jct. US 40 & 395 on 395
Plumas Co., Calif., El. 5700
24 May 1960 Larvae gone
Purshia tridentata

136) 3 mi. N. Hat Creek on Cal. 89
Shasta Co., Calif., El. 3300
28 May 1960 E(4)L(4, 5) A
Purshia tridentata

137) 17 mi. E. Weaverville on US 299
Trinity Co., Calif., El. 2300
31 May 1960 E(2)L(3, 4, 5) A
Ceanothus integerrimus, *Salix* sp. *Rosa* sp.

138) 6 mi. NE. Hayfork Summit
Trinity Co., Calif., El. 2000
31 May 1960 E(1)L(3, 4)
Ceanothus cuneatus, *Cercocarpus betuloides*

139) ½ mi. NE. Hayfork Summit
Trinity Co., Calif., El. 3400
31 May 1960 L(4) A
Ceanothus integerrimus

140) 1 mi. E. Wildwood on Cal. 36
Trinity Co., Calif., El. 3600
31 May 1960 E(4)L(2, 3)
Ceanothus cordulatus, apple

145) 10 mi. W. Susanville on Cal. 36
Lassen Co., Calif., El. 4600
1 June 1960 E(4)L(2, 3)
Purshia tridentata

146) 7.5 mi. W. Susanville on Cal. 36
Lassen Co., Calif., El. 4300
1 June 1960 E(5)L(2, 3, 4, 5) A
Purshia tridentata

147) 1 mi. W. US 395 on Nev. 27
Washoe Co., Nev., El. 4600
1 June 1960 E(0/2)L(gone) P
Prunus andersonii

148) 4 mi. W. US 395 on Nev. 27
Washoe Co., Nev., El. 6000
1 June 1960 E(0/8*)L(4, 5) A
Purshia tridentata

153) 23 mi. N. Klamath Falls on US 97
Klamath Co., Ore., El. 4200
5 June 1960 E(1)L(3, 4, 5) A
Purshia tridentata, Ribes sp.

154) 8 mi. N. Chemult on US 97
Klamath Co., Ore., El. 4500
5 June 1960 E(1)L(3)
Purshia tridentata

155) 10 mi. S. Bend on US 97
Deschutes Co., Ore., El. 4500
5 June 1960 E(1)L(3, 4)
Ribes sp., *P. tridentata*

156) 1 mi. W. Prineville on US 126
Crook Co., Ore., El. 3000
5 June 1960 E(1)L(5)
Purshia tridentata

Malacosoma californicum—Con.

157) 19 mi. E. Prineville on US 26
Crook Co., Ore., El. 3800
5 June 1960 L(4)
Ribes sp.

158) 9 mi. W. Mitchell on US 26
Wheeler Co., Ore., El. 3200
5 June 1960 E(2)L(5)
Purshia tridentata, Rosa sp.

159) 33 mi. E. John Day on US 26
Grant Co., Ore., El. 4500
5 June 1960 E(3)L(4, 5) A
Ribes sp.

160) 1 mi. E. Jordan Valley on US 85
Malheur Co., Ore., El. 4400
6 June 1960 L(5) P
Ribes sp., *Rosa* sp.

161) 1 mi. S. Jct. Nev. 34A & 8A on 8A
Humboldt Co., Nev., El. 6000
6 June 1960 E(2)L(4, 5) A
Purshia tridentata

162) W. Side, Cedar Pass, Warner Mtns.
Modoc Co., Calif., El. 5500
6 June 1960 E(2)L(3)
Purshia tridentata

165) 3 mi. N. Weed on US 97
Siskiyou Co., Calif., El. 3500
12 June 1960 E(1)L(3, 4)
Purshia tridentata

166) 2 mi. W. Keno on Ore. 66
Klamath Co., Ore., El. 4300
12 June 1960 E(2)L(3, 4, 5) A
Ceanothus velutinus

166A) Same data as 166, *Purshia tridentata* E(1)L(3, 4, 5) A

167) 1 mi. W. Pinehurst on Ore. 66
Jackson Co., Ore., El. 3600
12 June 1960 E(1)L(3, 4, 5) A
Prunus subcordata
Ceanothus cuneatus

168) Jct. Ore. 232 & US 97
Klamath Co., Ore., El. 4500
13 June 1960 E(1)L(3, 4)
Purshia tridentata

209) 7 mi. E. Cane Springs (sec. rd.)
Mohave Co., Ariz., El. 4200
9 Mar. 1961 E(0/1)L(2, 3 4) A
Prunus fasciculata

229) 11 mi. NE. Jct. Tex. 54 & US 180
on US 180, Guadalupe Mtns.,
Culberson Co., Tex., El. 5200
6 Apr. 1961 E(1)L(1) A
Quercus sp.

238) 14 mi. W. Cameron on Ariz. 64
Coconino Co., Ariz., El. 5000
12 Apr. 1961 E(0/2)L(4, 5) A
Amelanchier utahensis

239) Desert View, Grand Canyon N. P.
Coconino Co., Ariz., El. 7500
12 Apr. 1961 E(0/1)L(2)
Ribes sp.

240) 8 mi. N. Sedona on US 89A
Coconino Co., Ariz., El. 4800
13 Apr. 1961 E(0/2)L(2, 3, 4) A
Juglans major, *Prunus virens*
apple, plum

242) 12 mi. N. Payson (sec. rd.)
Gila Co., Ariz., El. 5400
13 Apr. 1961 L(3)
Prunus virens

245) 3 mi. above Paradise, Chiricahua Mtns., Cochise Co., Ariz., El. 6000
29 Apr. 1961 E(1)L(4) A
Prunus virens

Malacosoma californicum—Con.

246) Barfoot Park, Chiricahua Mtns.
Cochise Co., Ariz., El. 8200
29 Apr. 1961 E(3)L(1, 2)
Populus tremuloides

247) Barfoot Park, Chiricahua Mtns.
Cochise Co., Ariz., El. 8200
29 Apr. 1961 E(2)L(1 2, 3) A
Prunus virens

248) Rustler Park Rd., Chiricahua Mtns., Cochise Co., Ariz., El. 7500
29 Apr. 1961 L(3, 4)
Prunus virens

251) 14 mi. N. Clifton on US 666
Greenlee Co , Ariz., El. 6200
1 May 1961 E(0/1)L(3, 4) A
Quercus gambelii

252) 15 mi. N. Clifton on US 666
Greenlee Co., Ariz., El. 6400
1 May 1961 E(0/1)L(3, 4) A
Prunus virens

253) Emory Pass, Black Mountains, Sierra Co., N. Mex., El. 7800
2 May 1961 E(2)L(3, 4) A
Prunus virens, Prunus emarginata

254) 6 mi. W. Capitan on US 380
Lincoln Co., N. Mex., El. 6900
3 May 1961 E(1/1*)L(2) A
Quercus undulata

255) 14 mi. SW. Corona on US 54
Lincoln Co., N. Mex., El. 7100
3 May 1961 E(0/2)L(1, 2, 3) A
Berberis fremontii, Quercus undulata, Rhus trilobata

256) 2 mi. E. Chilili on N. Mex 10
Bernalillo Co., N. Mex., El. 7100
3 May 1961 E(0/2)L(1)
Quercus undulata

258) 2 mi. E. Albuquerque on US 66
Bernalillo Co., N. Mex., El. 5900
3 May 1961 E(0/9)L(4, 5) A
Quercus undulata,
Rhus trilobata

259) 5 mi. E. Sanders on US 66
Apache Co., Ariz., El. 6000
4 May 1961 E(1/4*)L(1, 2, 3) A
Berberis fremontii

260) 15 mi. N. Concho on US 260
Apache Co., Ariz., El. 5600
4 May 1961 E(0/4*)L(3, 4, 5) A
Cowania stansburiana

261) 4 mi. E. Showlow on US 60
Navajo Co., Ariz., El. 6600
4 May 1961 E(0/1*)L(2, 3) A
Rhus trilobata,
Berberis fremontii

262) 7 mi. NW. Carrizo on US 60
Navajo Co , Ariz., El. 5800
4 May 1961 E(0/7)L(4, 5) A
Prunus virginiana, Quercus gambelii, Prunus virens

263) Bear Canyon, Sta., Catalina Mtns.
Pima Co., Ariz., El. 5500
8 May 1961 E(5)L(4, 5) A
Prunus virens

268) 8.5 mi. E. Springville
Utah Co., Utah, El. 5400
13 May 1961 E(1)L(3) A
Prunus virginiana

269) 2 mi. N. Bountiful on Utah 106
Davis Co., Utah, El. 4400
13 May 1961 E(4)L(4, 5) A
sweet cherry

270) 1 mi. N. Farmington
Davis Co., Utah, El. 4250
13 May 1961 E(1)L(4)
peach (ornamental)

Malacosoma californicum—Con.

271) 1 mi. N. Hot Springs, Box Elder Co , Utah, El. 4300
13 May 1961 E(6)L(5) A
Populus alba

272) Howell Canyon, Sawtooth N.F. W. of Malta, Cassia Co., Idaho, El. 6000
14 May 1961 E(0/1)L(1, 2) A
Prunus virginiana, *Amelanchier* sp.

273) ½ mi. S. Salmon Falls Cr., US 30 Twin Falls Co., Idaho, El. 3000
14 May 1961 E(0/3*) P, A
Purshia tridentata

274) 5.5 mi. NE. Mountain Home Elmore Co., Idaho, El. 4000
14 May 1961 E(4)L(4, 5) A
Purshia tridentata, *Rosa* sp , *Prunus virginiana*

275) 16 mi. E. Dixie on Idaho 68 Elmore Co., Idaho, El. 5000
14 May 1961 E(1)L(1)
Prunus virginiana

276) 5 mi. S. Ketchum on US 93 Blaine Co., Idaho, El. 5500
14 May 1961 E(1)L(2) A
Prunus virginiana

277) 1 mi. E. Craters of the Moon Nat. Mon.
Butte Co., Idaho, El. 5700
15 May 1961 E(6)L(1, 2, 3) A
Purshia tridentata

278) 4 mi. SE. Inkon, ski area Rd. Bannock Co., Idaho, El. 5500
15 May 1961 E(1)L(2, 3) A
Prunus virginiana, *Purshia tridentata*

279) 3 mi. E. Brigham City on US 89 Box Elder Co., Utah, El. 4900
16 May 1961 E(3)L(3, 4)
Prunus virginiana

280) 1 mi. S. Jct. US 89 & US 30S Davis Co., Utah, El. 4700
16 May 1961 E(1)L(5)
Prunus virginiana

281) Buckhorn Wash, 25 mi. E. Castle Dale
Emery Co., Utah, El. 5300
19 May 1961 E(0/6)L(5) P, A
Cercocarpus ledifolius, *Amelanchier utahensis*

285) LaSal Mtns , 16 mi. SE. Moab San Juan Co., Utah, El. 5700
20 May 1961 L(5) P, A
Cercocarpus montanus

286) 8.5 mi. N. Monticello on US 160 San Juan Co., Utah, El. 6300
20 May 1961 L(5) A
Cercocarpus montanus, *Amelanchier utahensis*

287) 3 mi. N. Monticello on US 160 San Juan Co., Utah, El. 6800
20 May 1961 L(5) A
Peraphyllum ramosissimum

289) 10 mi. E. Cortez on U.S. 160 Montezuma Co , Colo., El. 6700
20 May 1961 E(0/4)L(4, 5) A
Peraphyllum ramosissimum
Amelanchier utahensis

290) 5 mi. W. Durango on US 160 LaPlata Co., Colo., El. 6800
21 May 1961 E(0/1)L(3)
Prunus virginiana

291) 4 mi. N. Durango on US 550 LaPlata Co., Colo., El. 6600
21 May 1961 L(4) A
Cercocarpus montanus

Malacosoma californicum—Con.

292) ½ mi. S. Ouray on US 550
Ouray Co., Colo. El. 7800
21 May 1961 E(1)L(3) A
Prunus virginiana

294) 1 mi. E. Glenwood Springs
Garfield Co., Colo., El. 5900
21 May 1961 E(1/7*)L(5) A
Prunus virginiana

295) Snowmass, Pitkin Co.,
Colo., El. 6700
21 May 1961 L(4, 5)
Prunus virginiana

296) 7 mi. N. Neola, Duchesne
Co., Utah, El. 7000
22 May 1961 E(0/1)L(4, 5) A
Amelanchier utahensis

297) Cave Creek, 15 mi. E. Ely
White Pine Co., Nev., El. 7300
25 May 1961 E(0/2)L(3)
Ribes aureum, *Rosa* sp.

298) Ruth Copper Pit, near Ruth,
White Pine Co., Nev., El. 7000
25 May 1961 E(0/1)L(4, 5) A
Purshia tridentata, *Rosa* sp.,
Ribes sp.

299) Pinto Summit, E. of Eureka,
Eureka Co., Nev., El. 7380
26 May 1961 E(0/1)L(4)
Purshia tridentata

300) Kingston Canyon, 20 mi. S. Austin,
Lander Co., Nev., El. 6800
26 May 1961 E(1/11*)L(4, 5) A
Prunus andersonii, *Rosa* sp.,
Ribes aureum, *Ribes* sp.,
Prunus virginiana

301) Lamoille Canyon, Ruby Mtns.,
Elko Co., Nev., El. 6300
26 May 1961 E(0/6*)L(4, 5) A
Prunus virginiana, *Ribes* sp.,
Purshia tridentata

302) 1 mi. W. Pequop Summit, US 40
Elko Co., Nev., El. 6600
27 May 1961 E(0/1)L(3, 4, 5) A
Purshia tridentata,
Amelanchier sp.

