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(Diptera: Muscidae, Muscinae)

BY
BRUCE F. KILDRIDGE and MAURICE T. JAMES
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Although several keys to the genera herein included in the Muscinae have been published, many of these have been in foreign languages and still others have not differentiated the subfamily from the large anthomyiid-muscid complex. Those keys that recognize the Muscinae as a distinct subfamily are scattered through the literature, often in hard-to-obtain journals or publications, and they are rarely available to field and laboratory workers in public health institutions.

Hough (1899) gave brief notes on most of the North American species and included keys to the genera, but this work, among the earliest on the North American Muscidae, represents an outdated classification. The phylogenetic position and taxonomic standing of both the family Muscidae and the subfamily Muscinae have been the source of confusion for many years. In recent years new characters, especially in the immature stages, seem to throw new light on muscoid taxonomy; these are here considered.

This study attempts to present a usable key to the tribes, genera, and species of the Muscinae of California, to give data on their bionomics and distribution, and to provide adequate illustrations to aid in the determination of specimens. Three species which have been seen by us from Washington and Oregon are included, since all these might well occur in California.

The subfamily Muscinae, although represented by only twelve North American genera, ten of which occur on the Pacific Coast, contains members which rank among the most important insect pests of man. Too much cannot be said about the importance of the common house fly, *Musca domestica* L. This one fly has been the subject of a very extensive literature, including books by Hewitt (1910), Howard (1911), and West (1951). The stable fly, *Stomoxys calcitrans* (L.), and the horn fly, *Siphona irritans* (L.), are both bloodsuckers, attacking cattle and frequently man. *Synthesiomyia nudiseta* (Wulp) usually breeds in decaying animal and vegetable matter, but has been implicated as a causal agent of secondary human myiasis (Siddons and Roy, 1942; James, 1948). The remaining members of the subfamily consist of wild flies which are of little, if any, medical or veterinary importance. *Morellia micans* (Macq.) is reported to be a common breeder in human excrement (Howard, 1900) and, although rarely encountered in houses, it could occasionally figure in the mechanical transmission of disease.

BIONOMICS

The four species of greatest medical and veterinary importance, *Musca domestica* L., *Stomoxys calcitrans* (L.), *Siphona irritans* (L.), and *Synthesiomyia nudiseta* (Wulp), have been the subject of much biological research. Literature on the bionomics of the remaining species is exceedingly scant, and in some cases, nonexistent. In some of our species, the immature stages have not been described. In this study, an attempt will be made partly to fill gaps by giving pertinent information that is available for related species.

In the larval stages, most of the members of the subfamily are coprophagous or saprophagous. Members of the genus *Graphomya*, however, are carnivorous (Townsend, 1935). The flies show little specificity for breeding materials, and each species has been reported from a variety of sources, most commonly excrement of one kind or another; however, *Synthesiomyia nudiseta* (Wulp) breeds in a wide variety of decaying animal and vegetable tissues. The length of development time varies widely and is dependent on many factors, the most important of which is temperature.

Young are produced oviparously for the most part, but two closely related species, *Hypodermodes solitaria* Knab and *Mesembrina latreillei* R.-D., produce young ovo-larviparously (Portchin-

sky, 1910; Keilin, 1916; Séguy, 1923; Townsend, 1935). Eggs in the subfamily are of two types. Thomson (1937) has characterized these types, and his terminology will be used in this paper. Most species have the type described by Thomson as the "musca type": cylindrical in cross section, oval in shape, slightly concave on the dorsal surface and convex on the ventral surface, and with faint parallel longitudinal dorsal ribs which never project as flanges (pl. 3, fig. 32). Members of the tribe Graphomyini have eggs of the type described by Thomson as the "phaonia type." In this type, the ribs are produced into two flanges which run parallel to each other throughout their entire length and which are never produced into processes anteriorly but are equally developed at each end (pl. 3, fig. 33).

Three larval stages are usually present, plus a pupal stage. The second instar is omitted as a separate stage in some cases, and there is a record of a species of *Mesembrina* omitting the first instar (Thomson, 1937). The first stage larvae usually possess one slit on the posterior spiracular plate and are metapheustic. Second and third stage larvae have two and three slits respectively on the posterior spiracular plate and are amphipneustic. The anterior spiracles bear five to eighteen lobes, depending on the species and stage.

The pupae are enclosed in a brown or black barrel-shaped puparium. Members of the genus *Synthesiomyia* enclose the puparium in a cocoon composed of sand imbedded in salivary secretions (Siddons and Roy, 1942).

Adult feeding habits are varied. Some species feed on excrement, others on flowers, and still others on a variety of materials.

It appears that most members of the subfamily overwinter as larvae or pupae. In the case of the house fly, this is still the subject of much speculation. The adults of most species are present only in the warmer months, usually appearing in temperate regions of the Northern Hemisphere in April and May and becoming scarce in late September or early October.

CLASSIFICATION

The classification of the family Muscidae and the subfamily Muscinae has been the subject of much disagreement among dipterists. Collin (1948) has given a brief review of this taxonomic problem. The present consideration is whether to give the Muscinae, as treated here, separate family rank, or to rank them together with the Coenosiinae, Fucelliinae, Lispinae, Phaoniinae, and Faniinae, as subfamilies of a broader Muscidae.

Townsend (1935) has stated that *Musca* is more closely related to *Calliphora* than to *Anthomyia* and that a larger break has occurred between the typical Muscidae and the Phaoniinae, which he referred to the Anthomyiidae, than between the Muscidae and Calliphoridae. Townsend's classification, based on the characters of weak pteropleural and hypopleural vestiture supported by wing venation, would raise the subfamily Muscinae to family rank, if followed, and would place the remaining subfamilies of what is here recognized as the family Muscidae in the Anthomyiidae. This classification is followed in essence by Brues, Melander, and Carpenter (1954) and by Hall (1948)

Roback (1951) considers the Calliphoridae much more closely related to the Anthomyiidae than to the Muscidae on the basis of the following larval characters: the mouth hooks are separate in the Calliphoridae and Anthomyiidae but are fused in the Muscidae (*sensu lato*); parastomal bars are present in the Calliphoridae and Anthomyiidae and absent in the Muscidae; and the cornua flare and have windows in the Anthomyiidae and Calliphoridae but do not flare or have windows in the Muscidae.

From the available evidence, the view is adopted here that the typical Muscinae are not as closely related to the Calliphoridae as to the Anthomyiidae and that, since they grade evenly into the genera which form a bridge between the typical Muscinae and the typical Anthomyiinae, they form a subfamily of the Muscidae. The family Muscidae, thus interpreted, includes all calyptrate genera in which the anal vein does not reach the wing margin, hypopleural bristles are lacking, and either two or more sternopleural bristles are present, or the proboscis is fitted for sucking blood.

The similarities of the Calliphoridae and the Muscidae might be explained on the basis of convergent evolution. The medial vein can be followed from a straight condition (Anthomyiidae and lower Muscidae) to a curved (some Muscinae) and finally to an elbowed one (*Musca, Orthellia,* and all Calliphoridae). Also, a tendency toward metallic coloration, a more robust body, and the presence of pteropleural bristles – characters which also are common in the Calliphoridae – are seen in some Muscinae.

Roback's definition of the family Muscidae, except for his exclusion of the Faniinae, is followed in this study. His subfamily classification is not strictly followed, since genera such as *Graphomya* and *Polietes* key out to different sub-

families in his larval and adult key, respectively.

