# Biological Studies in Hawaiian Water-Loving Insects—Part III Diptera or Flies—C, Tipulidae and Psychodidae

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The Series Nematocera, or Nemocera to which the Tipulidae, Psychodidae, Culicidae, Chironomidae, Ceratopogonidae and some other Families not represented in Hawaii belong, are regarded as the more generalized or simpler flies, with the antennae consisting of more than five segments, the larvae for the most part having a well-defined head and the pupae being more or less active. My chief references to these insects have been Dr. O. A. Johannsen's very fine papers on Aquatic Diptera: Memoirs 164, June 1934, 177, June 1935, 205, June 1937, and 210, December 1937, of the Cornell University Agricultural Experiment Station. These Memoirs are well supplied with keys, descriptions, illustrations and an extensive list of references.

## FAMILY TIPULIDAE (Crane-Flies)

This is an extensive family of small to very large and slender long-legged flies that usually inhabit damp places. The adults may sometimes be observed in the late afternoon or at dusk in a dancing flight about the eaves of buildings, the prominent portion of some tree or bush, by a streamside bank or boulder, etc. Crane-flies also have the curious habit of swinging in unison by the fore legs from a suitably horizontal strand of a spider web in a sheltered place. They are often mistaken by the layman for very large mosquitoes; unlike the latter, however, they are quite incapable of biting, although their mouth portion is frequently produced, and indeed occasionally to such an extent in a few genera, as to simulate the slender beak of a mosquito. Such long-billed tipulids may be observed during the day probing flowers for nectar. Certain other kinds of crane-flies — *Chionea* and the females of others — are practically wingless. The larvae are generally slender, cylindrical and dull-colored; they usually live in damp ground, decaying wood, among or under moss, or they may be more or less aquatic—a few of these being marine. A small number feed on leaves like caterpillars. In the Hawaiian Islands Mr. O. H. Swezey discovered a leaf-mining tipulid (Proc. Haw. Ent. Soc., III, 1915, 87-89, 1 pl.), while in Samoa he brought to light an undetermined species mining the fronds of a fern (Hawaiian Planters' Record, 1941, XLV, 38).

The crane-flies of the Hawaiian Islands are small to moderately small species that are usually found in forests. They are thus more in evidence at higher altitudes. In his check list of the Tipulidae of Oceania, Alexander (Bernice P. Bishop Museum, Occ. Papers, IX, No. 2, Pac. Ent. Surv. Publ., 1932, pp. 1-12) lists 15 species as occurring in the Hawaiian Islands, while in Proc. Haw. Ent. Soc., 11, 1941, 1-12, he adds two more species. Of these 17 species, *Trimicra pilipes* (Fab.), *Styringomyia didyma* Grim. and *Erioptera* (*Meterioptera*) *bicornifer* Alexander are introduced species and have a wide range elsewhere, while *Limonia* (*Libnotes*) *perkinsi* (Grim.) occurs also in the Marquesas, Society Islands, Samoa and Fiji. The 13 remaining species are endemic. Additional species are sure to be discovered.

I have found "The Crane-flies of New York" by C. P. Alexander, Cornell Univ. Agric. Exp. Sta., Mem. 38, 1920, a mine of information. Very helpful also is the work of Johannsen already referred to, as well as Malloch's Prelim. Classification Dipt. Excl. of Pupipara, based on larval and pupal characters; Ill. State Lab. Nat. Hist., Bull. 12, (1916-1917), 161-410, 1918.

## Subfamily LIMONIINAE

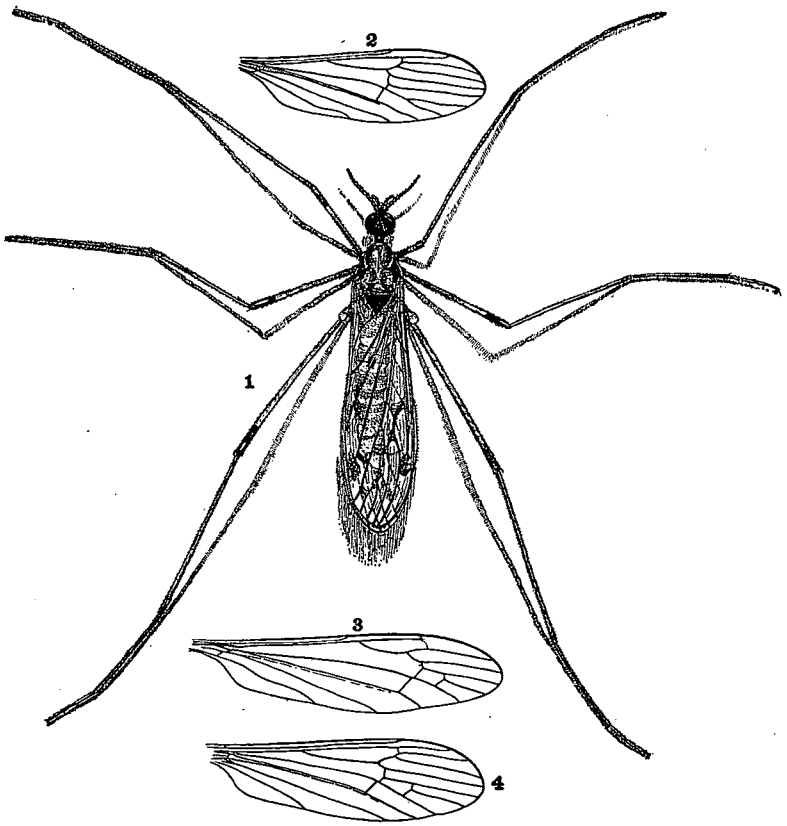
### Tribe *Limoniini*

**Limonia (Libnotes) perkinsi** (Grimshaw). (Figures 1, 5, 13 and 18 and text figure 1.)

Grimshaw, P. H., Fauna Hawaiiensis, III, Diptera, pp. 6-7, pl. 1, fig. 12, 1901.

This is a common species with spotted wings. It probably occurs in all the larger islands of the Hawaiian Archipelago and is found elsewhere in Polynesia.

A few eggs were laid by a captive specimen. They were shallowly inserted in soft decaying leaf tissue and were whitish, subovoid and with very finely granulated shells. No adults were secured from these eggs but the fly was often reared from last-instar larvae. These larvae were commonly dirty whitish and rather glassy in appearance. They were usually found off the ground, as in tree holes partly filled with mud and water, at the leaf bases of the pandanus or hala tree (*Pandanus odoratissimus* L.), the ieie vine (*Freycinetia arborea* Gaud., Pandanaceae), the ti plant (*Cordyline terminalis* Kunth, Liliaceae), behind banana leaf sheaths in moist regions (Swezey and Fullaway), even in the damp humus of potted ferns, once or twice in decaying sugar cane (*Saccharum officinarum* Linn.) (O. H. Swezey, 1907), and in old tree trunks, such as *Charpentiera* (O. H. Swezey, 1922). On one occasion it was found breeding together with a species of *Psychoda* or moth fly in the sap of a freshly-cut trunk of a paper bark tree (*Melaleuca*




CRANE-FLIES

Explanation of Plate VIII

1. *Limonia* (*Dicranomyia*) *perkinsi,* female. Length from head to tip of wings 7.2 mm.
2. *Erioptera* (*Meterioptera*) *bicornifer.*
3. *Limonia* (*Dicranomyia*) *grimshawi.*
4. *Trimicra pilipes.*

*leucadendron* Linn.). Sometimes, however, the larvae dwelt more or less immersed at the margin of little mud-floored pockets of water in a stream bed. Where the habitat is between leaf bases, particularly those of the pandanus, much debris, even including such large objects as decaying guava fruit, may lodge. The larva then, is quite adaptable; in dry weather it may develop in humus or in damp decaying wood or, with sufficient rainfall, live under aquatic or semi-aquatic conditions so that the terminal spiracular disc, whence it obtains air, is brought to the surface of the water.