303) S. Willow Canyon, 12 mi. S. Grantsville, Tooele Co., Utah
El. 6200, 27 May 1961 E(1)L(4, 5)
Rosa sp., *Prunus virginiana*

304) 6 mi. S. Hatch on US 89
Garfield Co., Utah, El. 7000
28 May 1961 E(0/1)L(4, 5) A
Purshia tridentata, *Prunus virginiana*, *Peraphyllum ramosissimum*

305) 3 mi. N. Glendale on US 89
Kane Co., Utah El. 6100
28 May 1961 E(3)L(4) A
Populus angustifolia

306) 8 mi. N. Jacob Lake on US 89A
Coconino Co., Ariz., El. 7400
28 May 1961 E(0/5*)L(5) A
Ribes sp., *Amelanchier utahensis*

307) North Rim, Grand Canyon N.P.
Coconino Co., Ariz., El. 8200
28 May 1961 L(5)
Amelanchier utahensis

308) 8 mi. S. Jacob Lake on US 67
Coconino Co., Ariz., El. 8400
29 May 1961 E(5)L(2, 3, 4) A
Populus tremuloides

309) Bryce Canyon Nat. Park
Garfield Co., Utah, El. 8600
29 May 1961 E(2)L(4) A
Populus tremuloides

Malacosoma californicum—Con.

310) Bryce Canyon Nat. Park
Garfield Co., Utah, El. 8600
29 May 1961 E(1)L(3, 4)
Ribes sp.

311) Bryce Canyon Nat. Park
Kane Co., Utah, El. 8900
30 May 1961 E(0/3)L(4, 5) A
Ribes sp.

312) 4 mi. E. Fairview on Utah 31
Sanpete Co., Utah, El. 7500
1 June 1961 L(4)
Prunus virginiana

313A) 10 mi. W. Huntington, Utah 31
Emery Co., Utah, El. 6700
1 June 1961 L(gone) P, A
Amelanchier utahensis

314) 14 mi. NE. Montrose on Colo. 347
Montrose Co., Colo., El. 8300
1 June 1961 L(5) A
Amelanchier utahensis

315) 3 mi. W. Sargents on US 50
Saguache Co., Colo., El. 8200
2 June 1961 E(2)L(3, 4, 5) A
Prunus virginiana

316) 4 mi. W. Maysville on US 50
Chaffee Co., Colo., El. 9000
2 June 1961 E(4/6*)L(4, 5) A
Ribes sp.

317) Hopewell L. Rd. 7 mi. W. US 285
Rio Arriba Co., N. Mex., El. 8700
2 June 1961 E(0/8*)L(4, 5) A
Ribes sp.

318) Hopewell L. Rd., 12 mi. W. US 285
Rio Arriba Co., N. Mex., El. 9200
2 June 1961 L(2)
Populus tremuloides

319) 11 mi. E. Taos on US 64
Taos Co., N. Mex., El. 8000
2 June 1961 L(4) A
Prunus virginiana

320) 24 mi. SW. Colo. Springs (sec. rd.)
El Paso Co., Colo., El. 5700
3 June 1961 E(0/1)L(4, 5) A
Rhus trilobata, *Cercocarpus montanus*, *Prunus virginiana*

321) 5 mi. SW. Sedalia on Colo. 67
Douglas Co., Colo., El. 6100
3 June 1961 L(4, 5)
Quercus gambelii, *Prunus virginiana*

322) 3 mi. W. Golden on US 6
Jefferson Co., Colo., El. 5800
3 June 1961 L(4, 5) A
Ribes sp., *Cercocarpus montanus*

323) 11 mi. N. Jct. US 40 & Colo. 84
Grand Co., Colo., El. 7600
4 June 1961 E(2)L(4)
Ribes sp.

324) 1 mi. S. Steamboat Springs
Routt Co., Colo., El. 6700
4 June 1961 E(0/1*)L(5) A
Prunus virginiana

325) 2 mi. W. Maybell on US 40
Moffat Co., Colo., El. 6000
4 June 1961 L(5) P, A
Purshia tridentata

326) 21 mi. E. Daniels Summit, US 40
Wasatch Co., Utah, El. 8000
4 June 1961 E(1)L(4, 5) A
Prunus virginiana

Malacosoma californicum—Con.

327) 8 mi. E. Ephraim on Utah 29
Sanpete Co., Utah, El. 8200
6 June 1961 L(3)
Prunus virginiana

328) 5 mi. N. Ashton on US 191
Fremont Co., Idaho, El. 5600
8 June 1961 L(4, 5) A
Prunus virginiana,
Purshia tridentata

360) 9 mi. S. Casper, Casper Mtn.,
Natrona Co., Wyo., El. 7600
22 June 1961 E(1)L(4, 5)
Populus tremuloides

361) 30 mi. SW. Douglas (sec. rd.)
Converse Co., Wyo., El. 6900
23 June 1961 E(1)L(4, 5) A
Populus tremuloides

362) 30 mi. SW. Douglas (sec. rd.)
Converse Co., Wyo., El. 6900
23 June 1961 E(2)L(4, 5)
Ribes sp., *Rosa* sp.
Prunus virginiana

363) 3 mi. W. Centennial on Wyo. 130
Albany Co., Wyo., El. 8400
23 June 1961 E(6)L(4, 5) A
Populus tremuloides

364) 20 mi. SE. Saratoga on Wyo. 130
Carbon Co., Wyo., El. 7700
23 June 1961 E(1)L(5) P, A
Populus tremuloides

365) 10 mi. NE. Pinedale (sec. rd.)
Sublette Co., Wyo., El. 7100
24 June 1961 E(5)L(5) P, A
Purshia tridentata, Ribes sp.,
Populus tremuloides, Rosa sp.,
Prunus virginiana,
Amelanchier sp.

366) 12 mi. SE. Bondurant on US 167
Sublette Co., Wyo., El. 7500
24 June 1961 E(3)L(4, 5) P, A
Prunus virginiana, Populus
tremuloides, Amelanchier sp.

367) 20 mi. SE. Jackson on US 187
Teton Co., Wyo., El. 6000
24 June 1961 E(1)L(5) A
Salix sp.

368) 2.5 mi. E. Mammoth Hot Springs
Yellowstone N.P., Wyo., El. 6000
1 July 1961 L(5) P, A
Rosa sp., *Ribes* sp.,
Populus tremuloides

369) ¾ mi. below Holly Lake
Grand Teton N.P. Wyo., El. 9000
25 July 1961 E(1)L(5) A
Ribes sp., *Salix* sp.

432) 13 mi. W. Walsenburg
Huerfano Co., Colo., El. 7000
5 June 1962 E(0/1)L(4, 5) A
Rhus trilobata

433) 7 mi. E. Pagosa Springs, US 160
Archuleta Co., Colo., El. 7300
6 June 1962 L(5)
Prunus virginiana

434) Piedra R. on US 160
Archuleta Co., Colo., El. 7100
6 June 1962 E(1)L(5) P
Populus angustifolia,
Crataegus sp.

437) 3 mi. S. Grover on Utah 117
Wayne Co., Utah, El. 8000
8 June 1962 E(7)L(5) P, A
Populus tremuloides

Malacosoma californicum—Con.

438) 8 mi. N. Boulder on Utah 117
Garfield Co., Utah, El. 8000
8 June 1962 E(0/5)L(4, 5) A
Purshia tridentata,
Amelanchier utahensis

439) 8 mi. N. Boulder on Utah 117
Garfield Co , Utah, El. 8000
8 June 1962 L(4) A
Prunus virginiana,
Populus tremuloides

441) Bryce Canyon Nat. Park
Garfield Co., Utah, El. 8500
9 June 1962 E(5)L(5) A
Prunus virginiana

441A) Bryce Canyon Nat. Park,
Garfield Co., Utah, El. 8500
9 June 1962 E(0/4)L(gone)
Prunus virginiana

442) Bryce Canyon Nat. Park,
Garfield Co., Utah, El. 8500
9 June 1962 E(4)L(4, 5) A
Populus tremuloides

443) Bryce Canyon Nat. Park,
Garfield Co., Utah, El. 8700
9 June 1962 E(3)L(3, 4, 5) A
Populus tremuloides

444) Bryce Canyon Nat. Park.
Garfield Co., Utah, El. 8700
9 June 1962 E(5)L(4, 5) A
Ribes sp.

445) Bryce Canyon Nat. Park,
Garfield Co., Utah, El. 8000
9 June 1962 L(5) A
Purshia tridentata, *Ribes* sp.

446) Grand Canyon Nat. Park, Ariz.
5 mi. N. Cape Royal, El. 8500
10 June 1962 E(4)L(4, 5) A
Populus tremuloides

447) Grand Canyon Nat. Park, Ariz.
2 mi. N. Cape Royal, El. 8200
10 June 1962 L(4)
Ribes sp.

448) 8 mi. S. Jacob Lake on Ariz. 67
Coconino Co., Ariz., El. 8400
10 June 1961 E(6)L(4, 5) A
Ribes sp.

449) 8 mi. S. Jacob Lake on Ariz. 67
Coconino Co., Ariz., El. 8400
10 June 1961 E(11)L(4, 5) A
Populus tremuloides

450) 1 mi. S. Jacob Lake on Ariz. 67
Coconino Co. ,Ariz., El. 8000
10 June 1962 L(4, 5) A
Populus tremuloides

451) 8 mi. N. Jacob Lake on US 89A
Coconino Co., Ariz., El. 7400
10 June 1962 E(0/4)L(4, 5)
Ribes sp.

452) 8 mi. W. Elba (sec. rd.)
Cassia Co., Idaho, El. 6500
11 June 1962 E(1/1)L(4, 5) A
Prunus virginiana

453) 4 mi. N. Ukiah on US 395
Umatilla Co., Ore., El. 3000
13 June 1962 E(3)L(5) P, A
Prunus virginiana, *Rosa* sp.
Ribes sp., *Amelanchier* sp.

454) 2 mi. E. Tieton Dam, Wash. Hy.
5
Yakima Co., Wash., El. 2800
13 June 1962 L(5) P, A
Purshia tridentata, *Rosa* sp.

459) W. side Leavenworth on US 2
Chelan Co., Wash., El. 1165
14 June 1962 L(5) P
Purshia tridentata, *Crataegus* sp.,
Prunus emarginata, *Prunus*
virginiana, *Amelanchier* sp.

Malacosoma californicum—Con.

460) 7 mi. E. Farmer in Moses Coulee
Douglas Co., Wash., El. 2000
15 June 1962 E(1)L(gone)
Ribes sp.

461) 9 mi. W. Spokane on US 2
Spokane Co., Wash., El. 2400
15 June 1962 L(4, 5) A
Rosa sp., *Prunus virginiana*

Malacosoma californicum californicum (Packard)

2) 1143 Treat Lane, S. of Concord
Contra Costa Co., Calif., El. 100
8 Mar. 1960 E(15)L(1, 2, 3) A
almond, plum

3) ½ mi. E. of Oakley
Contra Costa Co., Calif., El. 25
14 Mar. 1960 E(1)L(1, 2)
almond

4) 3 mi. N. Concord on Cal. 4
Contra Costa Co., Calif., El. 100
14 Mar. 1960 E(6)L(1, 2)
almond

5) 2 mi. S. Martinez on Cal. 4
Contra Costa Co., Calif., El. 100
14 Mar. 1960 E(10)L(1) A
almond

6) 1½ mi. SE. Vallejo
Solano Co., Calif., El. 100
15 Mar. 1960 E(3)L(1)
plum

7) 2385 Oakdale Rd., Hillsborough
San Mateo Co., Calif., El. 200
17 Mar. 1960 E(7)L(2, 3) A
Quercus agrifolia

8) 1810 Notre Dame Ave., Belmont
San Mateo Co., Calif., El. 350
17 Mar. 1960 E(12)L(2, 3, 4) A
ornamental plum, *Q. agrifolia*

10) Hill W. end San Rafael Bridge
Marin Co., Calif., El. 50
19 Mar. 1960 E(9)L(1, 2, 3)
Quercus agrifolia

11) Calif. Pt., 3 mi. E. Mill Valley
Marin Co., Calif., El. 75
19 Mar. 1960 E(12)L(2, 3, 4) A
Quercus agrifolia

12) 2 mi. N. Mill Valley (sec. rd.)
Marin Co., Calif., El. 400
19 Mar. 1960 E(7)L(1, 2)
Quercus agrifolia

13) 1006 D St., Petaluma
Sonoma Co., Calif., El. 15
19 Mar. 1960 L(2, 3) A
apple

15) 10 mi. N. Napa on Silverado Tr.
Napa Co., Calif., El. 150
20 Mar. 1960 E(5)L(1, 2) A
almond

16) Tulocay Cemetery, Napa
Napa Co., Calif., El. 50
20 Mar. 1960 E(13)L(2, 3)
Quercus agrifolia

18) Mission Rd., SE. Hayward
Alameda Co., Calif., El. 50
23 Mar. 1960 E(7)L(2, 3, 4) A
apricot, plum

25) 1 mi. W. Muir on Cal. 19
Contra Costa Co., Calif., El. 75
30 Mar. 1960 E(9)L(2, 3, 4)
Salix sp., *Q. agrifolia*,
Quercus lobata

Malacosoma californicum californicum—Continued

29) Veterans Hosp., Menlo Park
San Mateo Co., Calif., El. 25
8 Apr. 1960 L(5) A
Quercus agrifolia

36) Belmont Canyon Rd., Belmont
San Mateo Co., Calif., El. 400
9 Apr. 1960 E(1)L(4, 5)
Quercus agrifolia

37) 2872 Adeline Dr., Burlingame
San Mateo Co., Calif., El. 300
9 Apr. 1960 E(1)L(5)
Quercus agrifolia

44) Hill S. of Port Costa, Contra
Costa Co., Calif., El. 150
13 Apr. 1960 L(5)
Quercus agrifolia, peach

45) 6 mi. W. Martinez on Cal. 4
Contra Costa Co., Calif., El. 250
13 Apr. 1960 E(1)L(4, 5)
Rosa sp.