No one set of characters may be used to define a subfamily Muscinae, and attempts to do so usually result in the exclusion of some subfamily members. The following complex of characters may be used: color gray or black to metallic green or blue; frons definitely narrower in male than in female; sternopleurals never in an equilateral triangle (if more than 1:1, they are arranged in a shallow curve); either hairs or bristles present on hypopleura or hairs, but never a series of bristles present on hypopleura; apical cell narrowed, the medial vein curved anteriorly in its outer third; lower squamae triangular in shape, the posterior margin truncate; the inner surface often touching or underlying the base of the scutellum (p. 3, fig. 21); if the lower squamae are rounded, then the proboscis is hard and sclerotized and fitted for sucking blood. Larva: slits of posterior spiracular plate of third stage larva never straight, often sinuous and at least bent at one end (*Graphomya*). Egg oval in shape, usually without flanges (pl. 3, fig. 32); if flanges are present (*Graphomya* and *Synthesiomyia*, pl. 3, fig. 33) they never project anteriorly (pl. 3, fig. 34). This definition, if expanded to include forms over a wider geographical range, would have to be modified slightly to include such genera as *Polietes*.

The Muscidae agree with other calyptrate Diptera in the possession of a transverse dorsal suture on the mesonotum and a longitudinal seam on the outer surface of the second antennal segment.

The Muscinae, as here recognized, may be divided into three tribes, which may be characterized as follows:

Muscini: pteropleura haired or bristled; hypopleura bare; proboscis soft, not at all adapted for sucking blood; two or more sternopleurals always present; eggs of "musca type" (pl. 3, fig. 32); slits of posterior spiracular plate strongly sinuate.

Graphomyini: pteropleura bare; hypopleura haired; proboscis soft, not at all adapted for sucking blood; two or more sternopleurals always present; mesonotum with vivid gray pollinose stripes; eggs of "phaonia type" (pl. 3, fig. 33); slits of posterior spiracular plate but slightly bent or only moderately sinuate.

Stomoxyini: pteropleura haired, hypopleura haired or bare; proboscis hard, bright, heavily sclerotized and fitted for sucking blood; at most one sternopleural; eggs of "musca type" (pl. 3, fig. 32); slits of posterior spiracular plate moderately to strongly sinuate.

Collin (1948) has called attention to the significance of the form of the eggs, the shape of the spiracular slits in the third stage larva, and the presence or absence of pteropleural vestiture in defining the subfamily Muscinae. He has suggested the exclusion of *Graphomya* from the group because that genus has bare pteropleura, an egg of the "phaonia type," and slits of the posterior spiracular plates in the third stage larva which are only slightly bent. *Graphomya*, on the other hand, has a strongly haired hypopleuron, truncate thoracic squamae, and an upturned medial vein, and therefore shows affinities to the Muscinae.

Synthesiomyia, which Collin has not considered, has an egg very similar to that of *Graphomya* (pl. 3, fig. 33), but has the slits of the posterior spiracular plates in the third stage larva definitely sinuous. This genus shows further affinity to *Graphomya* in that it has a bare pteropleuron and a haired hypopleuron.

Graphomya and *Synthesiomyia* seem to be somewhat intermediate between the Phaoniinae and the Muscinae, but on the totality of characters, they would appear to be more closely allied to the Muscinae. Collin has suggested the *Graphomya* is an ancient genus, perhaps representing a separate subfamily. On the basis of the lack of pteropleural vestiture and because of the shape of the egg, *Graphomya* and *Synthesiomyia* are considered here to comprise a separate tribe of the Muscinae, the Graphomyini.

Séguy (1937) has incorrectly stated that the pteropleura and hypopleura are both haired in *Graphomya*. This is certainly not true of the generic type, *G. maculata* (Scop.), nor of the Australian (Malloch, 1925; Mackerras, 1932), nor of the Ethiopian species (Emden, 1939).

We do not feel that the tribe Stomoxyini is deserving of subfamily rank. In the adult stage, the main distinction from the tribe Muscini is the presence of a bloodsucking proboscis. This would seem to be a highly adaptive character. *Musca crassirostris* Stein for example, a secondary bloodsucker of the Eastern Hemisphere, has a partly sclerotized proboscis. Roback (1951) has based the subfamily Stomoxyinae on this and on larval characters. He states that, in the Muscinae, the spiracular slits of the third stage larva are strongly sinuate, and in the Stomoxyinae, the slits are only moderately so. This assertion is not entirely correct. In *Siphona irritans* (L.) (pl. 3, fig. 28), which Roback has not mentioned, the slits are highly sinuate. Thomson (1937) has figured the posterior spiracles of the third stage larva of *Stomoxys calcitrans* (L.), and Roback (1951) has reproduced this figure. It shows the slits as being but moderately curved. Larvae examined by us, however, and also those figured by Zimin (1951) have slits which are highly sinuate.

Muscina and *Myospila* have been included in the Muscinae by various authors, such as Aldrich (1905), Williston (1908), and Séguy (1923). As Collin (1948) has pointed out, both lack pteropleural vestiture (and hypopleural vestiture), and the eggs of both differ from those of most of the Muscinae. The egg of *Myospila* is shown in plate 3, figure 34. *Muscina* has an egg similar to that of *Sythesiomyia* (pl. 3, fig. 33). Both *Myospila* and *Muscina,* except *Muscina pascuorum* (L.), have rounded thoracic squamae.

Acridomyia canadensis Snyder, a member of a genus of grasshopper parasites, has been collected recently in Washington. Zimin (1951) places the genus *Acridomyia* Stack. in the tribe Stomoxyini, primarily on the basis of the rear margin of the eye being concave. Except this character, *Acridomyia* shows little affinity to the Stomoxyini. In the larvae, furthermore, the mouth hooks are separate (Arnoux and Reamaudiere, 1957), whereas in the Stomoxyini, the mouth hooks are fused. On the basis of the lack of similarities other than the shape of the rear margin of the eyes, Zimin's inclusion of *Acridomyia* is not accepted here.

ACKNOWLEDGMENTS

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METHODS

All illustrations were made freehand with the aid of a squared reticle in the ocular of a stereoscopic microscope. Mature larvae of *Musca domestica* L. and *Stomoxys calcitrans* (L.) and the puparia of the following species were examined: *Synthesiomyia nudiseta* (Wulp), *Hypodermodes solitaria* Knab, *Morellia micans* (Macq.), *Orthellia caesarion* (Meig.), *Musca domestica* L., and *Stomoxys calcitrans* (L.). Since larvae of all species were not available and since some of the species have been figured in the literature, a few illustrations from such sources were included. In some instances, when illustrations of larvae were not available for Pacific Coast species but were for congeneric species, such illustrations were used but were checked for similarity with Pacific Coast species in most cases by comparison with puparia borrowed from the United States National Museum. Unfortunately, no immature stages of *Pyrellia cyanicolor* Zett. or *Mesembrina latreillei* R.-D. were available for comparison with the illustrations of congeneric species used.

In two cases, material examined by us differed from illustrations in the literature. The posterior spiracles of several specimens of *Stomoxys calcitrans* were mounted on microscope slides and examined under a magnification of 430 diameters. These were then compared with the illustration taken from Zimin (1951) and found to be nearly identical. They differed markedly from the illustration of Thomson (1937), reproduced by Roback (1951). The slits of the spiracles examined by us and of the figure published by Zimin are much more strongly sinuate, and one of the slits curves in the opposite direction to the slit figured by Thomson (1937) and Roback (1951).

The second was *Synthesiomyia nudiseta* (Wulp). The illustration of the posterior spiracle published by Siddons and Roy (1942) differed in the length and thickness of the slits from posterior spiracles of puparia of that species which we examined. We have therefore figured the posterior spiracle of the puparium, instead of reproducing the figure furnished by Siddons and Roy (1942).