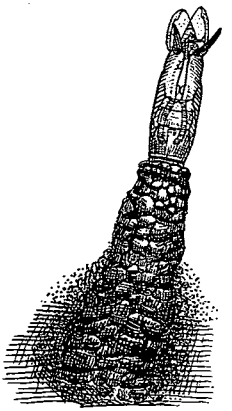


Fig. 1. Extruded pupal shell of *Limonia perkinsi.*

The rather slender cylindrical larva has a dark, strongly-chitinized head frame that is incomplete posteriorly; the body is provided with segmental "creeping welts"—cross bands clothed with fine short hair or bristles or little tooth-like processes—the ventral ones protruding somewhat like pseudopods. Posteriorly beneath are four extrusable finger-like gills, while above, the abdomen terminates in the spiracular disc. This is a rather obscurely-lobed area in which are the two oblong spiracles that, leading into the body through the "felt chamber"—an enlargement well provided with fine tracheae—extend through the length of the body as the two main tracheae. Exterior to each of these tubes at their posterior end is a tousled mass of fine tracheae that in life shows conspicuously silvery white through the body wall. The spiracular disc is margined with some fine bristles, and towards its caudal end is a pair of rod-like structures that serve as a distinguishing character for the species. When the larva is entirely submerged the spiracular disc is folded along the middle line, thus closing it book-like. The larva is very active when needs be, and will entirely retract its head if danger threatens from that quarter; it can proceed forward or

backward with about equal ease, clinging close to the substratum. It fashions for itself a rather flimsy glutinous tubelike retreat, fastening it to some decayed leaf or other substratum. It seems to feed upon decaying plant tissues, algae, diatoms, etc. Its mandibles are strong and toothed. In due time the full-sized *L. perkinsi* larva sheds its skin for the last time, thus turning into a slender subcylindrical pupa that is provided with a pair of wedge-shaped, closely-approximated "breathing horns" situated forward on the thoracic dorsum and extending to the top of the head (fig. 13). Hence the breathing intake has been transferred to the anterior part of the body. The pupa can squirm and move back and forth actively and this is no doubt useful in following any rise and fall of the water and perhaps in avoiding an excess of sunlight. The pupa rests for some days in its flimsy tube and finally, partly extruding itself therefrom, discloses the adult insect.

**Limonia (Dicranomyia) grimshawi** Alexander. (Figures 3, 6, 10, 11, 12, 15 and 20.)

Alexander, C. P., Ann. Soc. Ent. America, XII, 1919, pp. 27-28; new name for *Limonia* (*D.*) *apicalis* Grimshaw, not *apicalis* Wiedemann; Grimshaw: Fauna Hawaiiensis, Vol. 3, Pt. I, p. 7; Lanai and Hawaii.

This is one of our most abundant species. It has been taken on Molokai, Lanai, Oahu and Hawaii. It certainly occurs on Maui and probably also on Kauai. The wings are clear, the body brown and the knees dark.

Eggs were obtained from a captive specimen. They had been thrust part way into a soggy old leaf portion. They were ovoid, 0.33 mm. long, marked rather obscurely with very fine polygonal areas and covered with a gelatinous envelope.

The larva of this crane-fly may occasionally be found associated with the preceding species, but its ecology is generally different for, where *L. perkinsi* is common in tree holes and in the leaf axils of suitable plants, *L. grimshawi* seems usually to pass its immature stages in dripping wet banks; elsewhere, however, it develops in decaying banana stems, and it is this species that is found in the scummy fringe of algae that borders the swift waters of flumes on the Island of Hawaii. Once it was found breeding in the leaf axils of *Freycinetia* in the mountains behind Honolulu. A considerable colony was discovered in a dripping bank of wet earth on the slopes of Tantalus or Puu Ohia. Some of this wet soil when immersed in a dish of water revealed many *grimshawi* larvae all striving to extend their caudal extremities to the surface. Most of the observations were made along the tiny trickling stream in the canyon-like Hering Valley at an elevation of about 1,000 feet and just behind Honolulu. Here *L. grimshawi* might often be found in company with the smaller *L.* (*Dicranomyia*) *jacobus* (Alexan-

der) on a glistening wet rocky bank. The more-or-less immersed larvae would venture from tiny holes or cracks in the rock to feed on organic material. They moved in a rather jerky fashion, backing quickly into their retreats on being disturbed. *L. grimshawi* was also abundant under decaying leaves of *Aleurites* and of other trees that lay appressed to the wet rock. In any case, the larva forms a rather flimsy glutinous tube retreat.

The larva may attain a length of 16 mm. or more. Figure 6 shows the caudal extremity of the larva from above. Here one sees outlined the four finger-like gills, and the spiracular disc which differs in armature from that of *L. perkinsi.* One of the creeping welts is shown at W. See also figure 11.

Several larvae were dissected to determine what they had fed upon. Results: a quantity of brownish material, perhaps plant tissue, some diatoms and stellate plant hairs were revealed. A large larva was observed avidly biting off and swallowing pieces of a soggy decayed leaf. On the other hand, a large *grimshawi* larva devoured several pupae of *Limonia jacobus* with which it was confined.

The pupa is about 9 mm. long. Its breathing horns differ from those of *L. perkinsi* in being rounded rather than triangular or wedge shape. Under water these organs have a golden air-filled appearance with the distal margin finely beaded with silver.

**Limonia (Dicranomyia) jacobus** (Alexander). (Figures 8 and 16.)
Alexander, C. P., Ann. Ent. Soc. America, 12: 28-29, 1919. Iao Valley, Maui, 700 ft., January 3, 1914 (J. F. Illingworth).

This rather small species measures from about 4 to 6.5 mm. in length of body. It is common in the hills behind Honolulu, where

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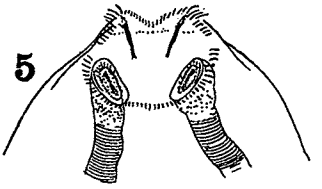
CRANE-FLIES