46) 3 mi. W. Napa on Cal. 12
Napa Co., Calif., El. 15
14 Apr. 1960 E(2)L(5)
Quercus agrifolia

47) 3 mi. E. Sonoma (sec. rd.)
Sonoma Co., Calif., El. 50
14 Apr. 1960 E(1)L(4, 5)
Quercus agrifolia

73) Gill Tract, U. Cal., Albany
Alameda Co., Calif., El. 30
19 Apr. 1960 E(1)L(5)
apricot

74) 10 mi. N. San Jose on Cal. 17
Alameda Co., Calif., El. 50
21 Apr. 1960 E(1)L(5) A
Salix sp.

81) 2 mi. N. Fairfield on US 40
Solano Co., Calif., El. 40
23 Apr. 1960 L(5)
apricot

Malacosoma californicum ambisimile (Dyar)

21) Just N. Saratoga on Cal. 9
Santa Clara Co., Calif., El. 500
24 Mar. 1960 E(1)L(2) A
apricot

22) 3 mi. SW. Morgan Hill
Santa Clara Co., Calif., El. 300
25 Mar. 1960 E(4)L(1, 2) A
apricot

23) 2½ mi. SW. Morgan Hill
Santa Clara Co., Calif., El. 350
25 Mar. 1960 E(1)L(1, 2)
apricot

24) 2 mi. W. Morgan Hill
Santa Clara Co., Calif., El. 500
25 Mar. 1960 E(1)L(2)
apricot, plum

30B) Purissima at Conception, Los
Altos, Santa Clara Co., Calif.
8 April 1960 E(1)L(4) A
apricot

33) ½ mi. SW. Los Altos, Grand Rd.
Santa Clara Co., Calif., El. 200
8 Apr. 1960 L(5)
apricot

34) Hicks Rd., SE. Los Gatos
Santa Clara Co., Calif., El. 400
8 Apr. 1960 E(1)L(3, 4) A
prune

38) 2 mi. S. Los Gatos on Cal. 17
Santa Clara Co., Calif., El. 700
9 Apr. 1960 E(2)L(2, 3)
plum, prune

Malacosoma californicum ambisimile—Continued

39) ½ mi. NE. Holy City, Santa
Clara Co., Calif., El. 1100
9 Apr. 1960 L(2, 3) A
prune

40) Morgan Hill along US 101
Santa Clara Co., Calif., El. 250
12 Apr. 1960 E(1)L(4) A
prune

41) ¼ mi. NW. San Martin, Santa
Clara Co., Calif., El. 280
12 Apr. 1960 E(1)L(4)
prune

43) 8 mi. S. Hollister, Cienga Rd.
San Benito Co., Calif., El. 1000
12 Apr. 1960 E(3)L(3, 4) A
apricot

75) 5 mi. W. Saratoga on Cal. 9
Santa Clara Co., Calif., El. 2000
21 Apr. 1960 E(2)L(3, 4)
Salix sp.

76) 9 mi. W. Saratoga on Cal. 9
Santa Cruz Co., Calif., El. 2500
21 Apr. 1960 E(1)L(2, 3, 4) A
Ceanothus thyrsiflorus

77) 3 mi. N. Boulder Creek, Cal. 9
Santa Cruz Co., Calif., El. 600
21 Apr. 1960 E(4)L(2, 3, 4)
Salix sp., *Ceanothus thyrsiflorus*

78) Mt. Hermon, 7 mi. N. Santa Cruz
Santa Cruz Co., Calif., El. 500
21 Apr. 1960 L(3, 4)
Ceanothus incanus

79) 3 mi. E. Santa Cruz (sec. rd.)
Santa Cruz Co., Calif., El. 100
21 Apr. 1960 E(1)L(4, 5) A
Quercus agrifolia

80) 3 mi. W. Mt. Madonna Co. Park
Santa Cruz Co., Calif., El. 500
21 Apr. 1960 E(1)L(2, 3)
apple

Intermediate populations—

Malacosoma californicum californicum (Packard)
Malacosoma californicum ambisimile (Dyar)

9) 24841 Summerhill Ave., Los Altos
Santa Clara Co., Calif., El. 300
17 Mar. 1960 E(3)L(2) A
apricot

20) ½ mi. SW. Los Altos, Grand Rd.
Santa Clara Co., Calif., El. 200
24 Mar. 1960 E(1)L(2, 3) A
apricot

30) Purissima at Conception, Los
Altos, Santa Clara Co., Calif.
8 April 1960 E(1)L(5) A
apricot
30A, C, and D: Same data as 30,
but on different trees.
30A) apricot, L(5) A
30C) prune, L(4, 5) A
30D) apricot, L(3)

31) ¼ mi. S. Purissima at Conception
Los Altos, Sta. Clara Co., Calif.
8 Apr. 1960 E(1)L(4, 5) A
prune

32) 569 Tyndall St., Los Altos,
Santa Clara Co., Calif., El. 200
8 Apr. 1960 E(1)L(5)
apricot

33B) ½ mi. SW. Los Altos, Grand Rd.
Santa Clara Co., Calif., El. 200
8 Apr. 1960 E(2)L(4, 5)
apricot

Intermediate populations—
M. californicum californicum
(Packard)—
M. californicum ambisimile
(Dyar)—Continued

35) 300 Fremont Ave., Los Altos
Santa Clara Co., Calif.
9 Apr. 1960 L(5)
apricot

35A, B, C, D, and E: Same data as 35, but on different trees.

35A) apricot, L(5) A
35B) apricot, L(5)
35C) apricot, E(1)L(4)
35D) apricot, L(4, 5) A
35E) apricot, L(3, 4)

Malacosoma californicum recenseo Dyar

17) Blue Can. Airport, US 40
Placer Co., Calif., El. 5280
22 Mar. 1960 E(5)
Ceanothus cordulatus

17A) Same data as 17
21 June 1960 E(4)L(3, 4) A

120) Jct. of Cal. 89 and US 99
Siskiyou Co., Calif., El. 3600
17 May 1960 E(1)L(1)
Ceanothus cordulatus

120A) Same data as 120, collected
12 June 1960 E(1)L(3, 4) A

141) 12 mi. W. Chester on Cal. 36
Tehama Co., Calif., El. 4500
1 June 1960 E(2)L(1, 2)
Ceanothus cordulatus

142) 1.8 mi. W. Chester on Cal. 36
Plumas Co., Calif., El. 4225
1 June 1960 E(1)L(1)
Ceanothus cordulatus,
Purshia tridentata

143) ½ mi. W. Chester on Cal. 36
Plumas Co., Calif., El. 4200
1 June 1960 E(1)L(2, 3)
Purshia tridentata

144) 2 mi. E. Chester on Cal. 36
Plumas Co., Calif., El. 4400
1 June 1960 E(3)L(2)
Prunus emarginata,
Ceanothus cordulatus

149) 1 mi. S. Jct. Nev. 27 & 28 on 28
Washoe Co., Nev., El. 6200
1 June 1960 E(7)L(1, 2, 3, 4) A
Purshia tridentata

150) 1 mi. SE. Sierraville on Cal. 89
Sierra Co., Calif., El. 4950
2 June 1960 E(4)L(3, 4, 5) A
Purshia tridentata, Prunus
virginiana, Rosa sp.

151) 3 mi. E. Canyon Dam on Cal. 89
Plumas Co., Calif., El. 4000
2 June 1960 E(1)L(2, 3)
Ceanothus integerrimus, Prunus
virginiana, C. cordulatus

163) 5 mi. E. McCloud on Cal. 89
Siskiyou Co., Calif., El. 3500
12 June 1960 L(3)
Ceanothus velutinus, Purshia
tridentata, C. cordulatus,
Prunus emarginata

164) 5 mi. W. McCloud on Cal. 89
Siskiyou Co. Calif., El. 4300
12 June 1960 E(1)L(3)
Ceanothus velutinus

169) 18 mi. W. Susanville (sec. rd.)
Lassen Co., Calif., El. 4600
22 June 1960 E(1)L(3, 4)
Ceanothus cordulatus

170) 4 mi. N. Lassen Nat. Pk. Bdry.
on Cal. 89
Shasta Co., Calif., El. 5300
30 June 1960 E(1)L(4) A
Ceanothus velutinus

Malacosoma californicum pluviale (Dyar)

121) 10 mi. N. Grants Pass on US 99
Josephine Co., Ore., El. 1650
17 May 1960 E(3)L(4) A
Ceanothus cuneatus,
Amelanchier sp.

122) 7 mi. .N. Eugene (sec. rd.)
Lane Co., Ore., El. 400
18 May 1960 E(2)L(3, 4) A
apple

122C) Same data as 122, collected
13 June 1960, *Rosa* sp. L(3) A
(heavily shaded)

123) 3 mi. N. Corvallis on US 99W
Benton Co., Ore., El. 200
18 May 1960 E(3)L(2, 3, 4)
apple, multiflora rose

124) 2 mi. N. Forest Grove on Ore. 47
Washington Co., Ore., El. 100
18 May 1960 E(1)L(3)
Amelanchier sp.

125) Just E. Port Angeles on US 101
Clallam Co., Wash., El. 100
19 May 1960 E(2)L(3, 4, 5) A
sweet cherry, apple, *Salix* sp.

126) 2 mi. N. Kelso on Wash. 124
Cowlitz Co., Wash., El. 100
19 May 1960 E(1)L(3)
apple

171) 8 mi. E. Cranbrook on B.C. 3
British Columbia, El. 2800
3 July 1960 E(7)L(5) A
Purshia tridentata, *Rosa* sp.,
Amelanchier sp.

172) 1 mi. E. Crowsnest on Alta. 3
Alberta, El. 4300
4 July 1960 E(1)L(4, 5) A
Amelanchier sp., *Salix* sp.
Populus tremuloides (height—3 ft.)

175) 1 mi. N. Grande Prairie
Alberta, El. 2200
27 June 1960 L(4, 5)
Rosa sp.
For. Biol. Lab. No. 60A-622

180) Weiparous Creek, 60 mi. NW.
Calgary on Forest Road,
Alberta, El. 4700
11 July 1960 E(10)L(5) P, A
Betula glandulosa, *Salix* spp.

181) Ft. Steele Jct., B.C., El. 2525
1 July1960 L(5) A
Purshia tridentata
For. Biol. Lab. B.C. 60-6179

182) Waterton Townsite, Waterton
Lakes Nat. Pk. Alta., El. 4300
18 July 1960 E(3)L(5) P
Amelanchier sp., *Prunus*
virginiana, *Alnus* sp., *Populus*
tremuloides, *Rosa* sp., *Ribes* sp.

183) 7 mi. NW. Babb on Mont. 17
Glacier Co., Mont., El. 5500
19 July 1960 E(2)L(5) P
Amelanchier sp., *Ribes* sp.,
Alnus sp., *Salix* sp.

340) 2 mi. SW. East Glacier Park
Glacier Co., Mont., El. 4900
11 June 1961 L(4)
Prunus virginiana

341) 4 mi. E. Kalispell on US 2
Flathead Co., Mont., El. 2950
11 June 1961 E(2)L(4, 5) A
Apple, *Amelanchier* sp.

342) 20 mi. E. Libby on US 2
Lincoln Co., Mont., El. 2900
12 June 1961 E(1)L(4, 5)
Prunus virginiana

Malacosoma californicum pluviale—Continued

343) 12 mi. S. Spokane on US 195
Spokane Co., Wash., El. 2300
12 June 1961 E(12)L(5) A
Rosa sp.

344) 2 mi. E. Moscow on Idaho
Latah Co., Idaho, El. 2600
13 June 1961 L(4, 5)
Amelanchier sp., *Rosa* sp.

345) Superior, on US 10
Mineral Co., Mont., El. 2300
14 June 1961 E(2)L(5)
Prunus virginiana,
Amelanchier sp.

346) 14 mi. E. Missoula on US 10
Missoula Co., Mont., El. 3000
14 June 1961 E(1)L(5) P
Rosa sp., *Amelanchier* sp.

348) 9 mi. W. Helena on US 10
Lewis & Clark Co., Mont., El. 4300
17 June 1961 E(8)L(4, 5) A
Purshia tridentata, *Ribes* sp.,
Prunus virginiana, *Rosa* sp.,
Amelanchier sp., *Ribes aureum*

358) 14 mi. SW. Bowman's Corner
Lewis & Clark Co., Mont., El. 4500
19 June 1961 L(4)
Rosa sp.