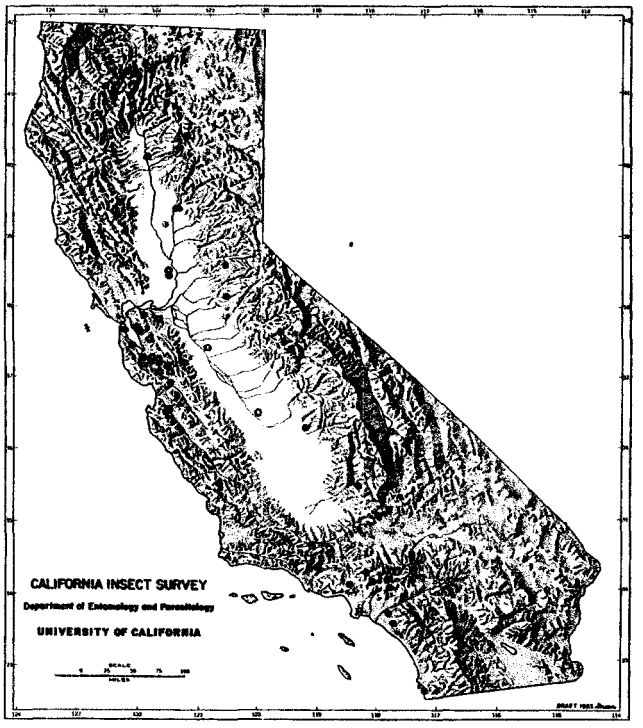
Key To The Tribes of Muscinae of California, Oregon, and Washington

1. Proboscis heavily sclerotized, bright and shiny, fitted for sucking blood; labella small; arista with hairs on upper surface only . . . . . STOMOXYINI
   Proboscis soft, not bright and shiny or heavily sclerotized; labella of normal size; arista haired on both upper and lower surface or bare 2
2. Pteropleural hairs present; hypopleura bare . . . . . MUSCINI
   Pteropleura bare; hypopleura with well-developed hairs . . . . . GRAPHOMYINI

Key To The Species of Muscinae of California, Oregon, and Washington

1. Proboscis heavily sclerotized, bright and shiny, fitted for sucking blood; labella small; arista with hairs on upper surface only (pl. 2, figs. 12, 13) 2
   Proboscis soft, not bright and shiny or heavily sclerotized; labella of normal size; arista haired on both upper and lower surface or bare (pl. 2, figs. 11, 14-18; pl. 3, figs. 19-20). 3
2. Palpi usually short and small, not nearly as long as sclerotized portion of proboscis (pl. 2, fig. 12); sternopleurals strong, black, 0:1; both hypopleural and pteropleural hairs present . . . . . *Stomoxys calcitrans* (p. 6)
   Palpi very prominent, fleshy, and as long as sclerotized part of proboscis (pl. 2, fig. 13); sternopleurals weak and pale, 1:0 or 1:1; pteropleura with bristly hairs, but hypopleura bare . . . . . *Siphona irritans* (p. 6)
3. M_{1+2} with a sharp bend under apical third of R_{4+5} (pl. 1, figs. 1,2); prosternal bristles present 4
   M_{1+2} broadly and evenly curved under apical third of R_{4+5} (pl. 1, figs. 3-7, 10); prosternal bristles absent 5
4. Head, thorax, and abdomen a brilliant metallic green; 2 pairs of acrosticals, namely a presutural and a prescutellar . . . . . *Orthellia caesarion* (p. 7)
   Head, thorax, and abdomen gray or black in background, nonmetallic; prescutellar acrosticals only present . . *Musca domestica* (p. 8)
5. Pteropleural hairs absent; well-developed hypopleural hairs present; mesonotum with vivid gray pollinose longitudinal stripes 6
   Pteropleural haris present; hypopleura bare; mesonotum without vivid gray pollinose longitudinal stripes (except that such stripes may be visible, especially under magnification, in *Morellia micans*) 7
6. Arista bare (pl. 3, fig. 20); eyes totally bare; all veins except costa absolutely bare; sternopleurals 1:2. *Synthesiomyia nudiseta* (p. 9)
   Arista plumose; eyes with definite villi which may appear as scattered hairs in old or worn specimens; at least 1 vein besides costa with numerous hairs; female with checkered appearance, male with yellowish-gold coloration, to dorsal aspect of abdomen; sternopleurals 0:2 . . . . . *Graphomya maculata* (p. 10)
7. Lateral margin of scutellum with numerous and strong bristles; base of wings brilliant yellow 8
   Lateral margin of scutellum with only the 2 or 3 usual pairs of bristles; base of wings never brilliant yellow 9
8. Abdomen and thorax covered largely with dense yellow pile; apical cell much narrowed, its mouth width less than half its greatest width (pl. 1, fig. 10); middle tibia slightly curved; robust, beelike flies; sternopleurals 1:1 . . . . . *Hypodermodes solitaria* (p. 10)
   Abdomen and thorax not covered with dense yellow pile; apical cell not greatly narrowed, its mouth width well over half its greatest width (pl.1, fig. 7); middle tibia not curved; sternopleurals 1:2 . . . . . *Mesembrina latreillei* (p. 11)
9. Sternopleurals 1:2; color shiny black; last pregenital tergite of female with a definite gold tint; middle tibia without a strong anteroventral bristle . . . . . *Morellia micans* (p. 11)
   Sternopleurals usually 1:3; color metallic blue-green; middle tibia with a strong anteroventral bristle[1] (pl. 3, fig. 35); no gold tint to last pregenital tergite in either sex . . . . . *Pyrellia cyanicolor* (p. 12)

[1] Dr. Fred Snyder writes us: "I've never been able to satisfy myself that the ventral bristle on T2 is actually anteroventrally situated. My own opinion is that it is a little more posteroventrally than anteroventrally situated."



Map 1. Distribution in California of *Stomoxys calcitrans* (L.), solid circles, and *Siphona irritans* (L.), open circles.

DISCUSSION OF SPECIES

Genus *Stomoxys* Geoffroy

Stomoxys calcitrans (L.)

Conops calcitrans Linnaeus, 1758, Systema Naturae, Ed. 10, p. 604.

Geographical distribution: Cosmopolitan.

Occurrence in California:

Undoubtedly throughout the state, where suitable breeding conditions are found, and from sea level to 4,000 ft. or higher. The paucity of northern and lack of southeastern records (map 1) are undoubtedly owing to lack of collecting in those parts of the state. More common in summer months, but records are on hand for every month of the year except January at lower elevations.

Discussion:

This is the common stable fly. It commonly bites cattle and horses and frequently man. Bishopp (1913*a*) regards it as the worst source of annoyance to cattle. Brues (1913) suspected that it was a transmitter of infantile paralysis in man, but this is now known not to be the case. The stable fly is occasionally found in houses and can become especially annoying toward the end of the summer. In temperate regions, it is common in the fields from the beginning of June until the middle of October.

The egg is of the typical "musca type," and about 1 mm. in length. Twenty-five to 100, but usually 25 to 50 eggs are laid at a time. One female may lay four or five such clutches. The eggs are laid in various types of excrement, but most often in horse manure or a mixture of straw and horse manure. It usually takes from two to five days, and more commonly three, for the eggs to hatch (Bishopp, 1913*b*).

The larvae pass through three stages. The mature larva resembles that of *Musca domestica* L., but can be differentiated on the basis of the size, shape, and position of the posterior spiracles which are somewhat triangular in shape, widely separated, and situated near the periphery of the posterior face of the larva in *Stomoxys* (in *Musca*, they are D-shaped, quite large, close together, and more central in position). The larval stages last from eleven to thirty days, depending on the temperature (Thomson, 1937).

The puparium is 6-7 mm. in length, brown in color, and somewhat barrel-shaped. It can be distinguished from puparia of other species by the posterior spiracles which remain visible. The pupal stage lasts from six to twenty-six days, and most commonly nine to thirteen days.

The time from egg to adult is twenty-two to fifty-seven days (average time, twenty-eight days). Bishopp (1913*b*) states that the fly overwinters in the larval or pupal state.

Genus *Siphona* Meigen

Siphona Meigen, 1803, Illiger's Mag. 2: 281; *nec* Meigen 1824.

