

**Biological Studies in Hawaiian Water-Loving Insects****PART III****Diptera or Flies****A, EPHYDRIDAE AND ANTHOMYIIDAE**

BY FRANCIS X. WILLIAMS  
Experiment Station, H.S.P.A.

(Presented at the meeting of December 3, 1937)

Biological studies in Hawaiian water-loving Diptera were begun late in 1929 and have continued—with many interruptions—up to the present time. None of these studies is in any way complete, so that future investigators in this subject will find much work both in the laboratory and in the field awaiting them. Most of my observations were made on the Island of Oahu, with Hawaii the largest Island of the group and the last to appear above the waves, ranking next in number of field studies.

The subject is replete with interest and not without its practical value. From its study we gain a better knowledge of denizens of the seashore, of lowland streams, ponds and marshes, of mountain waters and water-holding plants, and we must ascend even to heights of many thousands of feet above the level of the sea, in regions of subarctic climate in order to add to our knowledge of the few water-loving Diptera that appear at these elevations. The early stages of some of our flies may be passed in sewage, a few may affect our water supply, others are a nuisance at our lights and the mosquito is never welcome. Some may be beneficial and in some regions the larvae of certain midges are of value as fish food.

To definitely separate those water-loving flies that are sub-aquatic in one or more stages, from those that are terrestrial, rests in many cases with the worker's definition of these two terms as well as with the vagaries of certain of the flies themselves.

The writer has derived much assistance from the works of other entomologists. Among these are: Bryan, E. H., Jr., A Review of the Hawaiian Diptera, with Description of New Species, Proc. Hawaiian Entom. Soc. VIII, pp. 399-468, 1934; Johannsen, O. A., Aquatic Diptera, Part I, Nematocera, exclusive of Chironomidae and Ceratopogonidae. Cornell University Agric. Exp. Sta., Mem. 164, 1-71, pls. I-XXIV, 1934; Part II, Orthorrhapha-Brachycera and Cyclorrhapha, *ibid*, Mem. 177, 1-62, pls. I-XII, 1935; Part III, Chironomidae, Subfamilies Tanypodinae, Diamesinae, and Orthoclaadiinae, *ibid*. Mem. 205, 1-84, pls. I-XVIII, 1937; Karny, H. H., Biologie de Wasserinsekten, I-XV

& 1-311, 160 textfigs, Wien, 1934; and Séguéy, E., Diptères Anthomyides, Faune de France, 6, XI & 393, 813 figs., 1923; Dipteres (Brachyceres), Faune de France, 28, 832 pp., 27 pls. and 903 figs., Paris, 1934. Thanks are due to Mr. E. T. Cresson, Jr. of the Academy of Natural Sciences of Philadelphia for naming some of the ephydrid flies, and to Mr. E. H. Bryan, Jr., for similar work in other Diptera.

#### FAMILY EPHYDRIDAE (INCLUDING THE CANACINAE)

Seventeen species of this family are now recorded from the Hawaiian Islands. Over half of these appear to be endemic. Several are peculiar to the seashore. At least two are leaf-miners in the larval stage. Our most aquatic species is probably *Brachydeutera hebes* Cress. The largest genus is *Scatella* with six described species.