455) 3 mi. E. Renton on Wash. 5
King Co., Wash., El. 200
14 June 1962 E(2)L(4, 5) A
Salix sp., sweet cherry

456) 2 mi. E. Skykomish on US 2
King Co., Wash., El. 1000
14 June 1962 E(1)L(3)
Alnus oregona

457) 7 mi. W. Merritton on US 2
Chelan Co., Wash., El. 3200
14 June 1962 E(1)L(4)
Sorbus sitchensis, *Salix* sp.,
Prunus emarginata,
Amelanchier sp.

458) 1 mi. S. Winton on US 2
Chelan Co., Wash., El. 2000
14 June 1962 E(1)L(4)
Amelanchier sp.

Malacosoma californicum lutescens (Neumoegen and Dyar)

173) 3 mi. E. Beauvallon on Alta. 45
Alberta, El. 2000
2 June 1960 L, A
Prunus virginiana
For. Bio. Lab. No. 60A–119

174) 11 mi. N. Chauvin on Alta. 14
Alberta, El. 2000
1 June 1960 L, A
Amelanchier sp., *Ribes* sp.,
Rosa sp.
For. Biol. Lab. No. 60A–138

177) 1 mi. S. Drumheller on Alta. 9
Alberta, El. 2700
7 July 1960 E(8)L(5) P, A
Rosa sp., *Prunus virginiana*,
Amelanchier sp., *Ribes* sp.

179) 4 mi. W. Derwent on Alta. 45
Alberta, El. 2100
8 July 1960 E(1)L(5) A
Rosa sp., *Prunus virginiana*

329) 21 mi. S. Bozeman on US 191
Gallatin Co., Mont., El. 5200
8 June 1961 E(14)L(4, 5) A
Prunus virginiana

330) 15 mi. E. Livingston on US 10
Park Co., Mont., El. 4200
10 June 1961 E(2)L(gone)
Prunus virginiana

Malacosoma californicum lutescens—Continued

331) 9 mi. W. Harlowton on US 12
Wheatland Co., Mont., El. 4500
10 June 1961 E(9)(L5) P, A
Prunus virginiana,
Rosa sp., *Ribes* sp.

332) 7 mi. N. Neihart on US 89
Cascade Co., Mont.
10 June 1961 E(1)L(4)
Prunus virginiana

333) 25 mi. SE. Great Falls,
Cascade Co., Mont., El. 3700
10 June 1961 L(5)
Prunus virginiana

335) 4 mi. NE. Fort Benton
Chouteau Co., Mont., El. 2900
11 June 1961 E(1)L(5) A
Ribes aureum, *Rosa* sp.

336) 6 mi. SW. Havre on US 87
Hill Co., Mont., El. 2800
11 June 1961 E(1)L(4, 5)
Rosa sp.

337) 2 mi. E. Devon on US 2
Toole Co., Mont., El. 3300
11 June 1961 L(4, 5)
Rosa sp.

349) 9 mi. N. Bozeman, Bridger Mtns.,
Gallatin Co., Mont., El. 5000
19 June 1961 E(1)L(4, 5) A
Rosa sp.

350) 23 mi E. Townsend on US 12
Broadwater Co., Mont., El. 5300
19 June 1961 E(1)L(3, 4, 5)
Prunus virginiana, *Rosa* sp.

351) 18 mi. E. Townsend on US 12
Broadwater Co., Mont., El. 4800
19 June 1961 E(1)L(4, 5) A
Salix sp., *Ribes aureum*

352) 10 mi. E. Townsend on US 12
Broadwater Co., Mont., El. 4300
19 June 1961 L(5) P
Prunus virginiana

353) 13 mi. W. Townsend (sec. rd.)
Broadwater Co., Mont., El. 6200
19 June 1961 L(4) A
Rosa sp.

357) 3 mi. SE. Bowman's Corner
Lewis & Clark Co., Mont., El. 4200
19 June 1961 L(5) P
Rosa sp.

359) 24 mi. E. Lovell on Wyo. 14
Big Horn Co., Wyo., El. 6400
22 June 1961 E(1)L(5) A
Ribes sp.

415) 7 mi. S. Pampa on Tex. 70
Gray Co., Tex., El. 3000
24 April 1962 E(1)L(5) A
wild plum

416) 5 mi. W. Miami on US 60
Roberts Co., Tex., El. 2800
24 April 1962 E(7)L(5) A
wild plum

417) 11 mi. SE. Canadian on Tex. 33
Hemphill Co., Texas
24 April 1962 L(4)
Prunus virginiana

418) 6 mi. W. Jct. Okla. 33 & US 283
Roger Mills Co., Okla.
24 April 1962 L(4, 5)
wild plum

419) 12 mi. E. Butler on Okla. 33
Custer Co., Okla.
24 April 1962 E(1)L(5)
Ribes sp.

Malacosoma californicum lutescens—Continued

420) Watonga, Blaine Co., Okla.
24 April 1962 L(4, 5)
wild plum

421) 7 mi. W. Guthrie on Okla. 33
Logan Co., Okla.
25 April 1962 E(2)L(5) A
wild plum

423) 6 mi. E. Guthrie on Okla. 33
Logan Co., Okla., El. 1100
25 April 1962 E(1)L(4, 5) A
wild plum

424) 2 mi. E. Coyle on Okla. 33
Payne Co., Okla., El. 1000
25 April 1962 E(1)L(5)
wild plum

429) Burke, Gregory Co., S. Dak.
27 May 1962 L(3, 4, 5)
wild plum, *Salix* sp.

430) 9 mi. N. Iona on S.D. 47
Brule Co., S. Dak.
27 May 1962 E(1)L(5) A
wild plum

462) 30 mi. W. Bozeman (sec. rd.)
Madison Co., Mont., El. 5500
17 June 1962 L(4, 5)
Rosa sp., *Ribes* sp.,
Prunus virginiana

463) Summit, 15 mi. E. Ashland, Mont. 8
Powder R. Co., Mont., El. 4000
17 June 1962 E(1)L(4, 5) A
wild plum, *Prunus virginiana*

465) 9 mi. E. Neepawa on Man. 4
Manitoba, 30 June 1962 L(5) P
Prunus virginiana

466) Wasagaming, Manitoba
1 July 1962 L(5) P
Rosa sp., *Salix* sp.

467) 6 mi. W. Dauphin on Man. 10
Manitoba, 1 July 1962
E(1)L(5) P
Rosa sp., *Salix* sp.

469) Just N. Cowan, Manitoba
1 July 1962 L(5) P
Prunus virginiana

Intermediate populations—

***Malacosoma californicum lutescens* (Neumoegen and Dyar)**

***Malacosoma californicum pluviale* (Dyar)**

338) 16 mi. W. Cutbank on US 2
Glacier Co., Mont., El. 4200
11 June 1961 L(4) A
Salix sp., *Rosa* sp.

339) Cutbank R., W. of Cutbank
Glacier Co., Mont., El. 3800
11 June 1961 E(2)L(4, 5)
Ribes aureum, *Rosa* sp.,
Prunus virginiana

347) 12 mi. W. Whitehall on US 10
Jefferson Co., Mont., El. 4800
14 June 1961 E(2)L(5) P
Ribes sp., *Rosa* sp.,
Prunus virginiana

354) 12 mi. N. Helena on US 91
Lewis & Clark Co., Mont. El. 4200
19 June 1961 E(1)L(4, 5) A
Rosa sp., *Ribes* sp.

355) 12 mi. N. Helena on US 91
Lewis & Clark Co., Mont., El. 4200
19 June 1961 E(1)L(4)
Ribes sp.

Intermediate populations—
M. californicum lutescens (Neumoegen and Dyar)
M. californicum pulviale (*Dyar*)—Con.

356) 15 mi. N. Helena on US 91
Lewis & Clark Co., Mont., El. 4000
19 June 1961 E(1)L(5) A
Ribes sp.

Malacosoma californicum fragile (Stretch)

27) Morongo Valley, San Bernardino Co., Calif., El. 2350
3 Apr. 1960 E(0/23)L(5) A
Prunus fasciculata

28) 7–10 mi. SE. Lucerne Valley
San Bernardino Co., Calif., El. 4500
3 Apr. 1960. E(2)L(3, 4, 5) A
Prunus fasciculata

112) Near Aguerreberry Pt., Deat Valley, Inyo Co., Calif., El. 5500
7 May 1960 E(0/1)L(5) P, A
Prunus fasciculata

113) Hunter Mtn., 20 mi. N. Panamint Springs
Inyo Co., Calif., El. 6400
7 May 1960 E(0/4*)L(2, 3, 4) A
Purshia glandulosa

114) 2 mi. S. Tom's Place on US 395
Mono Co., Calif., El. 6700
7 May 1960 E(4/1)L(3, 4, 5) A
Purshia tridentata

115) Conway Summit, N. Mono L., US 395
Mono Co., Calif., El. 8100
8 May 1960 E(7/5)L(1, 2, 3)
Purshia tridentata

115A) N. side Conway Summit, El. 7000
Mono Co., Calif.
8 May 1960 E(0/1)L(2, 3, 4)
Ribes sp., *Purshia tridentata*

116) 2 mi. N. Sonora Jct. on US 395
Mono Co., Calif., El. 6500
8 May 1960 E(0/1)L(1, 2)
Purshia tridentata

117) 2 mi. N. Coleman on US 395
Mono Co., Calif., El. 5100
8 May 1960 E(1/3)L(5) P, A
Prunus andersonii

118) 6 mi. W. Jct. Cal. 89 & US 395
Mono Co., Calif., El. 6500
8 May 1960 L(4, 5)
Prunus andersonii

119) 1 mi. S. Woodsford on Cal. 89
Alpine Co., Calif., El. 5700
8 May 1960 E(0/2*)L(3, 4) A
Purshia tridentata

135) 2 mi. N. Virginia City on Nev. 17
Storey Co., Nev., El. 6700
24 May 1960 E(0/6)L(5) P, A
Purshia tridentata, *Prunus andersonii*

204) Mitchell Caverns St. Park area
San Bernardino Co., Calif., El. 4500
7 Mar. 1961 E(0/7)L(3, 4, 5) A
Prunus fasciculata, almond

205) 4 mi. W. US 95 on Nev. 39
Clark Co., Nev., El. 3000
8 Mar. 1961 E(0/1)L(2, 3, 4) A
Prunus fasciculata

206) 5 mi. W. Goodsprings on Nev. 53
Clark Co., Nev., El. 4300
8 Mar. 1961 E(0/3)L(2, 3, 4) A
Prunus fasciculata

Malacosoma californicum fragile—Continued

207) 1/4 mi. NW. Kingman on US 466
Mohave Co., Ariz., El. 3350
9 Mar. 1961 E(0/4)L(3, 4, 5) A
Prunus fasciculata

217) Hualpai Mtn. Park road
Mohave Co., Ariz., El. 4000
17 Mar. 1961 E(0/6)L(4, 5) A
Prunus fasciculata

218) Valentine, Mohave Co., Ariz., El. 3800
17 Mar. 1961 E(0/7)L(3, 4) A
Prunus fasciculata

219) 5 mi. E. Valentine on US 66
Mohave Co., Ariz., El. 4000
17 Mar. 1961 E(0/5)L(1, 2, 3) A
Prunus fasciculata

222) 6 mi. NW. Cajon on Calif. 2
San Bernardino Co, Calif., El. 4000
26 Mar. 1961 E(0/1)L(3, 4) A
Prunus fasciculata

230) 13 mi. SW. Glendale on US 91
Clark Co., Nev., El. 2000
10 Apr. 1961 E(1/2*)L(4, 5) P, A
Prunus fasciculata

232) Summit, US 91, Beaver Dam Mtns.
Washington Co., Utah El. 4500
10 Apr. 1961 E(0/1)L(5) P, A
Prunus fasciculata

234) 1 mi. E. Shivwits on US 91
Washington Co., Utah, El. 3200
10 Apr. 1961 E(0/5)L(4, 5) A
Prunus fasciculata, peach

235) Leeds, Washington Co., Utah, El. 3400
10 Apr. 1961 E(0/1)L(5) A
apricot

236) 2 mi. E. Verkin on Utah 15
Washington Co., Utah, El. 3500
11 Apr. 1961 L(4, 5)
Amelanchier utahensis,
Prunus fasciculata

237) Springdale, Washington Co., Utah El. 3700
11 Apr. 1961 E(0/3)L(5)
Prunus fasciculata

265) 1 mi. S. Kanarraville, Iron Co., Utah, El. 5500
9 May 1961 L(5) A
Amelanchier utahensis

266) 3 mi. S. Beaver on US 91
Beaver Co., Utah, El. 6000
9 May 1961 E(0/4)L(4, 5) A
Purshia tridentata

267) 8 mi. N. Cove Fort on US 91
Millard Co., Utah, El. 6300
9 May 1961 E(0/1)L(4, 5)
Purshia tridentata

Malacosoma incurvum incurvum (Henry Edwards)

200) 14 mi. W. Phoenix on US 80
Maricopa Co., Ariz., El. 1100
3 Mar. 1961 E(13)L(3, 4) A
Populus fremontii

201) 1 mi. W. Chandler on Ray Road
Maricopa Co., Ariz., El. 1200
3 Mar. 1961 E(5)L(5) A
Populus fremontii

202) 1303 E. Hedrick Dr., Tucson
Pima Co., Ariz., El. 2370
5 Mar. 1961 E(10)L(3, 4, 5) A
Populus fremontii

Malacosoma incurvum incurvum—Continued

203) 5 mi. SE. Wickenburg on US 60
Maricopa Co., Ariz., El. 2000
6 Mar. 1961 E(5)L(3, 4, 5) A
Salix sp., *P. fremontii*

208) 16 mi. N. Wikieup on Ariz. 93
Mohave Co., Ariz., El. 2700
9 Mar. 1961 E(2)L(3, 4, 5) A
Populus fremontii

210) Sabena Cyn., Sta. Catalina Mtns.
Pima Co., Ariz., El. 3000
11 Mar. 1961 E(1)L(3, 4, 5)
Populus fremontii, *Salix* sp.