Explanation of Plate IX

5. *Limonia (Dicranomyia) perkinsi,* last-stage larva, caudal end from above to show spiracular disc.
6. *Limonia (Dicranomyia) grimshawi,* last-stage larva, spiracular disc, tracheal tubes and the four finger-like gills. Creeping welt at W.
7. *Gonomyia (Lipophleps) hawaiiensis*(?), cauda, obliquely from above. *Gunnera* spring, Mt. Kaala.
8. *Limonia (Dicranomyia) jacobus,* spiracular disc.
9. *Limonia (Dicranomyia) casei,* to show the two separate plates of the spiracular disc.
10. *Limonia (Dicranomyia) grimshawi,* large larva, fore part of head, dorsal view: LE, labrum-epipharynx; MX, maxilla; MXP, maxillary palpus, the maxilla itself having been removed; A, antenna; M, mentum—the outer plate is the shaded one with the large median tooth and is continuous as a posterior fork with the head capsule. The inner plate (dorsad) bears numerous teeth. MD, mandible; SD, salivary duct; O, oesophagus; H, hypopharynx; E, eye.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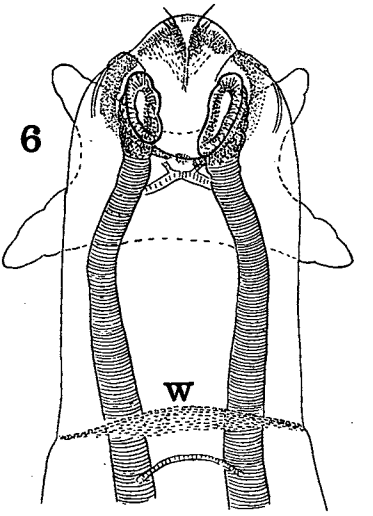
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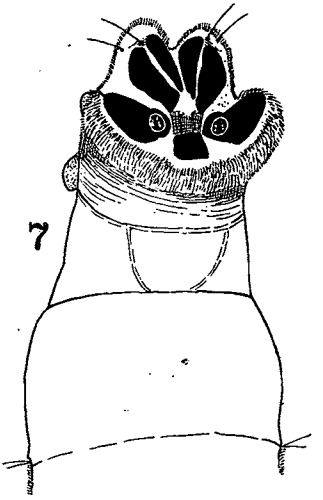
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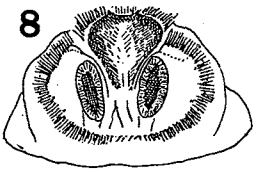
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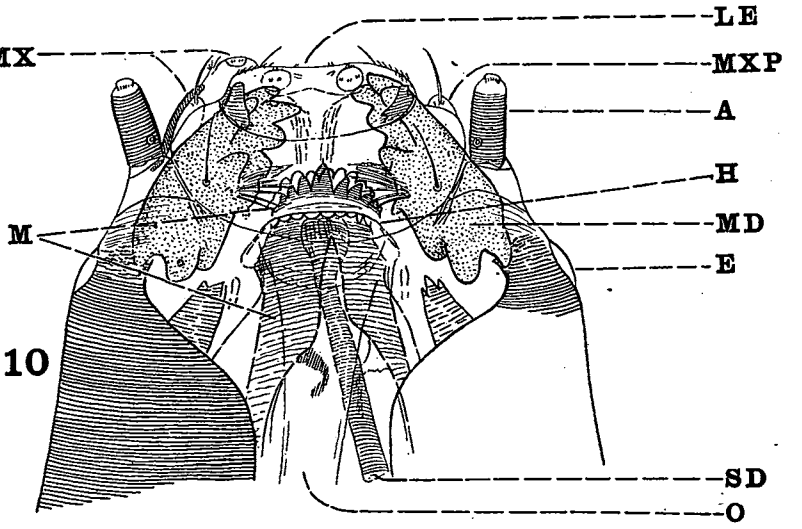
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it is often associated with *Limonia* (*Dicranomyia*) *casei* Alexander (Proc. Haw. Ent. Soc., XI: 23-24, fig. 1, 1941). The adults of one or both of these species have been seen in considerable numbers immovably fixed though lifelike—the victims of disease—to the underside of streamside boulders in upper Manoa Valley. The larvae occur among the fine debris and low algal growth, such as *Phormidium* on wet rocks and near waterfalls. They make tube retreats. In the larva of *jacobus* the plate on the spiracular disc while quite thin mesad is entire, whereas in *casei* it is clearly divided (figures 8 and 9). The pupa of *jacobus* has the extremity of the breathing horns but slightly swollen in contrast to the rather strongly swollen tips of the breathing horns in *L. casei* (figures 16 and 17), although these organs are not without variation. There are, no doubt, other characters separating the two species.

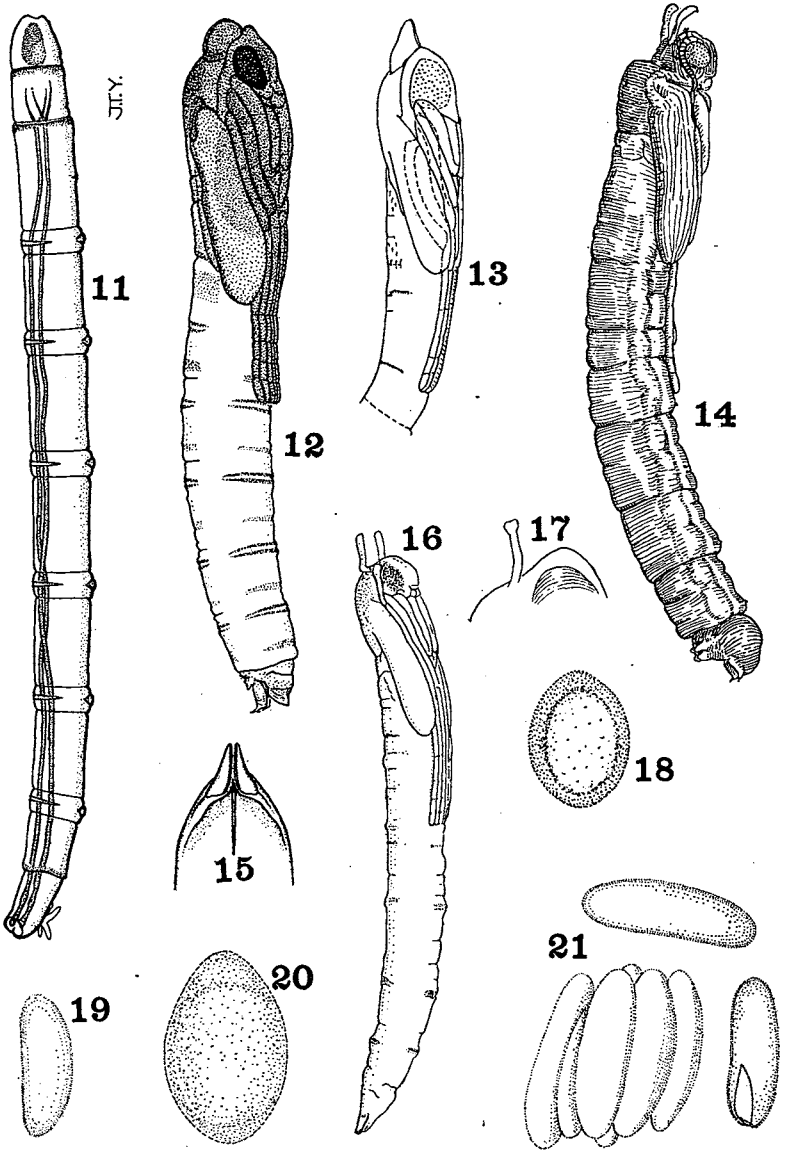
Eclosion of the adult of one or both of these species was observed along the Waihi-iki stream in upper Manoa Valley, as follows: May 30, 1936 at 8:45 a.m. In the leaf-filtered sunlight on a wet boulder that was practically surrounded by water several pupae of more or less greenish color having extruded themselves from their tubes lay prone on the substratum. Already a male fly had issued nearby, and it protruded upwards almost free of the pupal shell. Its perfectly cylindrical abdomen appearing rather void was greatly extended, being fully twice the length of the wings, already developed and held upwards over the back. This lengthening of the abdomen gives the tender developing insect clearance of the wet rock and debris and accommodates the long legs. In a short time the abdomen contracts—a matter of letting out gas—and the fly assumes a normal appearance. I am not certain that all such pupae that lie prone upon the substratum succeed in producing adults.

A very common species and evidently widespread in our archipelago is the dusky-winged *Limonia* (*Dicranomyia*) *stygipennis*

CRANE-FLIES

Explanation of Plate X

11. *Limonia* (*Dicranomyia*) *grimshawi*, last-stage larva.
12. *Limonia* (*Dicranomyia*) *grimshawi*, pupa, length 9 mm.
13. *Limonia* (*Dicranomyia*) *perkinsi*, pupa, upper two-thirds.
14. *Trimicra pilipes*, pupa. Kohala, Hawaii.
15. *Limonia* (*Dicranomyia*) *grimshawi*, pupa, breathing trumpets, from behind.
16. *Limonia* (*Dicranomyia*) *jacobus*, pupa.
17. *Limonia* (*Dicranomyia*) *casei*, pupa, top of head to show one breathing trumpet.
18. *Limonia* (*Dicranomyia*) *perkinsi*, egg.
19. *Erioptera* (*Meterioptera*) *bicornifer*, egg. Length 0.40 mm.
20. *Limonia* (*Dicranomyia*) *grimshawi*, egg. Length 0.33 mm.
21. *Trimicra pilipes*, eggs. Length 0.55 mm.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(Alexander) (Ann. Ent. Soc. America, XII, 1919; *Dicranomyia brunnea* Grimshaw, not Doane). Numbers of these insects are often disturbed from dark earthy nooks or from the underslope of boulders along forest streams. Very little was learned of its life-history. The egg is ovoid in shape.