Haematobia Le Peletier de Saint-Fargeau et Audinet-Serville, 1828, Ency. Meth. Ins., 10 (2): 499.

Lyperosia Rondani, 1856, Dipt. Ital. Prodr., 1:93.

Siphona irritans (L.)

Conops irritans Linnaeus, 1758, Systema Naturae, Ed. 10, p. 604.

Haematobia stimulans of Authors, *nec* Linnaeus.

Geographical distribution: United States, Mexico, Southern Canada, and Central Europe.

California records (map 1):

Alameda Co.: Unknown locality, IV-21-20 (A. J. Basinger, C.A.S.).

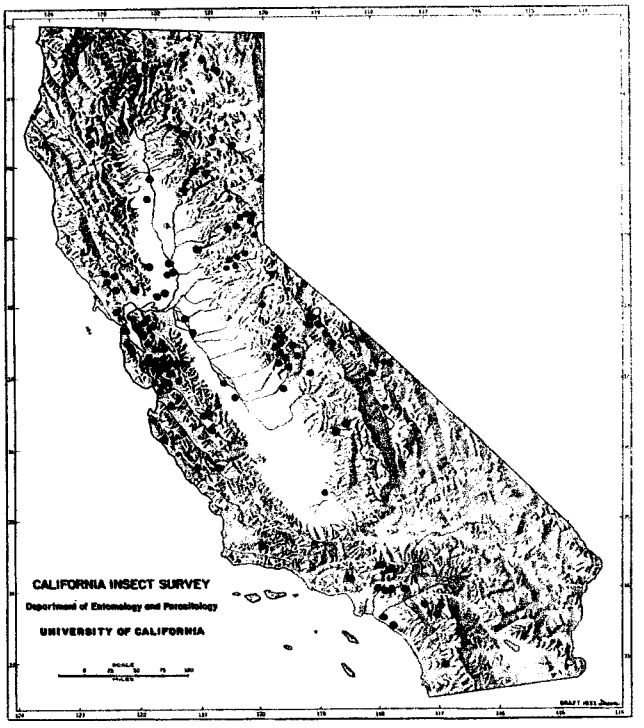
Butte Co.: Oroville, V-24-21 (C.I.S.).
Contra Costa Co.: Vine Hill, VI-7-08 (F. E. Blaisdell, C.I.S.).
Fresno Co.: Hammer Field, V-6-52 (S.C.C.); V-6-52 (E. G. Myers, B.V.C.).
Inyo Co.: Olancha, VI-5-17 (C. L. Fox, C.A.S.).
Kern Co.: Lebec, VIII-23-49 (U.C.L.A.).
Santa Clara Co.: Almaden, VIII-19-54 (S.C.C.). Los Gatos, VII-22-55 (B. F. Eldridge, S.C.C.). San Jose, III-17-47 (K. Hughes, S.J.S.). Stanford, IX-9-05 (Stan.). Sunnyvale, VIII-24-54 (S.C.C.).
Stanislaus Co.: Turlock, IX-15-50 (D. C. Thurman, B.V.C.).
Tehama Co.: Red Bluff, VIII-11-48 (C.I.S.).
Yolo Co.: Davis, VII-1925 (C.I.S.).

Discussion:

This is the horn fly. There is, at this time, considerable disagreement regarding its correct generic name. In the opinion of many dipterists Meigen did not have the horn fly, but rather a small larvaevorid when he erected the genus *Siphona*. Furthermore, *Stomoxys irritans* Fabr., as interpreted by Meigen, may already have been misidentified by Fabricius for what was in reality *Stomoxys stimulans* (L.), a closely related species. The nomenclature is further complicated by varying generic concepts. Rather than attempting to decide the issue, we are accepting the usage of the dipterists at the United States National Museum.

The horn fly is a severe tormentor of cattle and horses. Unlike the stable fly, *Stomoxys calcitrans*, it remains with the cattle constantly, even while they are in the field (Thomson, 1937). The presence of these flies results in a marked loss of weight and milk production in dairy cattle. It has been reported as biting man (Séguy, 1923). Knapp *et al.* (1955) report a surprising case of human myiasis which was apparently owing to the horn fly.

The horn fly is about 4 mm. long and can be readily distinguished from the stable fly by its small size and greater length of its palpi. It appears in early spring and becomes most common in late summer and autumn. The egg is reddish or yellowish in color and is of the typical "musca type." It is quite large, 1.3-1.5 mm. in length, measuring somewhat longer than that of *Stomoxys calcitrans*. The eggs are laid almost exclusively on cow manure, being deposited in groups or singly on the surface of the manure. The larvae pass through three stages. The mature larva of *Siphona* is similar to that of *Stomoxys*, especially in the size, shape, and position of the posterior spiracles. The larval stages last from three to five days. The puparium is dark-brown and barrel-shaped. This stage lasts six to eight days. The entire cycle, from egg to adult, takes from ten to fourteen days.



Map 2. Distribution in California of *Orthellia caesarion* (Meig.)

Genus *Orthellia* Robineau-Desvoidy

Orthellia Robineau-Desvoidy, 1863, Hist. Nat. Dipt., 2: 837.
Cryptolucilia Brauer and von Berganstamm, 1893, Denskr. Akad. Wiss. Wien, 60: 179.
Pseudopyrellia Girschner, 1894, Berliner Ent. Zeit., 38: 306.

Orthellia caesarion (Meigen)

Musca caesarion Meigen, 1838, Syst. Beschr., 5: 97.
Geographical distribution: Europe, Mongolia, North and Central America.

Occurrence in California:

Widespread and common throughout the state (map 2), from sea level to the high mountains. At the higher elevations, specimens have been taken

from Sequoia (Welverton), 7,000-9,000 ft., Tulare Co. VI-17-29 (VanDyke, C.A.S.); at Eagle Pass, 7,773 ft., Yosemite National Park, Mariposa Co., VI-2-31 (C.I.S.); at Snowline Camp, Eldorado Co., VII-7-48 (A. Bartel, C.I.S.); at Blanco's Corral, 10,000 ft., White Mountains, VI-28 to VII-20-53 (U.C.L.A.; J. T. Brooks, C.I.S.; W. D. McLellan, U.C.D.; J. W. MacSwain, C.I.S.; N. Malley, U.C.D.; E. I. Schlinger, U.C.D.); and at numerous other localities. At low elevations, seasonal records range from late January to November, with most records in May through July and a distinct peak in June. Specimens were taken at Davis in pollination traps (carrots) VI-27-55, VI-29-55 (R. W. Bushing, U.C.D.).

Discussion:

This bright metallic green fly is very common on the Pacific Coast and is easily mistaken for one of the blow flies (Calliphoridae). It can be distinguished by its lack of hypopleural bristles. It also differs from most calliphorids in that its head, in large part, as well as its thorax and abdomen, is metallic green, a condition rarely encountered in blow flies.

This fly has been referred to various genera in the past mainly because of attempts by European authors, such as Séguy (1937), to divide the genus *Orthellia* into two smaller genera, in which the common European species, *Orthellia cornicina* (Fabr.), would be placed in the genus *Orthellia*, thus restricted, and *Orthellia caesarion* (Meig.) our common species, in another genus. Emden (1939) and Curran (1935) have pointed out that the character used for this separation varies even within a single species, and therefore they advocate leaving the old genus *Orthellia* intact. The name *Orthellia* is accepted here, therefore, for our local species.

Girault (1908) has recorded the life cycle of *Pseudopyrellia cornicina* (Fabr.) in New York. This account obviously applies to *Orthellia caesarion* (Meig.), since *O. cornicina* is not known to occur in North America.