211) Mt. Lemmon Rd., Santa Catalina Mtns.
Pima Co., Ariz., El. 4300
11 Mar. 1961 E(1)L(2, 3, 4)
Populus fremontii

212) 3.5 mi. SW. Patagonia on Ariz. 82
Santa Cruz Co., Ariz., El. 4000
12 Mar. 1961 E(3)L(2, 3, 4) A
Salix sp.

213) Pima, Graham Co., Ariz., El. 2900
13 Mar. 1961 E(6)L(1, 2, 3, 4) A
Populus fremontii

214) Miami, Gila Co., Ariz., El. 3550
14 Mar. 1961 E(1)L(1, 2, 3, 4) A
Populus fremontii, peach

215) 9 mi. W. Miami on US 70
Gila Co., Ariz., El. 4500
14 Mar. 1961 E(5)L(1, 2, 3) A
Prunus virens

216) Winkelman at Gila R. bridge
Gila Co., Ariz., El. 2000
14 Mar. 1961 E(12)L(3, 4, 5) A
Salix sp., *Populus fremontii*

220) Cottonwood, Yavapai Co., Ariz., El. 3300
20 Mar. 1961 L(3) A
peach

241) 13 mi. W. Pine (sec. rd.)
Gila Co., Ariz., El. 3700
13 Apr. 1961 E(1)L(5) P, A
Populus fremontii

243) Madera Canyon, Santa Rita Mtns.
Santa Cruz Co., Ariz., El. 5500
26 Apr. 1961 E(1)L(4) A
Prunus virens

244) Ramsey Canyon, Huachuca Mtns.
Cochise Co., Ariz., El. 5500
28 Apr. 1961 E(4)L(5) A
Prunus virens, *Salix* sp.,
apricot

249) 8 mi. N. Clifton on US 666
Greenlee Co., Ariz., El. 4700
1 May 1961 E(2)L(5) P, A
Populus fremontii

250) 9 mi. N. Clifton on US 666
Greenlee Co., Ariz., El. 5000
1 May 1961 E(3)L(5) P, A
Prunus virens

Malacosoma incurvum discoloratum
(Neumoegen)

231) Mesquite, Clark Co.,
Nevada, El. 1700
10 Apr. 1961 E(17)L(5) P, A
Populus fremontii, *Salix* sp.

233) 1 mi. E. Shivwits on US 91
Washington Co. Utah El. 3200
10 Apr. 1961 E(2)L(3, 4) A
Populus fremontii, *Salix* sp.

Malacosoma incurvum discoloratum—Continued

235A) Leeds, Washington Co.,
Utah, El. 3400
10 Apr. 1961 L(4, 5) A
apricot, *Populus fremontii*,
Populus alba

282) San Rafael R., 30 mi. E. Castle
Dale, Emery Co., Utah, El. 5000
19 May 1961 E(15)L(5) A
Populus fremontii

283) Colo. R., 2 mi. NW. Moab,
Grand Co., Utah, El. 4000
19 May 1961 E(1)L(gone) P, A
Populus fremontii

284) LaSal Mtns., 16 mi. SE. Moab,
San Juan Co., Utah, El. 5700
20 May 1961 E(1)L(5) A
Populus angustifolia

288) 1 mi. N. Bluff on Utah 47
San Juan Co., Utah, El. 4700
20 May 1961 E(1)L(5) P, A
Populus fremontii

293) Colo. R. at Grand Junction
Mesa Co., Colo., El. 4600
21 May 1961 E(2)L(5) A
Populus fremontii, *Rosa* sp.,*
Populus alba

313) 10 mi. W. Huntington, Utah 31
Emery Co., Utah, El. 6700
1 June 1961 E(1)L(5) A
Populus angustifolia

436) 15 mi. W. Hanksville, Utah 24
Wayne Co., Utah, El. 4500
7 June 1962 E(5)L(5) P, A
Populus fremontii

440) Boulder, Garfield Co.,
Utah, El. 5300
8 June 1962 E(1)L(4, 5) A
Populus angustifolia

APPENDIX II

Explanatory Notes on North American *Malacosoma* Types

Neotype designation of *Malacosoma californicum* (Packard)

In 1864 Alpheus S. Packard described a species of *Malacosoma* under the name *Clisiocampa californica* from specimens sent to him from California by "Mr. Edwards." This "Mr. Edwards" was undoubtedly Henry Edwards, since he had visited California as an actor before 1864 and lived there from 1865 to 1878 (Essig, 1931). In addition, he was especially interested in moths, while the other "Mr. Edwards" actively working on Lepidoptera at that time was W. H. Edwards, who spent most of his life in the East and was an authority on butterflies.

The type of *M. californicum* (Packard), if one was designated, appears to be lost or destroyed. A personal search of the *Malacosoma* in the United States National Museum, the American Museum of Natural History, the Carnegie Museum, and the Chicago Museum of Natural History did not reveal any specimen which had labels indicating it could be the type.

The Museum of Comparative Zoology at Harvard University, the Academy of Natural Sciences of Philadelphia, the New York State Museum, the Boston Museum of Science (formerly the Boston Society of Natural History), the Northeastern Forest Experiment Station, the University of Connecticut, the Connecticut Agricultural Experiment Station, Cornell University, and Rutgers University all indicate they do not have it. It is not among any of the specimens borrowed from various other institutions, and these institutions have not indicated that they have any types of *Malacosoma*.

Dr. Packard was Professor of Zoology and Geology at Brown University from 1878 until his death, but Dr. J. Walter Wilson of the Biological Laboratory at Brown University states that if the type was ever in Packard's collection at Brown University, it has long since disappeared, for after his death in 1905 the museum was allowed to deteriorate and specimens gradually disappeared as space was needed from time to time.

In view of the fact that the name "*californicum*" has priority over other names which have been given to the western populations of this species of *Malacosoma*, it is desirable to tie it to a single specimen of what is believed to be the species which Packard described. The original description is brief, but sufficiently detailed to make it fairly certain that Packard did not have *M. disstria* or *M. constrictum* before him. It probably was not *disstria* because Packard states that the male is "cinnamon brown, with two transverse pale lines." Most male *disstria* have two transverse dark lines, but rare specimens may have narrow light areas paralleling the lines which are more conspicuous than the lines. It probably was not *constrictum* because Packard states that "the female is lighter colored than the other sex." Female *constrictum* are darker than the males in most cases. Other *Malacosoma* which were originally described from California are *M. ambisimilis* (Dyar) and *M. pluvialis recenseo* Dyar; these are regarded as subspecies of *M. californicum* in this revision. Adult male *californicum recenseo* usually can be separated from male *californicum californicum* by their dark reddish-brown color and dark lines on the forewings. Most female *californicum recenseo* cannot be separated from female *californicum californicum*. Neither adult males nor adult females of *californicum ambisimile* can be separated from *californicum californicum* by any known characters. Therefore, to avoid any possible doubt as to which species, subspecies, or population the name *californicum* applies, a neotype has been designated. It has been selected on the basis of the following findings.

Up to the present time the name "*californicum*" generally has been attached to those populations of *Malacosoma* which are characterized by the larvae being nearly black with conspicuous orange setae both dorsally and laterally (figs. 352 and 353). This population occurs in the vicinity of San Francisco Bay (fig. 3). Packard listed the locality in the original description only as "California," but the specimens which he described as *californicum* in 1864 most likely came from the area around San Francisco Bay since Henry Edwards worked in the San Francisco area as an actor prior to 1864.

One can assume that Edwards retained some specimens from the series that he sent Packard. Most of Henry Edwards' collection is in the American Museum of Natural History or the United States National Museum (his *Malacosoma* types are in the USNM), but none of his specimens in either museum can be dated with certainty before 1864. Some of his *Malacosoma* which may have been part of the original series of specimens from which *californicum* was described are in the American Museum of Natural History.

There are two different catalogs of Henry Edwards' specimens in the American Museum of Natural History. One is his original catalog in which he apparently made most of the entries. This catalog is referred to as "Henry Edwards' personal catalog" in the following discussion, and it seems to be quite accurate. The second catalog is one that was prepared by somebody after his collection was obtained by the museum. It contains a second set of identification numbers, and at least as far as the *Malacosoma* entries are concerned, it is full of errors of various sorts. This catalog is referred to as the "AMNH catalog of Henry Edwards' collection" in the following discussion.

In Henry Edwards' personal catalog at the AMNH the following entry appears:

CALIFORNIA

No.	Genus and species	Habitat	Locality	By whom collected or whence received	Date	Remarks
101	Clisiocampa californica Pack.	oak groves	Alameda Co.	H.E.	6	Caterpillar gregarious. This is Clis. frutetorum Bois.

There is no date on this page, but the catalog is not arranged in chronological order since there are various pages dated as early as 1839 which follow this page. The fact that the specimens are identified as *Clisiocampa californica* Pack. indicates that the entry was made after 1864, and the comments under "remarks" indicate that it was made after 1868–69, since Boisduval described *frutetorum* in 1868–69. (Edwards' remarks are incorrect since *frutetorum* is actually a synonym of *M. americanum*. The other two species which Boisduval described at the same time, *pseudoneustria* and *drupacearum*, are both synonyms of *M. californicum*.) The fact that the entries were made after 1868 does not mean the specimens were not collected at an earlier time, since many of his entries in the catalog bearing higher catalog numbers than "101" have dates as early as 1838.

Even if Packard designated a type(s) in 1864 there does not appear to be a specimen of *californicum* in existence bearing a label in his handwriting. Therefore, it must be assumed that the type(s) is lost, destroyed, or unrecognizable because it was not labeled.

It is possible that Packard returned the type(s) to Henry Edwards, but a check of their correspondence which is filed in the American Museum of Natural History has been made through the cooperation of Mr. F. Martin Brown and Dr. Frederick H. Rindge, and no mention of *Clisiocampa californica* was found in any letters dated between 14 January 1869 and 23 October 1890. Dr. Rindge says it is apparent that Packard returned many specimens to Henry Edwards, but in no case was there any listing of the actual specimens or species that were returned. Therefore, it seems very unlikely that any reference to *Clisiocampa californica* would be found in Packard's pre-1869 correspondence with Henry Edwards if it still exists.

Judging from the original description, it seems most likely that Packard had one male and one female before him when he described *californicum*, since he does not mention any color variations such as a predominantly yellow male in Henry Edwards' collection in the American Museum of Natural History. Also, Packard gives measurements for *a* male and *a* female, indicating that he had no other specimens before him.

Henry Edwards must have known what *californicum* looked like, since he sent the specimens to Packard. As his specimens bearing the No. "101" label were identified as *Clisiocampa californica* by him, the most logical type candidate is one of his "101" specimens, especially since the locality (Alameda Co., California) is well within the range of what has been generally regarded as *M. californicum* up to the present time.

As far as presently known there are nine Henry Edwards "101" specimens in existence, but there could easily be others since four of these are in the American Museum of Natural History, two in the Strecker collection at the Chicago Museum of Natural History, two in the New York State Museum, and one in the Museum of Comparative Zoology. None of these bears any of Packard's labels. Since no specimens of *Malacosoma* bearing Packard's labels are known, it seems best to designate a type from Henry Edwards' "101" specimens. Therefore, a male in the AMNH which fits Packard's description most closely and is in nearly perfect condition is designated as the neotype of *Malacosoma californicum* (Packard). See the section on *M. californicum californicum* (Packard) for the description and data for this type specimen.

Malacosoma constrictum constrictum (Henry Edwards)

In 1874 Henry Edwards described the larva, chrysalis, and cocoon of *M. constrictum constrictum* under the name "*Clisiocampa constricta* Stretch n. sp." This description fits *c. constrictum* larvae quite closely, and there can be no doubt that he had *c. constrictum* larvae before him. Stretch did not publish his description of *c. constrictum* until 1881, so the name should be credited to Henry Edwards. Edwards did not designate a type, gave no locality, and obviously knew that Stretch had a name in mind for this species or he could not have used "*Clisiocampa constricta* Stretch n. sp." for the immatures which he described. It seems evident that he intended only to supplement Stretch's description by describing the immature stages, since he had an adult which he could have described. (He notes: "Larva May 22d, changed to chrysalis, May 29th. Imago, June 16th.") Nevertheless, he was the first person to name and describe *c. constrictum*, so the citation must be changed to *M. constrictum constrictum* (Henry Edwards).