Tribe *Eriopterini*

**Gonomyia (Lipophleps) hawaiiensis** Alexander. (Figure 7.)

*Gonomyia (Liponeura) hawaiiensis* Alexander, C. P., Ann. Ent. Soc. America, XII, p. 30. Oahu.

This small species inhabits the mountains of Oahu. The sides of the thorax are white with two wide brown stripes. What appears to be the larva of this insect was taken in January 1939 in mud and minute plant growth of a spring high up on Mt. Kaala. The larva in one case measured 8 mm. long. It was dull wood-brown in color and was in great measure covered with fine erect pile giving it a velvety appearance. This pile was more patchy on the thorax, and there were some fine erect hairs before the caudal extremity. The small head was retractile, the thoracic segments rather conspicuously arched, while the abdomen, lacking any creeping welts, was swollen bulblike before the caudal end that bears the 5-lobed spiracular disc so well marked by blackish strips. Short digit-like gills are present caudally beneath. None of the three larvae secured was reared.

**Trimicra pilipes** (Fabricius). (Figures 4, 14 and 21 and text figure 2.)

*Tipula pilipes* Fabricius, J. C., Mantissa Insectorum, 1787.
*Trimicra lateralis* Grimshaw, P. H., Diptera, Fauna Hawaiiensis, III, pt. I, pp. 9-10: Hawaii, Olaa, 1,500 ft., 1892.

This rather hairy-legged crane-fly, an immigrant in the Hawaiian Islands, occurs in both hemispheres. We have taken it on the Islands of Oahu and Hawaii.

Eggs laid by a captive specimen measured about 0.55 mm. long; they were creamy white and covered with fine granulations giving them a delicate prickly appearance. The figure (21) shows that they are relatively elongate. In lowland marshes on Oahu the writer found this insect breeding in the mud. A specimen was reared from egg to adult in 21 days. In Kohala on the Island of Hawaii a few adults and empty pupal shells were found at the margin of a taro pond. The spiracular disc of the larva is strongly hairy lobed; the lobes may be brought together to form an air cup. The pupa including the rather forward-pointing breathing horns may attain a length of about 10 mm. It is armed with a sort of thorny collar on the shoulders.

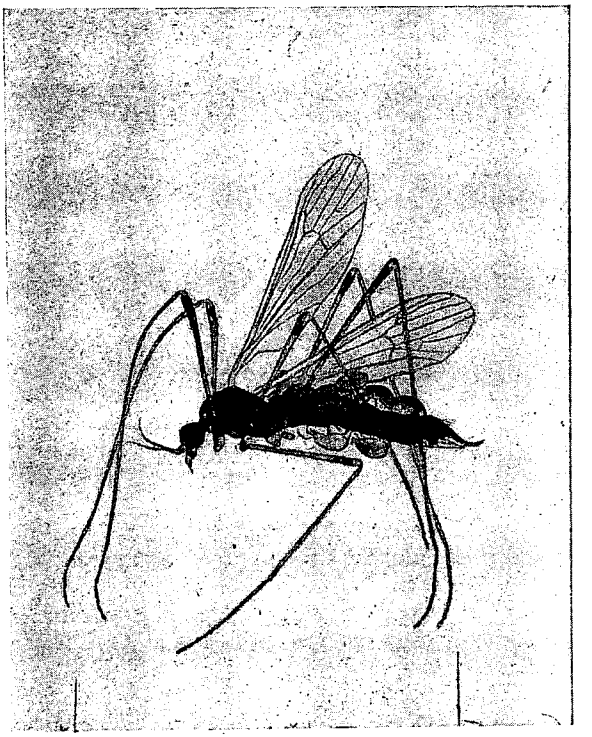


Fig. 2. *Trimicra pilipes* infested with acari.

**Erioptera (Meterioptera) bicornifer** Alexander. (Figures 2 and 19.)

*Erioptera* (*Erioptera*) *bicornifer* Alexander, C. P., Ann. Ent. Soc. America, XIV, 1921, p. 116.

This small species, which occurs also in Eastern Asia, was bred from mud in the lowlands near Honolulu, in April 1931. The egg is much like that of *Trimicra pilipes* but is smaller. The pupa has slender forward-curved breathing horns.

No doubt other species of Hawaiian Tipulidae have subaquatic habits. No marine species have been found here, although representatives of these occur on the seashore of widely separated countries. For example, *Dicranomyia signipennis* Coquillet breeds in great numbers ". . . in the bright green *Enteromorpha* sp. coating rocks in sheets and patches a foot or two below high-water mark" on the coast of British Columbia. (Saunders, Some Marine Insects of the Pacific Coast of Canada. Ann. Ent. Soc. America, XXI, 1928, 521-545: 9 figures). Tokunaga has studied *Limonia* (*Di-*

*cranomyia*) *trifilamentosa* Alexander, of the Pacific coast of Japan (Philippine Jour. Sci., 50, 1933: 327-344, 2 figs. and 3 pls.). And Alexander states (p. 5, Check List of the Tipulidae of Oceania): "It is now believed that all or virtually all of the species of *Idioglochina* will be found to be marine in larval habitat." This would bring marine species well out in the Pacific—New Hebrides, New Caledonia and Samoa.

Our Hawaiian Tipulidae have numerous enemies, though I found no parasites. The adults are often caught in spider webs. Crabronid wasps sometimes store their cells with them; dragonflies catch them, and they often succumb to disease. A species of *Philonthus* beetle of the Family Staphylinidae hunts diligently about wet rocks and the banks of streams behind Honolulu where it has been observed devouring the larvae of *Limonia* sp. *Saldula* bugs probe the algae-covered boulders with their deadly beaks, and tipulids number among their victims. The small water-running bug *Microvelia vagans* (White) hunting in gangs for hatching chironomid flies may also attack emerging crane-fly pupae or adults. Such damselflies as *Megalagrion hawaiiense* (McLachan) and *M. oceanicum* (McLachan), the nymphs of which are frequently found on wet streamside rocks and banks, may feed extensively on *Limonia* larvae. So also the carnivorous larvae of anthomyid and dolichopodid flies may prey upon the early stages of our Tipulidae. Mites (acari) sometimes attach themselves to the adults (text figure 2). In Europe and the mainland of America tachinid flies have been bred from Tipulidae (Alexander: The Crane-Flies of New York, Part II, pp. 730-733, 1920). C. Pierre in Faune de France, 8, Dipteres: Tipulidae, 1924, pp. 13-14, mentions both Diptera and Hymenoptera as parasitic on craneflies, and figures the larva of a hymenopterous (?) parasite issuing from the abdomen of an adult tipulid.

### FAMILY PSYCHODIDAE
### (Moth-Flies, Owl-Midges)

These are tiny moth-like flies with body, wings and legs clothed with coarse hair or with both coarse hair and scales. The wings are usually held roof-like over the body, or they may extend horizontally, or more rarely somewhat back and upwards. They are usually found in damp situations, their larvae being aquatic, semi-aquatic or living in filth and other decayed organic matter.

Species of the genus *Phlebotomus*—which is not found in Hawaii—are blood suckers and vectors of certain serious diseases. Some of the moth-flies of the large genus *Psychoda* may cause considerable annoyance by breeding about households in great numbers, their larvae occurring in cesspools, in sinks and in wash

basins, despite soap and hot water. In this connection the reader is referred to "Observations on Sewage-Flies: Their Seasonal Incidence and Abundance." Lloyd, L., Proc. Inst. Sewage Purif., 1937, pt. I, 16 pp.; charts and references. (Refers to *Psychoda alternata.*) Another paper is "The Pacific Drain Fly in Homes." Mallis, A., and Pence, R. J., Jour. Econ. Ent., 34, 1941, pp. 586-587, 2 figures; references. (Refers to *Psychoda pacifica* Kincaid.) Occasionally as with other small Diptera they spoil a fresh paint job in being attracted to the turpentine and settling on and adhering to the surface in large numbers.