The adults feed on both feces and nectar of flowers (Townsend, 1935). The eggs are of the "Musca type" and are almost identical with those of *Musca domestica* L., but are somewhat larger, being about 2 mm. long. Oviposition usually takes place on cow dung. The eggs are laid about 30 at a time, but as many as 50 may be deposited. They are usually laid just under the surface of the dung. The egg stage usually lasts about twenty-four hours (Girault, 1908; Thomson, 1937).

The larvae are similar in shape to those of *Musca*, but are characterized by a bright blue coloration (Girault, 1908; Townsend, 1935; Séguy, 1937; Thomson, 1937). The posterior spiracular plates, furthermore, are heavily sclerotized so that the peritreme and external scar are not as distinct as in *Musca* (Thomson, 1937). The larval stages usually last about four and a half days (Girault, 1908).

The puparium is light-brown in color, smoothly barrel-shaped, and 6-7 mm. in length. The heavily sclerotized ventral plate is a conspicuous feature. The pupal stage lasts about eight days (Girault, 1908).

Patton and Gibbins (1934) have figured the male terminalia of this species and commented on its phylogenetic position.

Map 3. Distribution in California of *Musca domestica* L., solid circles; *Graphomyia maculata* (Scop.), open squares; and *Synthesiomyia nudiseta* (Wulp), open circles. Inset: Distribution of *Synthesiomyia nudiseta* in the United States; circles indicate state or national records only.

Genus *Musca* Linnaeus

Musca domestica L.

Musca domestica Linnaeus, 1758, Systema Naturae, Ed. 10, p. 596.

Geographical distribution: Nearly cosmopolitan.

Occurrence in California:

Probably throughout the state (map 3), in association with human habitations, from sea level

to at least 6,000 ft. The paucity of records, particularly from the more northern counties, can be interpreted only as owing to lack of collecting of this common domestic pest. At the lower elevations adult flies may be encountered in houses throughout the year, but their numbers increase greatly during the summer months.

Discussion:

This is the common house fly, or typhoid fly, as it is sometimes called. It is by far the most frequent entrant of all flies into houses in the United States. Howard (1900) reports that of more than 23,000 flies collected in dining rooms in this country, 98 per cent were *Musca domestica* L. Because of its habit of breeding in various types of excrement and feeding on foods in houses, it has become an unequaled mechanical distributer of germs. It has been implicated in the spread both of bacterial diseases and of protozoan infections, including typhoid fever, amoebic dysentery, and cholera. Excellent accounts of its importance as a public health menace can be found in West (1951) and Howard (1900). Adults feed on all types of filth, as well as on fresh foods of all kinds (Townsend, 1935).

Some workers believe that the fly overwinters as an adult (Hewitt, 1914, 1915), but others believe that the pupa is the overwintering form (Howard, 1900). Doubtless both are true, the variation probably resulting from the difference in climate from one part of the country to another (West, 1951).

The egg is white in color and about 1 mm. long. The shape is, of course, the typical "musca type". The eggs are laid in horse, human, and many other types of excrement, as well as in filth of all kinds, including various vegetable wastes. The eggs are usually deposited singly, 75-150 at a laying, with a single female laying four to six such batches (West, 1951; Townsend, 1935). The egg usually hatches in from twelve to twenty-four hours. The larvae are usually white in color, rather slender in form, with the posterior end pointed. Their similarity to the larvae of *Stomoxys* has been already pointed out. They are more similar in form to the larvae of *Orthellia*, but lack the bright blue coloration of these larvae. The larval stage lasts about five days in the summer. The puparium is dark-brown in color, barrel-shaped, and on an average 6.5 mm. in length. The pupal stage lasts four or five days (West, 1951).

The duration of the entire life cycle varies widely, depending on temperature and food. It normally takes eight to twenty days to go from egg to adult.

Genus *Synthesiomyia* Brauer and von Bergenstamm

Synthesiomyia nudiseta (Van der Wulp)

Cyrtoneura nudiseta Van der Wulp, 1883, Tijdschr. Ent., 26: 42.

Synthesiomyia brasiliana Brauer and von Bergenstamm, 1893, Denskr. Akad. Wiss. Wein, 60: 96, 110.

Geographical distribution: Southern United States, Mexico, Central and South America, India, Southern Africa, Australia, and Pacific Islands.

California records:

Monterey Co.: Carmel, VII-14-54 (L. S. Slevin, C.A.S.).

Orange Co.: Unknown locality, VII-2-51 (U.S. N.M.).

Riverside Co.: Palm Springs, XII-28-52 (P. H. Arnaud, Jr., P.A.). Riverside, VII-27-49 (L. W. Quate, U.S.N.M.).

San Luis Obispo Co.: San Luis Obispo (D. G. Hall, U.S.N.M.),

Santa Clara Co.: Alum Rock Park, XI-5-48 (P. H. Arnaud, Jr., P.A.).

Discussion:

This rather uncommon fly is occasionally captured in southern and central California during the warmer parts of the summer months. It can be readily distinguished from the other Muscinae by the bare arista and from the other Muscidae by the wing venation. In habitus, it closely resembles certain Sarcophagidae. The fly breeds in decomposing animal and vegetable wastes and has been recorded as breeding in human cadavers (Townsend, 1935; Siddons and Roy, 1942). It has been implicated as an occasional causal agent of human myiasis (Siddons and Roy, 1942; James, 1948). The adults normally do not visit fresh foods but commonly feed on fermenting substances and flowers (Townsend, 1935).

The eggs are similar in shape to those of *Graphomya*, but differ from those of other Muscinae, being of the "phaonia type" (pl. 3, fig. 33). They are oval in shape and narrowed toward the micropylar end. The chorion is expanded into broad dorsolateral flanges with a reticulate pattern. The rest of the surface shows longitudinal striae. The egg measures about 1.3 mm. in length (Siddons and Roy, 1942). About 255 eggs are laid at a time by a single female. The egg hatches in about fifteen hours.

The larvae are creamy-white and relatively thick. The slits of the posterior spiracle are S-

shaped and somewhat radially arranged. The larval stages last about seven and one-half days days (Siddons and Roy, 1942).

The brown, somewhat transparent puparium is enclosed in a cocoon which is about 8 mm. long. This cocoon is probably formed from salivary secretions. When the cocoon is first secreted, sand grains become attached and eventually become cemented to the finished cocoon (Townsend, 1935; Siddons and Roy, 1942). The pupal stage lasts about seven days. In Calcutta, India, the only place where the life cycle has been timed, it required an average of fifteen days for development from egg to adult. The entire life cycle from egg to egg averaged twenty days (Siddons and Roy, 1942).

Genus *Graphomya* Robineau-Desvoidy

Graphomya maculata (Scopoli)

Musca maculata Scopoli, 1763, Ent. Carn., pp. 326 and 870.

Geographical distribution: Europe, North Africa, Australia, North and South America.

Occurrence in California:

Probably throughout the state (map 3), from below sea level to 10,000 ft., the data representing extremes of elevation being: Furnace Creek, Death Valley, Inyo Co., III-31-51, IV-1-51 (P. D. Hurd, C.I.S.); Blanco's Corral, 10,000 ft., Mono Co., VII-1953 (N. Malley, U.C.D.). July is the month of peak occurrence, both at higher and lower elevations; at the latter, we have records extending from March to November. Adults were taken on anise flowers at Milpitas, Santa Clara Co., VIII-26-54 (S.C.C.) and VIII-16-55 (Tilden and Eldridge, S.C.C.), and on *Asclepias mexicanus* flowers at Lava Beds National Monument, Siskiyou Co., VIII-7-53 (J. Schuh, W.S.C.).

Discussion:

This widespread fly is captured with moderate frequency. So far as known, it is a wild fly and of no medical or veterinary importance. In temperate regions, it is usually seen from May through October. Very little is known of its biology. The adults feed almost exclusively on flowers, and visit dung and other materials for oviposition only. The larvae, according to Stackelberg (1956) live in dung or decaying vegetable matter and are predaceous or saprophagous; according to Séguy (1937); they may breed in liquid mud in small depressions in the ground.