There is no type(s) since Edwards noted that his larva changed to a chrysalis and then to an adult, and he did not describe the adult. Actually, the existence of an authentic type for *c. constrictum* is not necessary to identify the species, since the descriptions by both Edwards and Stretch are good enough to identify it with certainty. See below for a discussion of Stretch's *Malacosoma* types.

The R. H. Stretch *Malacosoma* types

Richard H. Stretch described five species of western *Malacosoma* (*fragilis*, *constricta*, *erosa*, *strigosa*, and *thoracica*), but only *fragilis* is presently retained as a subspecies of *M. californicum*. The names *erosa*, *strigosa*, and *thoracica* are synonyms and *constricta* must be credited to Henry Edwards (see above).

In all the original descriptions except that of *constricta* Stretch indicated that he obtained the specimens from Henry Edwards. In the description of *constricta* he says, "Mr. H. Edwards has raised the species frequently," so Stretch may have obtained these specimens from Edwards, too.

Apparently, Stretch did not designate any types of *Malacosoma*. It seems most probable that Stretch used Henry Edwards' specimens in describing all of his species of *Malacosoma*, and then returned them to Edwards without labeling them. Edwards then placed them in his collection after labeling them in various ways. In the Henry Edwards' collection in the American Museum of Natural History there are specimens of all five of Stretch's species which are supposed to be the types. Only one of these (*thoracica*) bears a label with "type" written on it, and this label is in Henry Edwards' handwriting. Two others (*erosa* and *fragilis*) have determination labels in Henry Edwards' handwriting. These two and the remaining two (*constricta* and *strigosa*) all have labels designating them as lectotypes by McDunnough in

1942, but these designations apparently were never published so they are not valid. Nevertheless, McDunnough chose specimens which Stretch probably had before him when he made the original descriptions, so the same specimens have been designated as lectotypes here.

All of the data in Henry Edwards' personal catalog of his collection in the American Museum of Natural History for these specimens are in agreement with the original descriptions with the exception of the locality for *thoracica*. Stretch gives the locality as "Congress Springs, San Mateo Co., California," but Edwards' catalog gives the locality as "Congress Springs, Santa Clara Co., California." This is probably an error on Stretch's part, since Congress Springs is actually in Santa Clara Co., although close to the San Mateo Co. line.

Congress Springs is near the northern edge of the range of *M. californicum ambisimile*. In the past *thoracica* has always been regarded as a form of *M. disstria* because of superficial resemblance, but the terminalia and epiphysis of the adult male type identify it as *M. californicum*. The name *thoracica* Stretch, 1881, has priority over *ambisimile* Dyar, 1893, but adult male *californicum ambisimile* cannot be separated from adult male *californicum californicum* Packard, 1864, the other subspecies which occurs near Congress Springs. *M. californicum californicum* is known to occur less than 10 miles north of Congress Springs and may occur even closer. Because of these uncertainties and to avoid a senseless change in names from *ambisimile* to *thoracica*, *thoracica* has been listed as a synonym of *M. californicum californicum*.

APPENDIX III

Common Names of *Malacosoma* Species

The most recent list of "Common Names of Insects" approved by the Entomological Society of America (Bulletin of Ent. Soc. of Amer., December, 1965) lists the following common names for species of *Malacosoma:*

Malacosoma americanum . . .	Eastern tent caterpillar
Malacosoma disstria	Forest tent caterpillar
Malacosoma californicum	California tent caterpillar
Malacosoma fragile	Great Basin tent caterpillar
Malacosoma lutescens	Prairie tent caterpillar
Malacosoma pluviale	Western tent caterpillar

The last four of these "species" are here regarded as subspecies of *M. californicum*. Subspecies are not given common names so the following changes are suggested.

The distribution of *M. californicum* (including the subspecies) covers much of the western half of North America (fig. 2). Three of the four common names which have been applied to the included subspecies are not appropriate for a species with such a wide distribution. The names "California tent caterpillar" and "Prairie tent caterpillar" are obviously too restrictive, as is the name "Great Basin tent caterpillar," although it is somewhat better. In the past the "species" *Malacosoma pluviale* has been known as the "Western tent caterpillar," but since its distribution extends from the Pacific Ocean as far east as Quebec across *northern* North America (fig. 2), the name is not entirely appropriate. Therefore, it is suggested that *M. californicum* (including all subspecies) be given the common name of the "Western tent caterpillar." This name is especially appropriate since the distribution of *M. californicum* includes nearly all of North America that is not occupied by *M. americanum*, the "Eastern tent caterpillar."

The list of common names does not include any for *M. constrictum*, *M. tigris*, or *M. incurvum*, so the following names are suggested for them.

Malacosoma incurvum occurs in the southwestern United States and Mexico (fig. 4). It builds a large tent as does *M. americanum*, the "Eastern tent caterpillar" and *M. californicum*, the "Western tent caterpillar." In keeping with these regional names for other large tent builders, it is suggested that *M. incurvum* be called the "Southwestern tent caterpillar" since it occurs in southwestern North America.

Malacosoma constrictum and *Malacosoma tigris* are closely related in many ways, but they are geographically well separated. Both of them are restricted to oaks, so "oak tent caterpillar" is not a good choice for either one. However, since *M. constrictum* occurs only in the western parts of Washington, Oregon, California (fig. 4), and probably in Baja California (*M. constrictum austrinum*) it is suggested that it be called the "Pacific tent caterpillar."

Malacosoma tigris occurs in Colorado, Utah, Arizona, New Mexico, Texas, and southwestward through the Mexican plateau (fig. 1). There is no good regional or geographical name that applies to this area. The name "southern" is not appropriate since it implies the southeastern part of the United States, and states such as Colorado or Utah cannot be considered southern states. "Tiger" is not appropriate since it duplicates the scientific name. Therefore, it is suggested that it be called the "Sonoran tent caterpillar" since it occurs on oaks which are found in the Upper Sonoran life zone of Merriam (1898), and since "Sonoran" also suggests parts of Mexico where it also occurs.

APPENDIX IV

Parasites

The following list includes all of the egg, larval, and pupal parasites which were reared from *Malacosoma* during this study. The collection number, nearest landmark, and state are given for all but a few collections that were made by other people or at other times; the complete collection data can be obtained from Appendix I.

We wish to thank the following individuals to whom we are most grateful for the identification of the listed parasites: Dr. B. D. Burks of the United States Department of Agriculture, United States National Museum, who identified all of the Chalcidoidea except the Scelionidae which were identified by Dr. Paul Marsh of the same organization; Dr. Henry K. Townes, American Entomological Institute, Ann Arbor, Michigan, who identified the ichneumonids; Dr. C. F. W. Muesebeck, U.S. National Museum, who identified the braconids (except the *Rogas* which it has not been possible to have identified as to species at the present time); and Dr. H. J. Reinhard, Texas A. and M. University, who identified the tachinids (with the exception that F. W. Stehr is responsible for the specific identifications of the genus *Lespesia* using Beneway's 1963 revision). Without their prompt cooperation this list of parasites could not have been included in this publication. All of the specimens are in the University of Minnesota Insect Collection except for a few which were retained by the persons who made the identifications.

Egg Parasites

As outlined in Appendix I, one or more egg masses were collected for each collection at each locality whenever possible. The number of egg masses per collection varied from zero to as high as 23, and is given in Appendix I. These egg masses were held in 8-dram vials plugged with cotton so any emerging parasites would be trapped for later examination. Nearly all egg masses were collected after the larvae had hatched, so any egg parasites which emerged before larval hatching (such as *Trichogramma*) were missed. One or more egg masses were found for 346 out of a total of 466 collections, but egg parasites were obtained from only 159 of these collections, despite the fact that more than one egg mass was obtained for many collections. In addition, the percent of parasitized eggs was very low in nearly every case. This supports the generally held idea that egg parasites are relatively unimportant as control factors influencing *Malacosoma* populations.

No biological information is given, since the primary purpose of this study was not the study of parasites. Consequently very little biological information could be obtained. See Langston (1957) for the most recent synopsis of egg parasites of western *Malacosoma*, and for references to other pertinent literature. Dr. H. M. Kulman, Department of Entomology, Fisheries and Wildlife, University of Minnesota, has in preparation a key to the known egg parasites of *Malacosoma*.

It is possible that a few of the following records are erroneous, since the egg masses were not removed from the host twigs, and scale insects, eggs of other insects, etc., may have been present from which parasites could have emerged. This appears unlikely, however, since all of the described species of parasites listed here except *Dirhicnus* sp. have been recorded from *Malacosoma* eggs in the past. Seven species of egg parasites were collected during this study. They are:

Scelionidae: *Telenomus clisiocampae* Riley. This species was found in 41 collections and was widely distributed, although it was most commonly collected in California. Langston (1957) reported *Telenomus clisiocampae* from the Great Basin areas, and *Telenomus* sp. from the coastal areas of California. It is probable that our specimens from coastal California identified by Dr. Marsh as *T. clisiocampae* are the same as those reported by Langston as *Telenomus* sp.

Eulophidae: *Tetrastichus malacosomae* Girault. This species was found in 62 collections and was widely distributed, although it was virtually absent from the Pacific coastal areas, and was most common in Arizona. Langston (1957) also found it to be quite rare in the coastal areas of California, and more abundant in the Great Basin and Sierra Nevada.

Eulophidae: *Tetrastichus* sp. This species was found in only three widely scattered localities (California, Montana, and Utah).

Eulophidae: *Ablerus clisiocampae* (Ashmead). This species was found in only four eastern localities (three in Texas and one in Missouri), but was collected from three different hosts (*americanum*, *disstria*, and *tigris*). Apparently, it has not been collected west of the Great Plains (see Langston, 1957).

Eupelmidae: *Anastatus* sp. This species was found in 12 collections, of which 9 were from California. The other three collections were from Texas, Arizona, and Utah. Five of the nine California localities were in the Modoc County area where Langston (1957) first recorded it from *Malacosoma* eggs.

Pteromalidae: *Dirhicnus* sp. This species was found in only two collections (both *M. constrictum* from California). Dr. Burks had not received it for identification before, and he does not know what its biological relationships may be.

Encyrtidae: *Ooencyrtus clisiocampae* (Ashmead). This species was found in 35 collections, and was widely distributed, although it was most common in the more southern states. Dr. Burks says that in his opinion this species is a secondary parasite. Langston (1957) reported *Ooencyrtus* sp. from *Malacosoma* in the San Francisco Bay area of California, and stated that it was not *Ooencyrtus clisiocampae* (Ashmead). All of our *Ooencyrtus* were identified by Dr. Burks as *Ooencyrtus clisiocampae* (Ashmead), but it seems likely that our specimens from the San Francisco Bay area are the same as Langston's *Ooencyrtus* sp. In this case as in the similar *Telenomus* case (see above), we can only accept the opinion of the specialists who work with these groups, and point out that differences of opinion exist.

Malacosoma disstria Hübner
- *Tetrastichus malacosomae:* Coll. No. 178 (Two Hills, Alberta).
- *Ooencyrtus clisiocampae:* Coll. No. 406 (Georgetown, Tex.).
- *Ablerus clisiocampae:* Coll. No. 406 (Georgetown, Tex.).

Malacosoma constrictum constrictum (Henry Edwards)
- *Tetrastichus malacosomae:* Coll. Nos. 42 (Pacheco Pass, Calif.); 110 (Priest Valley, Calif.).
- *Dirhicnus* sp.: Coll. No. 111 (Woodlake, Calif.).

Malacosoma constrictum austrinum Stehr
- *Tetrastichus malacosomae:* Coll. Nos. 26 (Santa Ysabel, Calif.); 221 (Temecula, Calif.).
- *Ooencyrtus clisiocampae:* Coll. No. 26 (Santa Ysabel, Calif.).
- *Dirhicnus* sp.: Coll. No. 26 (Santa Ysabel, Calif.).

Malacosoma tigris (Dyar)
- *Ooencyrtus clisiocampae:* Coll. Nos. 223 (Garner State Park, Tex.); 226 (Leakey, Tex.); 228 (Leakey, Tex.); 257 (Tijeras, N. Mex.).
- *Ablerus clisiocampae:* Coll. No. 223 (Garner State Park, Tex.).

Malacosoma americanum (Fabricius)
- *Tetrastichus malacosomae:* Coll. Nos. 401 (Dover, Ark.); 404 (Thorndale, Tex.); 412 (Kerrville, Tex.); 426 (Corning, Kan.); 427 (Hutchinson Co., S. Dak.); 428 (Pickstown, S. Dak.); 431 (Tunerville, S. Dak.).
- *Ooencyrtus clisiocampae:* Coll. Nos. 225, 227 (Leakey, Tex.); 401 (Dover, Ark.); 404 (Thorndale, Tex.); 408 (Inks Lake State Park, Tex.); 422 (Guthrie, Okla.); 427 (Hutchinson Co., S. Dak.).
- *Telenomus clisiocampae:* Coll. Nos. 401 (Dover, Ark.); 422 (Guthrie, Okla.); 428 (Pickstown, S. Dak.); 431 (Tunerville, S. Dak.).
- *Ablerus clisiocampae:* Coll. Nos. 401 (Dover, Ark.); 408 (Inks Lake State Park, Tex.).
- *Anastatus* sp.: Coll. No. 408 (Inks Lake State Park, Tex.).