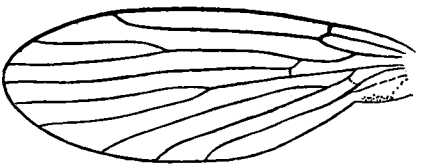


Fig. 3. *Trichomyia* sp., wing divested of hair. Mt. Olympus, Oahu.

Interesting species of the American mainland *Ulomyia* and *Maruina* pass their adaptively-flattened and adhering larval and pupal stages in the splash or wash of cascades.

The larva of *Trichomyia* lives in decaying wood (Keilin, D., Sur la biologie d'un Psychodide á larve xylophage. C. R. Soc. Biol. Paris, 76, 1914, pp. 434-437). In 1936 the writer discovered a species of this genus in the mountains behind Honolulu but he did not observe its early stages. The wing venation and male terminalia of this insect are shown in text figures 3 and 4.

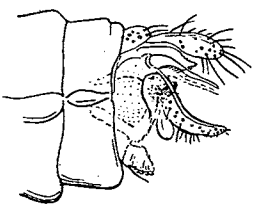


Fig. 4. *Trichomyia* sp., male terminalia, from side. Mt. Olympus, Oahu.

At least six species of Psychodidae have been taken in the Hawaiian Islands. It is not certain that any of these is endemic. The relatively large *Telmatoscopus albipunctatus* (Williston) is a recent arrival here and is well known elsewhere. *Psychoda alternata* Say is found in many parts of the world. Shortly before his death, Mr. A. Tonnoir, world authority on these insects, examined

collections of Psychodidae from Hawaii and discovered a new species among them, to which he gave the manuscript name of *Psychoda pseudalternata,* it greatly resembling *Psychoda alternata,* less common here. Grimshaw in Fauna Hawaiiensis, III, p. 6, pl. I, fig. 11, describes *Psychoda inornata* from Kona, Hawaii. An unidentified species, likewise with inornate wings, occurs in Honolulu. *Trichomyia* sp., already mentioned, was found on the Mt. Olympus trail behind Honolulu.

After examining the terminalia of several of our *Psychoda* species, the writer decided to forego any taxonomic studies in this group, particularly in view of the synonymy existing among some of the species.

A good monograph of the genus *Psychoda* has been written by Dr. F. Del Rosario (The American Species of Psychoda [Diptera: Psychodidae]) in the Philippine Journal of Science, LIX, 1936, pp. 85-148, 1 text figure and 4 plates.

**Telmatoscopus albipunctatus** (Williston)*. (Plates XI and XII.)
*Psychoda albipunctata* Williston, S. W., Entomological News, IV, p. 113, 1893. Type ♂, Havana, Cuba.

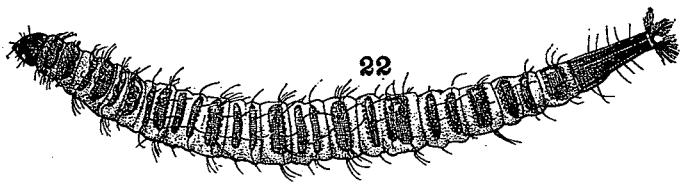
This little moth-fly seems dressed against the cold, for it has a thickish furry appearance even to the stout legs and hoary recurved antennae. Larger than its few relatives here and with more distinct markings, it is further distinguished from them by holding its wings in a horizontal or flat position (Fig. 24) instead of roof-like over the back as in figure 37.

Though a widely distributed tropical insect it is quite a new arrival in the Hawaiian Islands, the first record of its capture being by Mr. O. H. Swezey in Honolulu on May 14, 1929. Shortly thereafter it was recorded by others from Honolulu, and it now seems well distributed on Oahu, but has not yet been reported from the other islands. It breeds in sinks, drains, etc., in dark locations, and so may be found in lavatories; it is common in the lower Tantalus forest behind Honolulu, where it passes its early stages in very wet mud, or water in tree holes, in rain barrels, as well as in

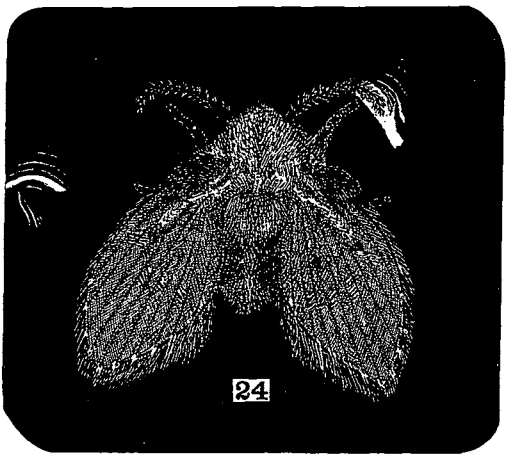
* * Determined by Dr. G. A. K. Marshall.

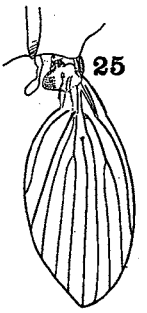
Explanation of Plate XI

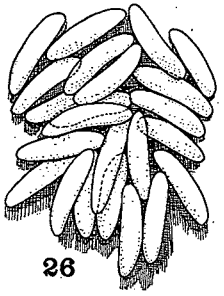
22. Full-grown larva, dorsal view. Length 11 mm.
23. Hatched egg showing finely ribbed pattern and characteristic emergence slit.
24. Adult fly, female in characteristic posture. Length of body about 3.25 mm.
25. Wing and haltere or reduced wing.
26. Batch of eggs. One egg is about 0.45 mm. long.
27. Pupa.
28. Posterior end of body of large larva; end view to show the suspensory hair fan which, resting upon the surface of the water, exposes the pair of spiracles to the air.

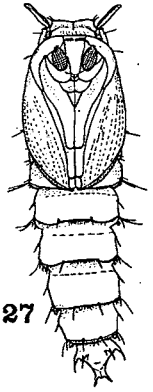


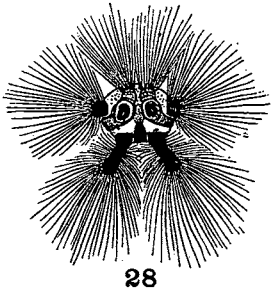





*Telmatoscopus albipunctatus*

shallow detached little pools that are partly filled with dead leaves and other debris. From this mountain locality at an elevation of about 1,000 ft. in the narrow little Hering Valley, a branch of the Makiki, nearly all my field notes and material were secured. The steep valley slopes, with their great kukui trees (*Aleurites moluccana* Willd.) with their spreading branches and large leaves combine to give the place the somber atmosphere that *Telmatoscopus* likes. Here, above the water line in a tree hollow we may sometimes find the dusky little fly resting or, if it has but issued from the pupa, perched high on its legs on the water or wet mud itself.

It is very easy to rear in the laboratory; a dish shallowly filled with water, a little mud and some old leaves, or the rind of a kukui tree fruit, with an occasional dead insect—the organic matter changed or added to from time to time — will suit its breeding requirements.