The egg is of the "phaonia type" and is very similar in shape to that of *Synthesiomyia* (pl. 3, fig. 33). The eggs are deposited in excrement of various kinds, including horse and cow dung, as well as in decomposing bodies of various animals (Keilin, 1917). The eggs are laid in groups of 40 or 50 (Townsend, 1935). No data are available to us for the length of time spent in any stage, or for the length of the entire life cycle. The larvae are carnivorous. They are distinguished by the presence of sclerotized hooks on the ventral surface of abdominal segments IV-XI. Portchinsky (1910) states that the second instar is omitted.

Genus *Hypodermodes* Townsend

Hypodermodes solitaria Knab

Hypodermodes solitaria Knab, 1914, Canad. Ent. 46: 325.

Geographical Distribution: Alaska, British Columbia, Alberta, Ontario, Colorado, Montana, Idaho, Washington, Michigan, Minnesota.

California records: None. This uncommon fly might quite reasonably be expected to occur in the mountains of northern California or in the high Sierra.

Discussion:

Townsend (1908) divided the old genus *Mesembrina* Meig. into three genera: *Mesembrina, Metamesembrina,* and *Eumesembrina,* and designated as the respective types *M. mystacea* (L.), *M. meridiana* (L.), and *M. latreillei* R.-D. *Mesembrina meridiana* (L.), however, had already been designated by Westwood in 1840 as the type of *Mesembrina* Meig. *Metamesembrina* Townsend therefore became a synonym of *Mesembrina* Meig. Townsend (1912) discovered the error, proposed the name *Hypodermodes,* and designated *M. mystacea* (L.) as the type. Séguy (1937) has reunited Townsend's genera into the genus *Mesembrina* and has listed *M. latreillei* as a synonym of *M. meridiana.*

On the basis of wing venation, it appears that *Mesembrina meridiana* (L.) and *Mesembrina latreillei* R.-D. are distinct species, but congeneric. *Eumesembrina* Townsend is therefore a synonym of *Mesembrina* Meig. In our opinion, *Hypodermodes solitaria* Knab and *Mesembrina latreillei* R.-D. are not congeneric. These two species differ markedly in wing venation, chaetotaxy, and over-all appearance. *Hypodermodes* Townsend is, therefore, a valid genus.

This fly is rarely encountered at the lower elevations and is only occasionally captured in mountainous regions. To our knowledge, nothing has been published on its biology[2]. Some data have been published on the genus as a whole and some on *Hypodermodes mystacea* (L.), a closely related species. The following information was obtained from these sources. The adults are seen to feed both on decaying vegetables and on fresh feces of various kinds (Townsend, 1935). The egg is of the "musca type" and is quite large, exceeding in size those of the closely related genus *Mesembrina* (Séguy, 1937). The eggs are usually deposited on cow dung (Townsend, 1935).

Séguy (1923) reports that *H. mystacea* (L.) is ovo-larviparous. The egg hatches immediately upon deposition and the first stage larva crawls into dung. Species of the genus *Mesembrina* are also ovo-larviparous (Thomson, 1937). It is probable that this holds true for *H. solitaria* Knab, also. According to Portchinsky (1910), *H. mystacea* (L.) omits the second instar.

Genus *Mesembrina* Meigen

Mesembrina latreillei Robineau-Desvoidy

Mesembrina latreillei Robineau-Desvoidy, 1830 Myod., p. 401.

Geographical distribution: North America, including Washington and Oregon, and Japan.

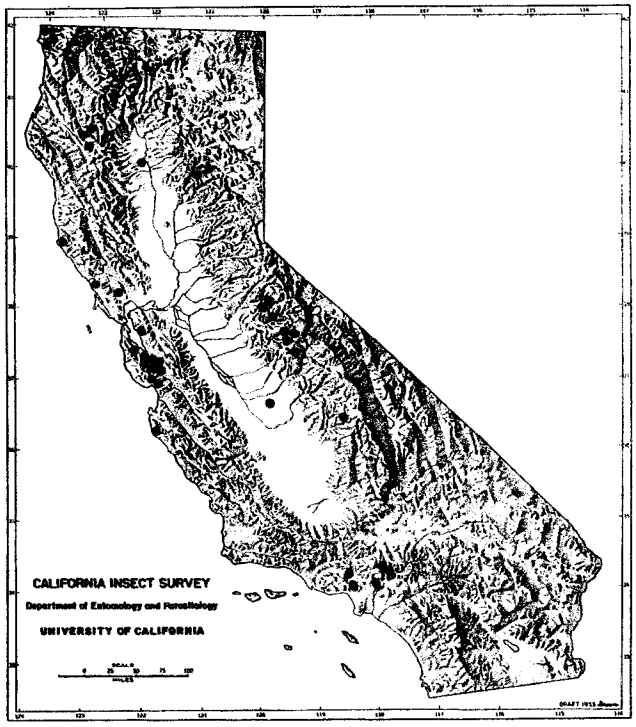
California records: None.

Discussion:

This species is closely related to members of the genus *Hypodermodes*. It is somewhat rare but is captured more frequently and at somewhat lower elevations than *Hypodermodes solitaria* Knab.

In view of the lack of knowledge of the biology of this species, literature on the genus as a whole or on *M. meridiana* (L.), a closely related species from Europe, must be used. The adults, which are present from May to October, feed on both decaying vegetables and fresh feces. They are frequently observed resting on tree trunks (Townsend, 1935; Thomson, 1937). The egg is 4.5 mm. in length and is of the typical "musca type." It differs only in size from the eggs of *Musca*, *Orthellia*, and *Morellia* (Thomson, 1937). The flies are ovo-larviparous, and the first stage larva ecloses immediately upon deposition of the egg (Keilin, 1916; Thomson, 1937). Eggs are laid on cow manure, usually 4 or 5 at a time (Thomson, 1937). The larval stages last from fifteen to seventeen days (Thomson, 1937). The puparium is about 14 mm. long and somewhat oval in cross section. The lateral surfaces are prominent, and form two lateral ridges. The pupal stage lasts about sixteen days (Thomson, 1937). Development from egg to adult takes about thirty to thirty-three days (Thomson, 1937).

[2] Sabrosky (*in litt.*) tells us that he has collected this fly on Isle Royal, Michigan, where there are moose but no cattle; being a dung breeder, it probably was breeding in moose dung. Snyder (*in litt.*) says: "I have a female specimen... from Minnesota which has been partially broken along the line of the third and fourth tergites and beautifully exposes about 15 very large eggs, each of which is about 0.4 to 0.5 the length of the female abdomen."



Map 4. Distribution, in California of *Morellia micans* (Macq.).

Genus *Morellia* Robineau-Desvoidy

Morellia micans (Maquart)

Cyrtoneura micans Macquart, 1855, Dipt. Exot. Suppl., 5: 116.

Geographical distribution: North America.

Occurrence in California:

Throughout the state (map 4), from sea level up to 6,000 ft. or higher. Our seasonal records, at lower elevations, run from March to October, with the peak coming in May, June, and July.

Discussion:

This is a common species, but little is known of its biology. Howard (1900) states that it breeds almost exclusively in human excrement though he later (Howard, 1901) reported it from cow dung. Since it rarely occurs in houses, it is of little medical importance. Thomson (1937) states that the related *Morellia simplex* (Loew) commonly antagonizes cattle in Scotland by its presence, and in the summer months may become more bothersome than the horn fly, *Siphona irritans* (L.). Most of the information given here comes from Thomson (1937) who has reported on the genus as a whole.