Malacosoma californicum (Packard)

Tetrastichus malacosomae: Coll. Nos. 132 (Nubieber, Calif.); 136 (Hat Creek, Calif.); 138 (Trinity Co., Calif.); 154 (Chemult, Ore.); 155 (Bend, Ore.); 157 (Prineville, Ore.); 166 (Keno, Ore.); 209 (Cane Springs, Ariz.); 239 (Grand Canyon Nat. Park, Ariz.); 246 (Chiricahua Mtns., Ariz.); 251 (Clifton, Ariz.); 259 (Sanders, Ariz.); 261 (Showlow, Ariz.); 268 (Springville, Utah); 292 (Ouray, Colo.); 308 (Jacob Lake, Ariz.); 315 (Sargents, Colo.); 236 (Daniels Summit, Wasatch Co., Utah); 365 (Pinedale, Wyo.); 366 (Bondurant, Wyo.); 437 (Grover, Utah); 441, 442, 443 (Bryce Canyon Nat. Park, Utah); 449 (Jacob Lake, Ariz.).

Ooencyrtus clisiocampae: Coll. Nos. 60 (Healdsburg, Calif.); 67 (Willits, Calif.); 83 (St. Helena, Calif.); 90 (Calistoga, Calif.); 145 (Susanville, Calif.); 240 (Sedona, Ariz.); 251 (Clifton, Ariz.); 305 (Glendale, Utah); 308 (Jacob Lake, Ariz.); 442 (Bryce Canyon Nat. Park, Utah).

Telenomus clisiocampae: Coll. Nos. 14, 16 (Healdsburg, Calif.); 65 (Hopland, Calif.); 131 (Chemult, Ore.); 145 (Susanville, Calif.); 148 (Reno, Nev.); 292 (Ouray, Colo.); 298 (Ruth, Nev.); 300 (Austin, Nev.); 316 (Maysville, Colo.); 323 (Grand Co., Colo.); 364 (Saratoga, Wyo.); 366 (Bondurant, Wyo.).

Anastatus sp.: Coll. Nos. 91 (Calistoga, Calif.); 132 (Nubieber, Calif.); 136 (Hat Creek, Calif.); 145, 146 (Susanville, Calif.); 162 (Alturas, Calif.); 240 (Sedona, Ariz.); 326 (Daniels Summit, Wasatch Co., Utah).

Tetrastichus sp.: Coll. No. 279 (Brigham City, Utah).

Malacosoma californicum californicum (Packard)

Telenomus clisiocampae: Coll. Nos. 5 (Martinez, Calif.); 6 (Vallejo, Calif.); 10 (Marin Co., Calif.); 11 (Mill Valley, Calif.); 16 (Napa, Calif.); 18 (Hayward, Calif.); 47 (Sonoma, Calif.).

Ooencyrtus clisiocampae: Coll. No. 12 (Mill Valley, Calif.).

Anastatus sp.: Coll. No. 5 (Martinez, Calif.).

Malacosoma californicum ambisimile (Dyar)

Telenomus clisiocampae: Coll. Nos. 22 (Morgan Hill, Calif.); 79 (Santa Cruz, Calif.).

Ooencyrtus clisiocampae: Coll. Nos. 22, 23, 24 (Morgan Hill, Calif.); 75, 76 (Saratoga, Calif.).

Anastatus sp.: Coll. No. 75 (Saratoga, Calif.).

Intermediate population between *M. californicum californicum* (Packard) and *M. californicum ambisimile* (Dyar)

Ooencyrtus clisiocampae: Coll. No. 9 (Los Altos, Calif.).

Telenomus clisiocampae: Coll. No. 9 (Los Altos, Calif.).

Malacosoma californicum recenseo Dyar

Tetrastichus malacosomae: Coll. No. 144 (Chester, Calif.).

Tetrastichus sp.: Coll. No. 17A (Blue Canyon, Placer Co., Calif.).

Telenomus clisiocampae: Coll. Nos. 144 (Chester, Calif.); 150 (Sierraville, Calif.).

Malacosoma californicum pluviale (Dyar)

Tetrastichus malacosomae: Coll. Nos. 121 (Grants Pass, Ore.); 180 (Calgary, Alberta.); 457 (Merritton, Wash.).

Telenomus clisiocampae: Coll. Nos. 122 (Eugene, Ore.); 180 (Calgary, Alberta.); 171 (Cranbrook, B.C.).

Ooencyrtus clisiocampae: Coll. Nos. 124 (Forest Grove, Ore.); 171 (Cranbrook, B.C.).

Tetrastichus sp.: Coll. No. 346 (Missoula, Mont.).

Malacosoma californicum lutescens (Neumoegen and Dyar)

Tetrastichus malacosomae: Coll. Nos. 177 (Drumheller, Alberta.); 331 (Harlowton, Mont.); 332 (Neihart, Mont.); 349 (Bozeman, Mont.); 350 (Townsend, Mont.).

Telenomus clisiocampae: Coll. No. 463 (Ashland, Mont.).

Ooencyrtus clisiocampae: Coll. No. 415 (Pampa, Tex.).

Intermediate population between *M. californicum pluviale* (Dyar) and *M. californicum lutescens* (Neumoegen and Dyar)

Ooencyrtus clisiocampae: Coll. No. 339 (Cutbank, Mont.).

Malacosoma californicum fragile (Stretch)

Tetrastichus malacosomae: Coll. Nos. 27 (Morongo Valley, Calif.); 204 (Mitchell Caverns State Park, Calif.); 206 (Goodsprings, Nev.); 207, 217 (Kingman, Ariz.); 218, 219 (Valentine, Ariz.).

Telenomus clisiocampae: Coll. Nos. 27 (Morongo Valley, Calif.); 28 (Lucerne Valley, Calif.); 114 (Tom's Place, Calif.); 115 (Conway Summit, Mono Co., Calif.); 116 (Sonora Jct., Calif.); 117 (Coleman, Calif.); 217 (Kingman, Ariz.); 222 (Cajon, Calif.).

Anastatus sp.: Coll. No. 117 (Coleman, Calif.).

Malacosoma incurvum incurvum (Henry Edwards)

Tetrastichus malacosomae: Coll. Nos. 212 (Patagonia, Ariz.); 213 (Pima, Ariz.); 216 (Winkelman, Ariz.); 250 (Clifton, Ariz.).

Ooencyrtus clisiocampae: Coll. No. 212 (Patagonia, Ariz.).

Malacosoma incurvum discoloratum (Neumoegen)

Tetrastichus malacosomae: Coll. Nos. 231 (Mesquite, Nev.); 282 (Castle Dale, Utah); 288 (Bluff, Utah); 313 (Huntington, Utah).

Ooencyrtus clisiocampae: Coll. Nos. 282 (Castle Dale, Utah); 293 (Grand Junction, Colo.); 313 (Huntington, Utah).

Larval and Pupal Parasites (Hymenoptera)

Ichneumonidae

Hyposoter fugitivus (Say) was by far the most widespread and numerous ichneumon reared during this study (22 different collections), and *Coccygomimus sanguinipes erythropus* (Viereck) was the next most common species (8 different collections). All of the other species were reared from no more than three different collections. The following list does not separate primary from secondary parasites. Virtually all of these records are from larvae, since very few pupae were collected.

Malacosoma disstria Hübner

Coccygomimus pedalis (Cresson): Coll. No. 178 (Two Hills, Alberta).

Malacosoma constrictum constrictum (Henry Edwards)

Coccygomimus sanguinipes erythropus (Viereck): Coll. No. 42 (Pacheco Pass, Santa Clara Co., Calif.).

Hyposoter fugitivus pacificus Cushman: Coll. No. 121B (Grants Pass, Ore., all hyperparasitized).

Malacosoma constrictum austrinum Stehr

Coccygomimus sanguinipes erythropus (Viereck): Coll. No. 26 (Santa Ysabel, Calif.).

Malacosoma americanum (Fabricius)

Hyposoter fugitivus fugitivus (Say): Coll. No. 403 (Ratcliff, Tex.).

Labrorychus analis (Say): St. Croix Park, Minn. (larvae collected 30 May 1957); River Falls, Wis. (larvae collected 9 June 1957).

Gellus tenellus (Say): River Falls, Wis. (larvae collected 9 June 1957).

Malacosoma californicum (Packard)

Hyposoter fugitivus pacificus Cushman: Coll. Nos. 87A (St. Helena, Calif.); 129 (Wasco Co., Ore.); 132 (Nubieber, Calif.); 140 (Wildwood, Calif.); 159 (John Day, Ore.); 162 (Alturas, Calif.); 166, 166A (Keno, Ore.); 269 (Bountiful, Utah); 328 (Ashton, Idaho); 360 (Casper, Wyo.); 369 (Grand Teton Nat. Park, Wyo.); 453 (Ukiah, Ore., all hyperparasitized).

Hyposoter fugitivus fugitivus (Say): Coll. No. 245 (Chiricahua Mtns., Ariz.).

Coccygomimus sanguinipes erythropus (Viereck): Coll. No. 99 (Geyserville, Calif.).

Gambrus canadensis canadensis (Provancher): Coll. No. 298 (Ruth, Nev.).

Mesochorus sp.: Coll. No. 366 (Bondurant, Wyo.).

Trichonotus sp.: Coll. Nos. 366 (Bondurant, Wyo.); 148 (Reno, Nev.).

Malacosoma californicum recenseo Dyar

Hyposoter fugitivus pacificus Cushman: Coll. Nos. 120A (Mt. Shasta, Calif.); 170 (Lassen Nat. Park, Calif.).

Malacosoma californicum pluviale (Dyar)

Hyposoter fugitivus pacificus Cushman: Coll. Nos. 341 (Kalispell, Mont.); 344 (Moscow, Idaho).

Coccygomimus sanguinipes erythropus (Viereck): Coll. No. 125 (Port Angeles, Wash.).

Coccygomimus pedalis (Cresson): Coll. No. 180 (Calgary, Alberta).

Itoplectis quadricingulatus (Provancher): Coll. No. 344 (Moscow, Idaho).

Theronia atalantae fulvescens (Cresson): Coll. No. 180 (Calgary, Alberta).

Trichonotus sp.: Coll. No. 171 (Cranbrook, B. C.).

Malacosoma californicum lutescens (Neumoegen and Dyar)

Hyposoter fugitivus pacificus Cushman: Coll. Nos. 329 (Bozeman, Mont.); 350, 351 (Townsend, Mont.).

Intermediate population between *M. californicum pluviale* (Dyar) and *M. californicum lutescens* (Neumoegen and Dyar)

Hyposoter fugitivus pacificus Cushman: Coll. No. 347 (Whitehall, Mont.).

Malacosoma californicum fragile (Stretch)

Coccygomimus sanguinipes erythropus (Viereck): Coll. Nos. 113 (Panamint Springs, Calif.); 114 (Tom's Place, Calif.); 135 (Virginia City, Nev.).

Itoplectis viduata (Gravenhorst): 10 mi. S. Leevining, Mono Co., Calif., R. C. Hall (larvae collected 17 June 1958).

Malacosoma incurvum discoloratum (Neumoegen)

Coccygomimus sanguinipes erythropus (Viereck): Coll. No. 231 (Mesquite, Nev.).

Braconidae

Bracon xanthonotus Ashmead was reared from only a single collection of *Malacosoma californicum* (Packard). This was Coll. No. 446 (Grand Canyon Nat. Park, Ariz.).

Rogas sp. (or spp.) was the most common of all the larval parasites reared from *Malacosoma* in this study. It was reared from 51 different collections of *M. californicum* and its subspecies, and from one collection of *M. incurvum incurvum* in which all of the *Rogas* were hyperparasitized. It is not presently known whether more than one species of *Rogas* is involved, but many of the specimens are undoubtedly the same species as the one Langston (1957) called *Rogas* sp. All of the collections in the following list are records for *Rogas* sp. (or spp.).

Malacosoma californicum (Packard)

Coll. Nos. 129 (Wasco Co., Ore.); 132 (Nubieber, Calif.); 136 (Hat Creek, Calif.); 148 (Reno, Nev.); 154 (Chemult, Ore.); 155 (Bend, Ore.); 156 (Prineville, Ore.); 158 (Mitchell, Ore.); 166A (Keno, Ore.); 242 (Payson, Ariz.); 272 (Malta, Idaho); 274 (Mountain Home, Idaho); 278 (Inkon, Idaho); 285 (Moab, Utah); 289 (Cortez, Colo.); 296 (Neola, Utah); 300 (Austin, Nev.); 301 (Elko, Nev.); 312 (Fairview, Utah); 313A (Huntington, Utah); 314 (Montrose, Colo.); 328 (Ashton, Idaho); 360 (Casper, Wyo.); 364 (Saratoga, Wyo.); 366 (Bondurant, Wyo.); 437 (Grover, Utah); 442, 443 (Bryce Canyon Nat. Park, Utah); 446 (Grand Canyon Nat. Park, Ariz.); 449, 450 (Jacob Lake, Ariz.); 452 (Elba, Idaho).

Malacosoma californicum ambisimile (Dyar)

Coll. No. 77 (Boulder Creek, Calif.).

Malacosoma californicum recenseo Dyar

Coll. No. 170 (Lassen Nat. Park, Calif.).