It is not a strong flier, but walks about in a brisk jerky manner and, when placed with moist decaying leaves, may apply the mouth down to the surface, as if feeding. When a female was placed in a shallow glass dish with a little water, upon which floated a wet old leaf, she busied herself with her maternal duties. She made short jerky walks, shivered or wagged the body, wings sometimes aflutter, and then, with the thorn-like ovipositor brought somewhat forward beneath her like a sting, she deposited eggs here and there for some minutes, gluing them for their length on the leaf. The insect is prolific, 167 large eggs having been dissected out of a single female. These eggs are at first whitish, about a half millimeter in length and may be slightly curved and are a little thicker at one end (Fig. 26). Later on, the shell toughens, assumes a brownish tinge, the fine longitudinal ridges show more distinctly and the whole egg seems thicker, the dark eyes and the mouth area become visible through the shell, and then the body, and in two days—more or less—the larva breaks through the shell at the somewhat thicker end. The egg-shell is ruptured in a characteristic manner (Fig. 23), i.e., down from the apex of the broader end and curving to one side before the middle length; the part in the curve rolling up. Perhaps the emerging larva is provided with an egg breaker, such as occurs in *Phlebotomus,* a genus of Psychodidae with blood-sucking habits but not found in the Hawaiian Islands. Patton and Evans (Insects, Ticks, Mites and Venomous Animals of Medical and Veterinary Importance, Part 1, p. 215, 1929) figure the egg and hatching larva of *Phlebotomus chinensis;* the egg is sculptured rather like that of *Telmatoscopus albipunctatus,* and is cut open in much the same form of curve.

The larva sheds its skin four times—including the final moult to form the pupa; in these successive stages the head and the chitinized plates increase in size, become darker, the hairs longer and

recurved, while through the second and third moults is acquired a rather thick covering of short to very short spine-like hairs, that, in the last larval stage, may give it a generally dusky appearance. On each side of and just below the second dorsal plate of the prothorax, in second stage larvae, and perhaps also in the first stage, there is a small convex button of chitin, slightly modified in the center, that represents the plate bearing the stigma or breathing pore; in third-stage larvae this area resembles a truncated cone with the central stigma now rather well indicated and apparently connected with a tracheal tube; in the fourth or last stage larvae it takes the form of a conspicuous, dark finger-like process that seems clearly functional.

The *Telmatoscopus* larva (Fig. 22) can hardly be said to swim, although it may lash about slowly and, being heavier than water—at least in its later stages—is not a habitant of open and deep debris-free water. It must have access to the surface else it will drown, although experiments showed that some of the larvae withstood an immersion in a smooth-sided glass of water of 24 hours. In nature, however, it is able to scale almost any surface, climbing with caterpillar-like movements, greatly aided by the stiff curved hairs. It may crawl well out of water. Locomotion is effected largely by downwards and rearwards movements (extended through the thorax) of the head, the underside of which is more or less in contact with a surface. If in shallow water, the travelling larva is in part suspended from the surface by means of the tail fan or "floating cup." Thus it is usual to see *Telmatoscopus* larvae hanging down by the tail fan in shallow water, the head scraping at debris on the bottom. Many larvae thus feeding close together give the surface of the water a rather pitted appearance, by reason of the little depressions or funnels formed by the pull of the tail fans, in the center of which the two breathing pores are situated (Fig. 28). *Telmatoscopus* may thrive also in muck, and large decayed leaves particularly, that rest just beneath the surface enable the larvae simultaneously to feed beneath and breathe at the surface. When disturbed they sink, or hurry down the sloping surface, caterpillar-like, or disappear around the other side of the leaf. Their movements are, of course, far slower than those of mosquito larvae, with which they are often associated. When they are entirely submerged the fan may remain fully expanded, or else closed to retain an air bubble, for the radiating hairs are attached to chitinized bases situated in a membranous area in connection with muscles.

They feed upon organic matter; old kukui leaves that so frequently fall into their poolets are readily attacked, the larva penetrating between the layers, somewhat as a leafminer would, or they get between two appressed leaves. More than once I have found

large larvae eating out portions of the common millipede (*Orthomorpha gracilis* Koch) that had fallen into the water and perished. Under crowded conditions in the laboratory *Telmatoscopus* has been known to devour a fresh pupa of its own kind, holding it in the crook of its curved body and applying its jaws to the tender tissues.

Small larvae have paler chitinous plates and short hairs. The mature larva has a dark, well marked head, a whitish blotch chiefly behind the eyes, strong several-toothed, rather down-curved mandibles bearing some peculiar hairs, very short antennae, and the hairs long, stiff and curved. The mouth parts are by no means simple; they are shown in pl. V, figs. 29, 32, 33 and 34, and are adapted for tearing or scraping. The alimentary canal terminates at the base of the fan-bearing tube and is closed by three flaps. Particularly conspicuous in large larvae is a white area visible through the skin beneath behind the middle length of the body and representing a portion of one or more of the four Malpighian tubules (a sort of urinary system). This white part of the tubules is shorter, thicker, rather wavy and nodular and well packed with a whitish substance, some of which, upon pressure, can be made to pass down through the semitransparent ducts and into the alimentary canal. In moulting, the larva comes out of its old skin somewhat as a larger creature might burst out of a tight-fitting sack. The old head-skeleton or skull splits longitudinally above and below, the splitting on the upper side not being straight along the middle line but somewhat oblique and irregular; the first 3 (in the youngest larval stage, the first 2, as observed in one specimen) dorsal plates split apart along the middle line, and the new-skinned individual works its way out of this comparatively short gape.

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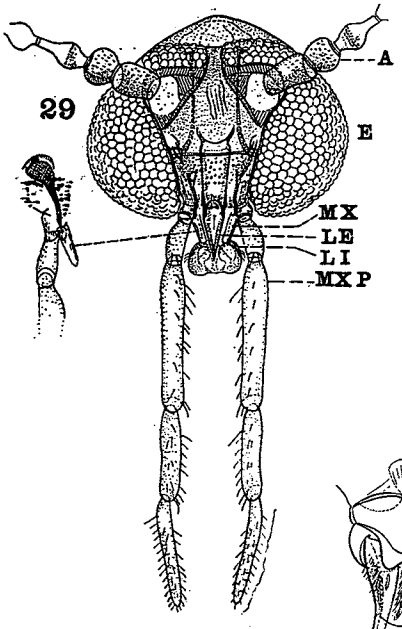
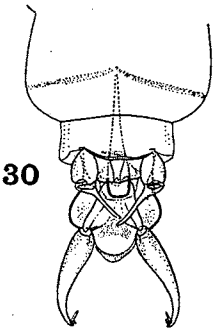
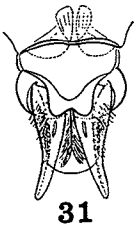
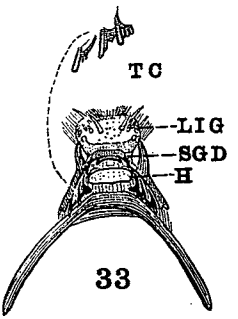
Explanation of Plate XII

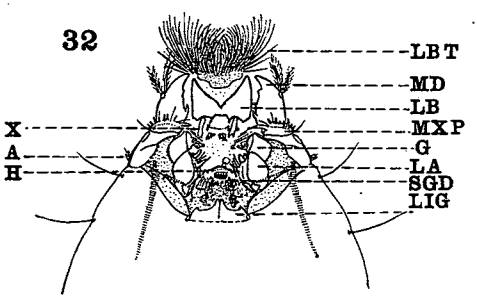
29. Head of adult fly, female, front view showing mouth parts and some internal structure. A, base of antenna denuded of hair; E, eye; MX, maxilla; MXP, maxillary palpus; LE, labrum-epipharynx; LI, paraglossa of labium.
30. Terminalia of male.
31. Ovipositor, with blades spread apart. Ventral view.
32. Fore part of head of large larva, from beneath, to show mouth parts: LBT, hair brush of labrum; MD, mandible; LB, labrum; MXP, maxillary palpus; G, galea of maxillary palpus; LA, lacinia of maxillary palpus; SGD, opening of salivary glands; LIG, submentum of labium; X, a hinged and dentate sclerite; A, antenna; H, hypopharynx.
33. Large larva; labium (in part) and hypopharynx: LIG, ligula; H, hypopharynx; TC, "trophicostae"; SGD, opening of salivary glands. The ligula is ventrad and, in its natural position, near the submentum.
34. Large larva; maxilla and mandible: LA, lacinia; G, galea; MXP, maxillary palpus; BM, base of mandible; MD, mandible showing peculiar hairs.