The eggs are of the "musca type" and are almost identical with those of *Musca* and *Orthellia* in size and shape. The eggs are deposited on the surface of the dung, usually 24 to 30 at a time. They are usually deposited in the shade. The eggs hatch in twenty-eight to forty hours. The larvae are readily distinguishable because of their heavy sclerotization. In the mature third stage larva, the slits of the posterior spiracles are almost completely obscured by a heavy sclerotization which protects the larvae from other carnivorous species. The posterior face of the larva is extremely flat, so much so that the larva may be stood upon its end. The puparium differs little from the third stage larva, except in the increase of sclerotization. The pupal stage lasts seventeen or eighteen days. Howard (1900) states that the minimum time for development from egg to adult is seventeen days.

Genus *Pyrellia* Robineau-Desvoidy

Pyrellia cyanicolor Zetterstedt

Pyrellia cyanicolor Zetterstedt, 1845, Dipt.Scand., 4: 1323.

Geographical distribution: Europe, North Asia, and North America including Washington.

California records: None.

Discussion:

This species is very rare in the Pacific Coast states, and its biology is virtually unknown. The adults are present from May to September (Séguy, 1923). The larvae breed in cow dung, and have been reported breeding in carrion and other decomposing materials (Séguy, 1923). The eggs are laid in groups of 20 to 30. The time of various stages of the life cycle is unknown.

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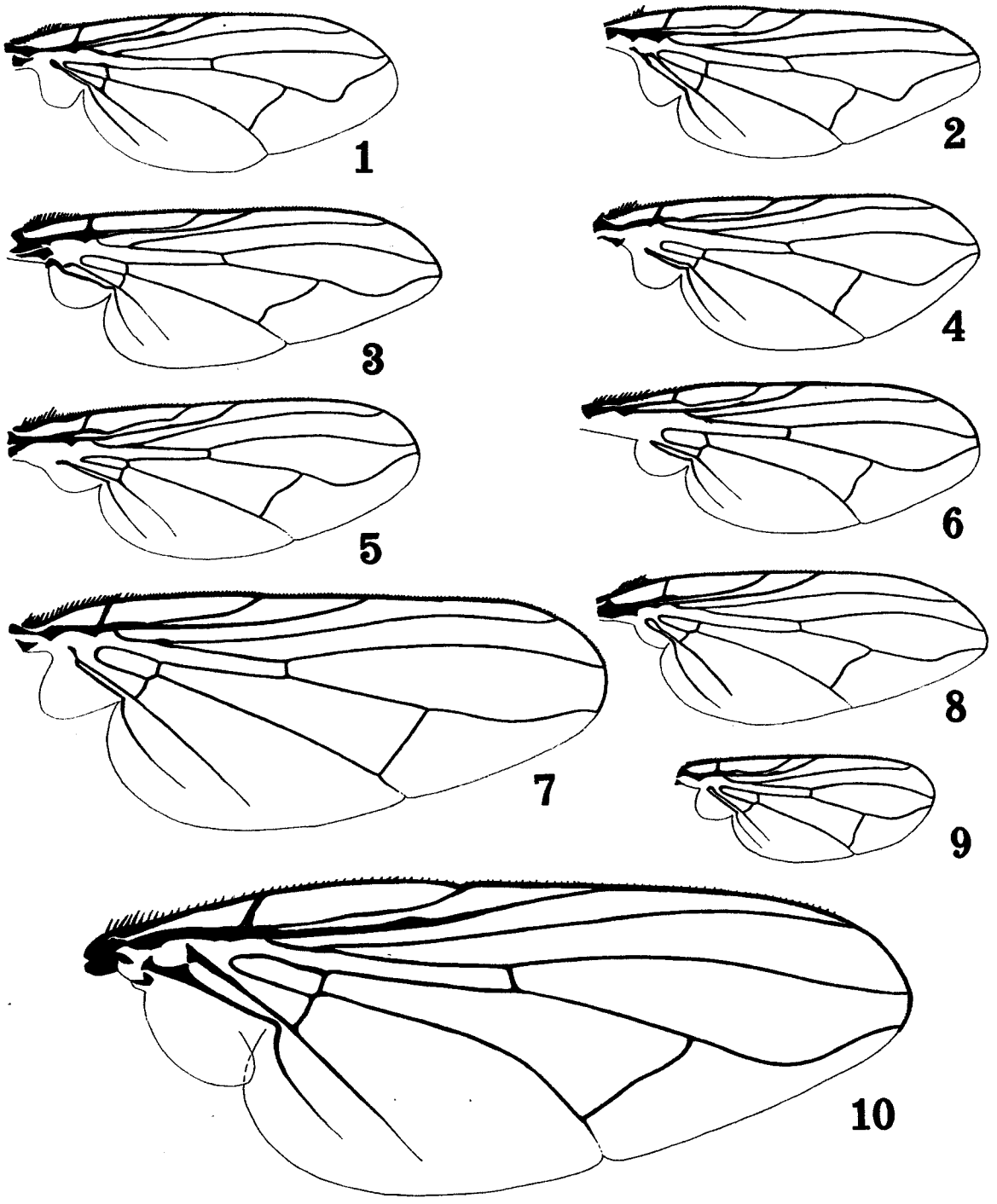

PLATE 1

Fig. 1. *Musca domestica* L., left wing.
Fig. 2. *Orthellia caesarion* (Meig.), left wing.
Fig. 3. *Graphomya maculata* (Scop.), left wing.
Fig. 4. *Synthesiomyia nudiseta* (Wulp), left wing.
Fig. 5. *Morellia micans* (Macq.), left wing.
Fig. 6. *Pyrellia cyanicolor* Zett., left wing.
Fig. 7. *Mesembrina latreillei* R.-D., left wing.
Fig. 8. *Stomoxys calcitrans* (L.), left wing.
Fig. 9. *Siphona irritans* (L.), left wing.
Fig. 10. *Hypodermodes solitaria* Knab, left wing.

All drawn to the same scale.