Malacosoma californicum pluviale (Dyar)

Coll. Nos. 121 (Grants Pass, Ore.); 125 (Port Angeles, Wash.); 344 (Moscow, Idaho); 345 (Superior, Mont., all hyperparasitized).

Malacosoma californicum lutescens (Neumoegen and Dyar)

Coll. Nos. 329 (Bozeman, Mont.); 350 (Townsend, Mont.).

Malacosoma californicum fragile (Stretch)

Coll. Nos. 28 (Lucerne Valley, Calif.); 114 (Tom's Place, Calif.); 117 (Coleman, Calif.); 119 (Woodsford, Calif.); 135 (Virginia City, Nev.); 205 (Las Vegas, Nev.); 232 (St. George, Utah); 236 (Verkin, Utah); 265 (Kanarraville, Utah).

Malacosoma incurvum incurvum (Henry Edwards)
  Coll. No. 249 (Clifton, Ariz., all hyperparasitized).

Chalcididae

Only one species of chalcid was reared which was not a secondary parasite. It is *Brachymeria ovata* (Say), and was reared from the following two collections.

Malacosoma americanum (Fabricius)
  Coll. No. 414 (Rocksprings, Tex.).
Malacosoma incurvum incurvum (Henry Edwards)
  Coll. No. 249 (Clifton, Ariz.).

Torymidae

Only a single species from a single collection was reared. This was the pupal parasite, *Microdontomerus fumipennis* Crawford.

Malacosoma californicum (Packard)
  Coll. No. 365 (Pinedale, Wyo.).

Hyperparasites

All of the parasites in the following list emerged from pupal "mummies" of either *Hyposoter fugitivus pacificus* Cushman or *Rogas* sp. No distinction is made between those which are secondary and any which may be tertiary.

Malacosoma constrictum constrictum (Henry Edwards)
  Pteromalidae: *Habrocytus* sp.: Coll. No. 121B (Grants Pass, Ore.), Ex *Hyposoter fugitivus pacificus.*
Malacosoma californicum (Packard)
  Chalcididae: *Ceratosmicra paya* Burks: Coll. No. 148 (Reno, Nev.), Ex *Rogas* sp.
  Chalcididae: *Spilochalcis albifrons* (Walsh): Coll. No. 453 (Ukiah, Ore.), Ex *Hyposoter fugitivus pacificus.*
  Pteromalidae: *Catolaccus aeneoviridis* (Girault): Coll. Nos. 148 (Reno, Nev.), Ex *Rogas* sp.; 158 (Mitchell, Ore.), Ex *Rogas* sp.
  Pteromalidae: *Dibrachys cavus* (Walker): Coll. No. 366 (Bondurant, Wyo.), Ex *Rogas* sp.
  Eulophidae: *Tetrastichus coerulescens* Ashmead: Coll. Nos. 148 (Reno, Nev.), Ex *Rogas* sp.; 156 (Prineville, Ore.), Ex *Rogas* sp.; 158 (Mitchell, Ore.), Ex *Rogas* sp.; 159 (John Day, Ore.), Ex *Hyposoter fugitivus pacificus.*
  Eulophidae: *Melittobia* sp.: Coll. No. 453 (Ukiah, Ore.), Ex *Hyposoter fugitivus pacificus.*

Malacosoma californicum pluviale (Dyar)

Chalcididae: *Spilochalcis albifrons* (Walsh): Coll. No. 344 (Moscow, Ida.), Ex *Hyposoter fugitivus pacificus.*

Pteromalidae: *Habrocytus* sp.: Coll. No. 345 (Superior, Mont.), Ex *Rogas* sp.

Eulophidae: *Tetrastichus coerulescens* Ashmead: Coll. No. 345 (Superior, Mont.), Ex *Rogas* sp.

Malacosoma californicum lutescens (Neumoegen and Dyar)

Pteromalidae: *Habrocytus* sp.: Coll. No. 351 (Townsend, Mont.), Ex *Hyposoter fugitivus pacificus.*

Eulophidae: *Tetrastichus coerulescens* Ashmead: Coll. Nos. 351 (Townsend, Mont.), Ex *Hyposoter fugitivus pacificus;* 353 (Townsend, Mont.), Ex *Hyposoter fugitivus pacificus* and/or *Rogas* sp.

Intermediate population between *M. californicum pluviale* (Dyar) and *M. californicum lutescens* (Neumoegen and Dyar)

Chalcididae: *Spilochalcis leptis* Burks: Coll. No. 347 (Whitehall, Mont.), Ex *Hyposoter fugitivus pacificus.*

Malacosoma californicum fragile (Stretch)

Pteromalidae: *Catolaccus aeneoviridis* (Girault): Coll. No. 236 (Verkin, Utah), Ex *Rogas* sp.

Malacosoma incurvum incurvum (Henry Edwards)

Pteromalidae: *Habrocytus* sp.: Coll. No. 249 (Clifton, Ariz.), Ex *Rogas* sp.

Larval and Pupal Parasites (Diptera)

Twelve different species of tachinids were reared from *Malacosoma* during this study. Parasites of the genus *Lespesia* (=*Achaetoneura*) were most common, the commonest species being *Lespesia archippivora* (Williston). Another species, *Lespesia ciliata* (Macquart), has previously been recorded only from saturniids of the genus *Hyalophora* according to Beneway (1963). The remaining specimens of *Lespesia* have been identified as *L. frenchii* (Williston), commonly recorded from *Malacosoma.*

Malacosoma disstria Hübner

Lespesia frenchii (Williston): Coll. No. 178 (Two Hills, Alberta).

Malacosoma constrictum constrictum (Henry Edwards)

Archytas lateralis (Macquart): Coll. No. 110 (Priest Valley, Calif.).

Malacosoma constrictum austrinum Stehr

Chaetogaedia sp. near *monticola* (Bigot): Guatay, San Diego Co., Calif., larva collected 18 May 1960, R. C. Hall.

Malacosoma tigris (Dyar)

Euphorocera tachinomoides (Townsend): Coll. No. 226 (Leakey, Tex.).

Malacosoma americanum (Fabricius)

Euphorocera tachinomoides (Townsend): Coll. Nos. 225 (Leakey, Tex.); 411 (Fredericksburg, Tex.).

Exorista mella (Walker): Coll. No. 411 (Fredericksburg, Tex.); River Falls, Wis., larvae collected 9 June 1957, F. W. Stehr.

Malacosoma americanum —Continued

Hyphantrophaga hyphantriae (Townsend): Coll. No. 411 (Fredericksburg, Tex.).

Lespesia archippivora (Williston): Coll. No. 411 (Fredericksburg, Tex.).

Lespesia frenchii (Williston): Duluth, Minn., larvae collected 2 June 1957, F. W. Stehr.

Malacosoma californicum (Packard)

Archytas lateralis (Macquart): Coll. Nos. 209 (Cane Springs, Ariz.); 368 (Mammoth Hot Springs, Yellowstone Nat. Park, Wyo.).

Euphorocera tachinomoides (Townsend): Coll. Nos. 258 (Albuquerque, N. Mex.); 263 (Santa Catalina Mtns., Ariz.).

Exorista mella (Walker): Coll. Nos. 159 (John Day, Ore.); 273 (Twin Falls, Idaho); 325 (Maybell, Colo.); 362 (Douglas, Wyo.); 365 (Pinedale, Wyo.); 368 (Mammoth Hot Springs, Yellowstone Nat. Park, Wyo.); 461 (Spokane, Wash.).

Hyphantrophaga hyphantriae (Townsend): Coll. No. 263 (Santa Catalina Mtns., Ariz.).

Leschenaultia fulvipes (Bigot): Coll. No. 317 (Hopewell, N. Mex.).

Lespesia archippivora (Williston): Coll. Nos. 60 (Healdsburg, Calif.); 62 (Cloverdale, Calif.); 86, 87A (St. Helena, Calif.); 93 (Healdsburg, Calif.); 100 (Cloverdale, Calif.); 325 (Maybell, Colo.).

Lespesia ciliata (Macquart): Coll. Nos. 247 (Chiricahua Mtns., Ariz.); 253 (Sierra Co., N. Mex.); 262 (Carrizo, Ariz.).

Lespesia frenchii (Williston); Coll. Nos. 93 (Healdsburg, Calif.); 146 (Susanville, Calif.); 167 (Pinehurst, Ore.); 304 (Hatch, Utah); 368 (Mammoth Hot Springs, Yellowstone Nat. Park, Wyo.); 461 (Spokane, Wash.).

Malacosoma californicum californicum (Packard)

Lespesia archippivora (Williston): Coll. No. 29 (Menlo Park, Calif.); Orinda, Contra Costa Co., Calif., Emgd. 7 June 1960, R. C. Hall.

Malacosoma californicum ambisimile (Dyar)

Lespesia archippivora (Williston): Coll. No. 30B (Los Altos, Calif.).

Intermediate population between *M. californicum californicum* (Packard) and *M. californicum ambisimile* (Dyar)

Lespesia archippivora (Williston): Coll. Nos. 30A, 30C, 31, 35A, 35D (Los Altos, Calif.).

Malacosoma californicum recenseo Dyar

Lespesia archippivora (Williston): Coll. No. 142 (Chester, Calif.).

Malacosoma californicum pluviale (Dyar)

Euexorista futilis (Osten Sacken): Coll. Nos. 122C (Eugene, Ore.); 343 (Spokane, Wash.).

Exorista mella (Walker): Coll. Nos. 171 (Cranbrook, B.C.); 180 (Calgary, Alberta); 345 (Superior, Mont.).

Lespesia archippivora (Williston): Coll. Nos. 343 (Spokane, Wash.); 348 (Helena, Mont.).

Lespesia frenchii (Williston): Coll. Nos. 122C (Eugene, Ore.); 171 (Cranbrook, B.C.); 180 (Calgary, Alberta); 183 (Babb, Mont.); 343 (Spokane, Wash.).

Malacosoma californicum lutescens (Neumoegen and Dyar)

- *Archytas lateralis* (Macquart): Coll. Nos. 177 (Drumheller, Alberta); 353 (Townsend, Mont.).
- *Exorista mella* (Walker): Coll. Nos. 177 (Drumheller, Alberta); 179 (Derwent, Alberta).
- *Lespesia ciliata* (Macquart): Coll. No. 179 (Derwent, Alberta).
- *Lespesia frenchii* (Williston): Coll. No. 179 (Derwent, Alberta).

Intermediate population between *M. californicum pluviale* (Dyar) and *M. californicum lutescens* (Neumoegen and Dyar)

- *Leschenaultia fulvipes* (Bigot): Coll. Nos. 354, 356 (Helena, Mont.).

Malacosoma californicum fragile (Stretch)

- *Archytas lateralis* (Macquart): Coll. No. 217 (Kingman, Ariz.).
- *Chaetogaedia* sp. near *monticola* (Bigot): Coll. Nos. 27 (Morongo Valley, Calif.); 28 (Lucerne Valley, Calif.); 204 (Mitchell Caverns State Park, Calif.); 217 (Kingman, Ariz.).
- *Euphorocera tachinomoides* (Townsend): Coll. Nos. 27 (Morongo Valley, Calif.); 236 (Verkin, Utah).
- *Leschenaultia fulvipes* (Bigot): Coll. No. 27 (Morongo Valley, Calif.).
- *Lespesia archippivora* (Williston): Coll. Nos. 27 (Morongo Valley, Calif.); 207 (Kingman, Ariz.); 230 (Glendale, Nev.); 232 (Washington Co., Utah); 236 (Verkin, Utah).
- *Lespesia frenchii* (Williston): Coll. No. 236 (Verkin, Utah).

Malacosoma incurvum incurvum (Henry Edwards)

- *Archytas lateralis* (Macquart): Coll. No. 249 (Clifton, Ariz.).
- *Euphorocera tachinomoides* (Townsend): Coll. Nos. 201 (Chandler, Ariz.); 216 (Winkelman, Ariz.); 249 (Clifton, Ariz.).
- *Exorista mella* (Walker): Coll. No. 202 (Tucson, Ariz.).
- *Hyphantrophaga hyphantriae* (Townsend): Coll. No. 243 (Santa Rita Mtns., Ariz.).
- *Leschenaultia fulvipes* (Bigot): Coll. No. 216 (Winkelman, Ariz.).
- *Lespesia archippivora* (Williston): Coll. Nos. 201 (Chandler, Ariz.); 202 (Tucson, Ariz.); 203 (Wickenburg, Ariz.); 208 (Wikieup, Ariz.); 216 (Winkelman, Ariz.).
- *Lespesia ciliata* (Macquart): Coll. No. 244 (Huachuca Mtns., Ariz.).
- *Xanthophyto labis* (Coquillett): Coll. No. 244 (Huachuca Mtns., Ariz.).

Malacosoma incurvum discoloratum (Neumoegen)

- *Chaetogaedia* sp. near *monticola* (Bigot): Coll. No. 231 (Mesquite, Nev.).
- *Euphorocera tachinomoides* (Townsend): Coll. Nos. 231 (Mesquite, Nev.); 233 (Washington Co., Utah).
- *Hyphantrophaga hyphantriae* (Townsend): Coll. Nos. 231 (Mesquite, Nev.); 283 (Moab, Utah).
- *Lespesia archippivora* (Williston): Coll. No. 231 (Mesquite, Nev.).

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Host Plant Index

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Parasite Index

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