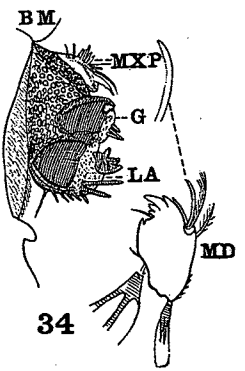



*Telmatoscopus albipunctatus*

Examination of a first-stage moult skin showed plate 3 entire and without a median line of weakness nor posterior notch, as is characteristic to the contrary, of plates 1 and 2 in this stage and in all 3 plates in subsequent stages. The fourth-stage moult discloses the pupa. Although thicker than the full-fed larva, the pupa is only about one-half its length, the larva being about 11 and the pupa 5 millimeters long.

The act of pupating was witnessed once in full: On October 21, 1932, at about 2:30 p.m. a large larva was observed floating in a dish of water, its tail fan at the surface; the rest of the body submerged. It had for the most part lost its activity, and was altogether somewhat shortened, though a little distended at the fore part of the thorax. Plates 4-7 were approximated, while the remaining 19 were pretty well separated, one from the other. The head and thorax were still capable of sluggish movement, and for some minutes a slight twitching of the tail indicated that the forming pupa was not yet wholly detached from the larval skin. It was observed that the prothoracic spiracles were air silvered. At 3:15 p.m. the larva was still capable of a little motion. At 3:45 p.m. plates 3, 2 and 1 successively, and then the head, split longitudinally, as the fore part of the pupa by segmental movements of the abdomen commenced to work out of the larval skin. In the meanwhile, the two pupal respiratory trumpets held against the sides by the tight-fitting larval skin, were, by the slipping back of the latter, suddenly released so that they flipped up into an earlike position. Thus, breathing has been transferred from the tail end of the body in the larva, to a region in the prothorax at the fore end, in the pupa (Fig. 27). The pupa is still soft and delicate, rather long in the body and, except for the eye spot, spines, breathing tubes and some hairs, quite pale. A silvery air tract leading from each respiratory trumpet into the body is visible. Eventually, the pupa hardens and becomes a dusky brownish. It rests in the water in a vertical or nearly vertical position, the respiratory trumpets just breaking the surface film. Capable of some activity, it moves with a slow and ponderous dignity, by a gentle sculling or squirming of the abdomen. Eight pupae placed in 2½ inches of water in a vial were pushed and tapped so that five of them sank stiffly to the bottom, the remaining three being too buoyant to descend from the surface. The five pupae ascended as follows:

Submerged at 1:09 p.m.

No. 1. 1:10 p.m. rose vertically to surface by a dorso-ventral sculling movement of the abdomen.

No. 2. 1:15 p.m. pushed itself off the bottom and with gentle abdominal undulations rose to the surface.

No. 3. 1:15 p.m. started as in No. 2, with a vigorous push of the tail and gained the surface.

No. 4. 1:17 p.m. lay prone on bottom of vial; after a few ineffectual sculls it stood on its tail, and at 1:25 p.m. sculled rather slowly to top.

No. 5. 1:20 p.m. prone on bottom—travelled and rested there; at 1:36 p.m. struggled again and at 1:46 standing on its tail, and at about 1:50 p.m. sculled slowly up to the surface.

These five pupae rested obliquely, or vertically at the surface, the respiratory trumpets showing a narrow oblong of silvery air and just piercing the surface film of water.

When the pupa is ready to disclose the adult moth-fly, the segments of the abdomen become distended so that considerable pale membrane appears between the dark plates. The two longitudinal tracheae are also seen in these pale areas and the wings show golden through their imprisoning sheath. One such pupa I carefully moved so that it lay with its back to the surface. For a while it was very quiet, but soon there was a little squirming of the abdomen, the thorax split apart in the middle line as far as the transverse ridge at the breathing trumpets, and the fly crawled out through this yielding cleft. Its body, legs and antennae were already fully formed but the wings were short, dark and wettish-looking and each somewhat arched down over the body; very soon, however, these stubby organs were elevated, they swelled and straightened out close together in a vertical plane over the back where they attained their full length; then, in a few seconds, the wings were brought down to the normal, horizontal resting position. The whole emergence process occupied perhaps a couple of minutes and the insect was ready to fly in at least as many minutes more.

Laboratory-reared *Telmatoscopus* showed the duration of the stages as follows:

Sept. 30. 7:50 a.m. Several freshly issued flies placed in dish with wet decaying *Aleurites* leaves.

Oct. 1. 9:05 a.m. Some eggs laid.

Oct. 2. 9:05 a.m. Several eggs hatched.

Oct. 3. p.m. A number of eggs have hatched.

Oct. 14. Before 2:30 p.m. 2 larvae pupated.

Oct. 15. 7:00 a.m. 1 larva pupated.

Oct. 16-17. 2 larvae pupated.

Oct. 17. Afternoon. 1 adult fly issued.

Oct. 18. Early a.m.? 2 adult flies issued.

Oct. 19. a.m. 1 adult fly issued.

Hence, 17 days was the minimum time of development; but as this particular fly was undersized (as were most of the others), better living conditions would probably have insured larger individuals and a more rapid development. A number of flies were reared from eggs laid by the flies of Sept. 30-Oct. 1, and the last of these issued on December 5, a period, from egg to adult, of approximately 66 days. On December 10 an old sick larva still lingered from this brood.

The larval and pupal stages of this insect are also figured by Johannsen. In Egypt, H. C. Efflatoun has studied this species under the name of *Telmatoscopus meridionalis* Eaton (Soc. Ent. Egypte. Bull. 1920: 22-34, 1914).

**Psychoda alternata** Say. (Text figure 5).

Say, T., Long's Expedition St. Peter's River, App. (1824) 358.

This widely distributed insect was first reported here by Grimshaw in 1892 from Kona, Island of Hawaii. It has until recently been regarded as our common pale brown species with some dark spots along the wing margin, but which, however, Tonnoir considered another species. *Ps. alternata* is definitely known from Hono-

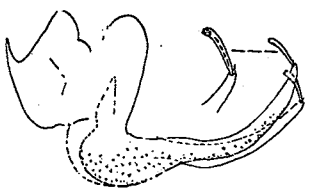


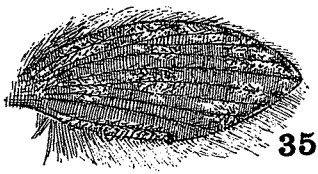
Fig. 5. *Psychoda alternata,* portion of male terminalia, divested of hair. Molokai. From a specimen determined by A. Tonnoir.

lulu and from the Island of Molokai and is probably well distributed over the Archipelago. It is abundant on the mainland of the United States and occurs in Europe. It is often a domiciliary spe-

MOTH-FLIES

Explanation of Plate XIII

35. *Psychoda* sp., wing of a domiciliary species.
36. *Psychoda* sp., wing divested of hair to show venation.
37. *Psychoda* sp. 1. Honolulu.
38. *Psychoda* sp., pupa, total length 3.75 mm. (abdomen distended).
39. *Psychoda alternata* or *pseudalternata,* larva near pupation. One breathing horn of the pupa shows through the larval skin as an oblique rod forward on the side of the thorax.
40. *Psychoda* sp. 1, eggs. Length 0.22 mm.
41. *Psychoda* sp. 1, pupa. Length 1.90 mm.
42. *Psychoda* sp. 1, larva. Last stage. Length 3.7 mm.