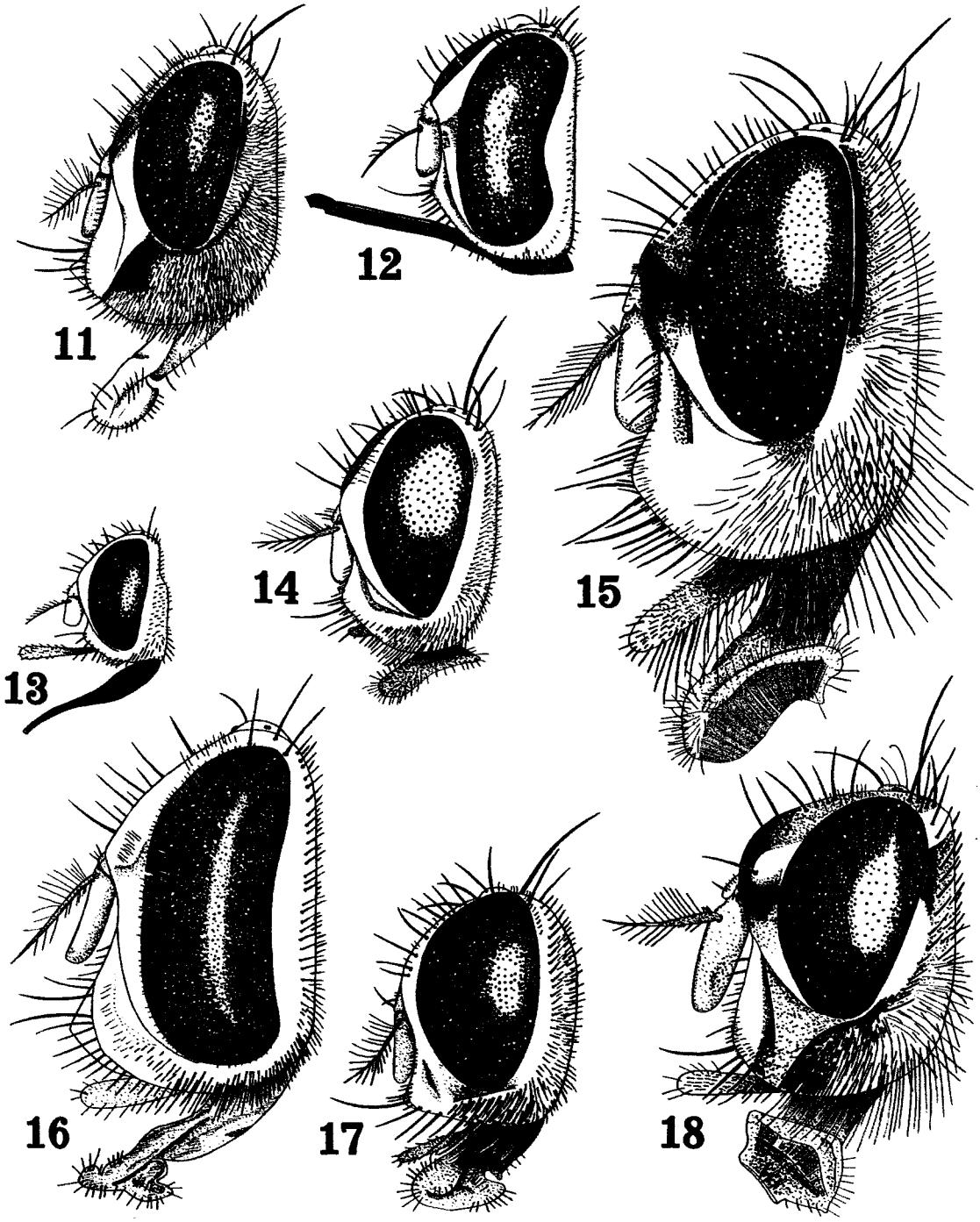

PLATE 2

Fig. 11. *Orthellia caesarion* (Meig.), head of female.
Fig. 12. *Stomoxys calcitrans* (L.), head of female
Fig. 13. *Siphona irritans* (L.), head of female
Fig. 14. *Musca domestica* L., head of female.
Fig. 15. *Hypodermodes solitaria* Knab, head of female.
Fig. 16. *Graphomya maculata* (Scop.), head of female.
Fig. 17. *Pyrellia cyanicolor* Zett., head of female
Fig. 18. *Mesembrina latreillei* R.-D., head of female.

Figures 11–20 all drawn to the same scale.

PLATE 3

Fig. 19. *Morellia micans* (Macq.), head of female.
Fig. 20. *Synthesiomyia nudiseta* (Wulp), head of female.
Fig. 21. *Musca domestica* L., right thoracic squama.
Fig. 22. *Hypodermodes mystacea* ().), posterior spiracle of third stage larva (after Zimin, 1951).
Fig. 23. *Orthellia caesarion* (Meig.), posterior spiracle of third stage larva (after Zimin, 1951).
Fig. 24. *Graphomya maculata* (Scop.), posterior spiracle of third stage larva (after Zimin, 1951).
Fig. 25. *Morellia simplex* (Loew), posterior spiracle of third stage larva (after Thomson, 1937).
Fig. 26. *Synthesiomyia nudiseta* (Wulp), posterior spiracle of puparium.
Fig. 27. *Pyrellia cadaverina* (L.), posterior spiracle of third stage larva (after Zimin, 1951).
Fig. 28. *Mesembrina meridiana* (L.), posterior spiracle of third stage larva (after Thomson, 1937).
Fig. 29. *Stomoxys calcitrans* (L.), posterior spiracle of third stage larva (after Zimin, 1951).
Fig. 30. *Siphona irritans* (L.), posterior spiracle of third stage larva (after Zimin, 1951).
Fig. 31. *Musca domestica* L., posterior spiracle of third stage larva.
Fig. 32. *Orthellia* sp., egg (after Thomson, 1937).
Fig. 33. *Synthesiomyia nudiseta* (Wulp), egg (after Siddons and Roy, 1942).
Fig. 34. *Myospila* sp., egg (after Thomson, 1937).
Fig. 35. *Pyrellia cyanicolor* Zett., middle tibia.

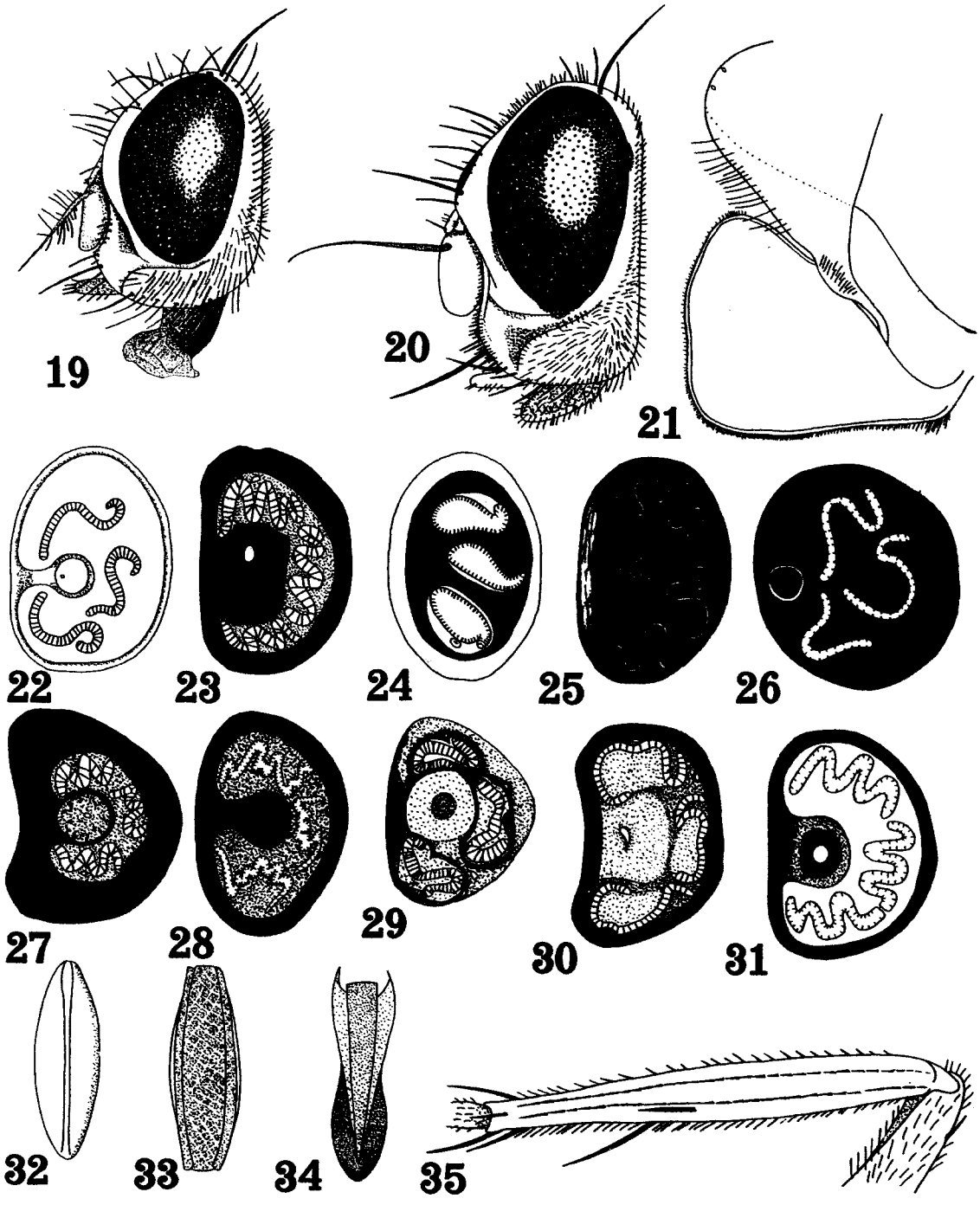

PLATE 3