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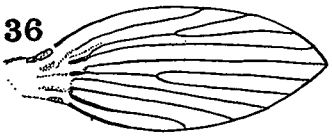

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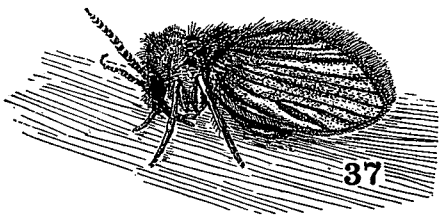

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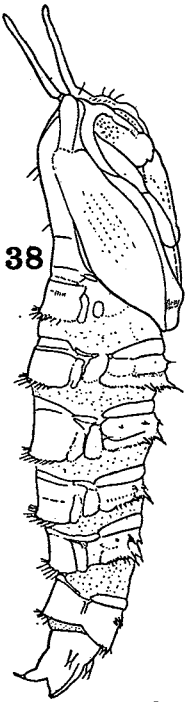

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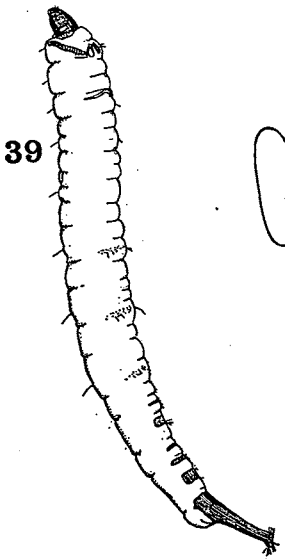

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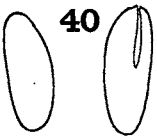

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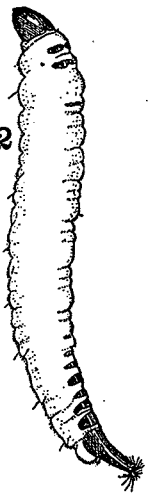

42

cies, breeding in sewage, etc. The larva and pupa are described by Johannsen (Cornell Univ. Agric. Exp. Sta., Mem. 164, 1934).

The characters which separate this species from the next appear quite slight.

**Psychoda pseudalternata** Tonnoir (unpublished). (Figures 35, 36 and 39 and text figure 6.)

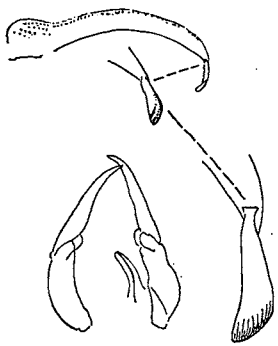

Fig. 6. *Psychoda pseudalternata* (Tonnoir MSS), terminalia, divested of hair.

This may also be a domiciliary species. At large, it has been found breeding in algal scum. Figure 39 illustrates a larva near pupation, one of the pair of breathing tubes of the forming pupa being visible anteriorly on the dorsum of the thorax.

**Psychoda** sp. 1. (Figures 37, 40, 41, 42 and text figure 7.)

This is a common and adaptable species that lives in the city, the field or the forest. The larva has several anterior and posterior dorsal plates. The pupa has the breathing horns considerably shorter than in the two foregoing species. The slaty gray adult is rather dark when fresh, but dried specimens soon fade. It is a brisk little fly that walks about in a jerky manner, antennae held upwards. Breeding in a variety of situations, this common species occurs indoors about wash-bowl drains, or outdoors often far from the haunts of man. In 1939-1940 it was found breeding conveniently in the marginal and submarginal scum of green algae in an iron drum tank that was filled nearly to the brim with gently circulating water. This was one of several such tanks in the grounds of the Experiment Station, H.S.P.A., that were used in experiments in sugar cane growth. Sharing this water with *Psychoda* were numerous copepod crustacea, the ephydrid fly *Scatella bryani* and the green midge, *Tanytarsus*. In our garden far up Manoa Valley we thinned out rows of hardy, quick-growing paper-bark

trees (*Melaleuca leucadendron*). From the cut stump of one of these trees oozed a quantity of sap upon which soon developed what seemed to be a felt-like green-brown alga in which were found early stages of the spotted-wing crane-fly (*Limonia perkinsi*) as well as of this *Psychoda*. Some of the latter were reared. During March 1937, more data were secured on this fly on the lower slopes of Palikea, Waianae Mts., Oahu. Here a slightly

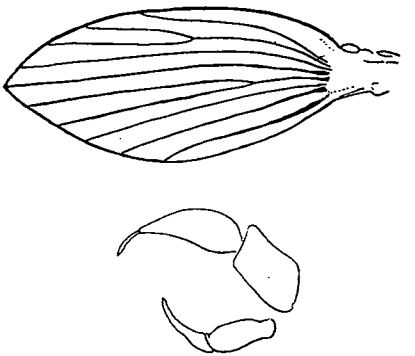

Fig. 7. *Psychoda* sp. 1, wing and aedeagus (from side), divested of hair.

overflowing water tank had produced a fine glistening sheet of green algal scum in which flourished the early stages of both the ephydrid fly, *Scatella hawaiiensis* Grimshaw and *Psychoda* sp. 1. Both species were reared. In the low forests of the Mt. Olympus ridge behind Honolulu, this *Psychoda* breeds at the leaf bases as well as in the decaying fruits of the climbing screw pine or ieie vine (*Freycinetia arborea*). This moth-fly lays a delicate and smooth whitish egg 0.22 mm. long. The mature larva has about 3 chitinized plates on the anterior dorsal portion and about 7 on the posterior end. The pupa has short, slightly curved breathing horns that are slightly swollen near their dusky base.

**Psychoda** sp. 2. (Text figure 8.)

This plain pale species differs from *Psychoda* sp. 1 in its somewhat broader wing and in the form of the aedeagus, as well as in the larva and pupa. Preserved material shows the larva to be rather broad and depressed. The dorsal plates are present from one end of the body to the other. The anal tube is well developed. The stocky pupa has the breathing horns relatively more elongate and slender than in sp. 1 and with a dark area near their middle length. Larvae were up to about 2.5 mm. long and the pupae slightly less. In the Experiment Station, H.S.P.A., collection are specimens of this unidentified species labelled as follows: Hono-

lulu, 1907, ex aquatic algae; Palolo Valley, Honolulu, ex banana (O. H. Swezey); Makiki Valley, Honolulu, July 16, ex rotten coffee (O. H. Swezey), and Honolulu, July 15, 1935, reared ex decayed *Passiflora* fruit (O. H. Swezey).

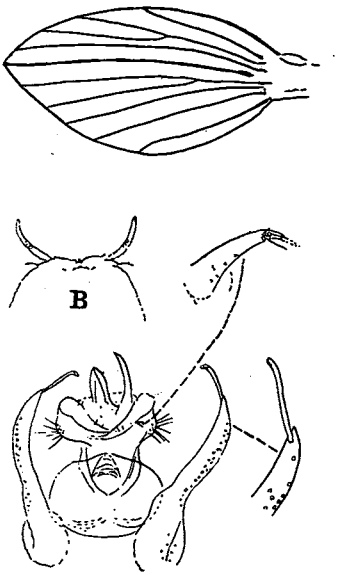


Fig. 8. *Psychoda* sp. 2, unspotted gray species reared from decaying fruit of *Passiflora,* wing and terminalia divested of hair; at B, portion of head of pupa to show breathing horns.

This species may well be Grimshaw's *Psychoda inornata,* although his description (Fauna Hawaiiensis, Diptera, p. 6, pl. 1, fig. 11, 1901: Kona, Hawaii, 1892) is far too brief for any degree of assurance. The present insect seems to be an old established species whereas the preceding and duskier species appears to have more recently come to notice.

Mrs. O. H. Swezey (Proc. Haw. Ent. Soc., I, 116-118, 1907) gives an account of what is apparently this *Psychoda* sp. 2. It was found breeding in a jar in which caterpillars had been reared and in cow manure. The adults proved a great annoyance, swarming at light as well as getting into food.

(To be continued)