The Ephydridae are a large though rather heterogenous assemblage of flies that exhibit great diversity in habits. Thus, the genus *Ochthera* and its immediate allies with greatly developed forelegs are evidently predacious. Many ephydrids feed by lapping wet surfaces, while their larvae consume decaying plant tissues, etc. A number of species mine the leaves and stems of aquatic or semi-aquatic plants, the adult fly in one case at least, scraping off the living tissues of the larval food-plant. The larva of the "petroleum fly", *Psilopa petrolei* Coq., is found in pools of crude petroleum in California, breathing by means of its posterior spiracles thrust above the surface of the oil. Its food seems to be chiefly foreign organic matter found in this medium (Crawford, D. L., Pomona Journ. Sci., IV, pp. 687-697, fig. 222, 1912; Thorpe, W. H., Trans. Entom. Soc. Lond., LXXVIII, pp. 331-343, 4 figs, & pls XXVIII & XXIX, 1930). The larva of the common European *Teichomyza fusca* Macq. frequents out-of-door urinals and excrement. It is noted for its highly developed thoracic respiratory organs (Vogler, C. H., Illus. Ztschr., Ent. 5: 1-4, 17-20, 33-36, 1900). Species of the genus *Ephydra* breed—often in immense numbers—in saline and alkaline waters and are able to adapt themselves to great fluctuations in the density of these waters. *Ephydra hians* Say frequently enters the water enveloped in a globule of air to lay its eggs. The larva of this and of some other species develop at some depth under water, not coming to the surface for air, the long posterior process and its filaments evidently functioning as tracheal gills (Aldrich, J. M. The Biology of Some Western Species of the Genus *Ephydra*. Journ. N. Y. Entom. Soc., pp. 77-98, 3 pls, 1912). A few Ephydridae are known to breed in hot springs. (For *Ephydra*, see Brues, C. T. Proc. American Acad. Arts and Sciences, 59, 1924, 63, 1928 and 67, 1932, and for *Scatella*, see Matsumura, S., Konch. Sek. Gifu, 19, 223-225, 1915, = *Scatella calida* Mats. (I have not seen this paper. F.X.W.), and Tuxen, S. L., Opuscula Entomologica, I, pp. 105-111, 1936, = *S. stagnalis* (Fall.) and *S. thermarum* Collin, the

latter regarded by Tuxen as a form of *stagnalis*). The widespread *Scatella stagnalis* (Fallen) occurs in such extremes of climate as Greenland and Alaska as well as in some of the tropical islands of the Pacific.

With reference to the Ephydriidae found in the Hawaiian Islands, no study was made of the biology of the following species: *Discomyza maculipennis* Cresson, a pantropic insect which has been bred from improperly cleaned and dead sea shells (Bryan, E. H. Jr., Proc. Haw'n. Entom. Soc., VI, 236, 1926); *Atissa antennalis* Aldrich, *Hecamede albicans* (Meig.) and *Hecamede persimilis* Hend., occurring at the seashore; *Paralimna insularis* (Grimm.), *Lytogaster aldrichi?* Cresson, and one or two others. The investigations in all cases leave much to be desired and this refers particularly to the interesting genus *Scatella*.

### **Hydrellia williamsi** Cresson. (Plate I)

Cresson, E. T. Jr., Trans. Am. Entom. Soc., LXII, pp. 259-261, 1936.

The writer remembers years ago in a public garden of a tropical South American city how a little child bent on exploration, wandered from the family group and, stepping forth boldly towards what appeared to be a smooth level piece of sward, soon found himself floundering in a pond coated over to invisibility with a myriad little duckweed plants.

More successful in its explorations of such a growth of duckweed or *Lemna*, is the tiny *Hydrellia williamsi* fly, a millimeter and a half long, with a silvery white face, a generally shining black body and the legs in large part yellowish brown (Pl. I, 1). Well raised on legs drawn close to the body, it moves over this relatively vast floating field of close-set and overlapping bright green lobes, with seeming care or hesitancy, now stopping for a moment, following one of its fellows a short distance or advancing in a sideways manner. It can wheel about quickly, and at one's too near approach will make a very short flight.

The delicately ribbed whitish eggs of *Hydrellia* (Pl. I, 3) are somewhat less than half a millimeter long. In hatching, the tiny larva cuts a gash-like opening at the broader end of the egg and by means of a pair of very finely toothed mouth-hooks (Pl. I, 4, D) soon works its way into a *Lemna* leaf. At first its body is nearly transparent but under sufficient magnification we can easily see these darkly chitinized mouth-hooks hinged to the fore end of a dusky head skeleton, scraping down the chlorophyll or green matter upon which it feeds, and leaving a trail or mine with semi-transparent walls as it progresses. As it increases in size and voracity its mines become broader and more irregular, with here and there matter voided from the intestine. It passes from one leaf to the other and then to an adjoining plant, but does not consume the entire leaf content. A larva that was followed in its

development of about 9 or 10 days worked through 15 large and several small leaves. Two exuviae or moult-skins were found in the mines. The third exuviae of course, consists of the puparium after the pupa is formed within it. Bands of exceedingly fine setulae girdle the fore part of the larva; posteriorly the bands may thin out or disappear on the sides, but are accentuated as rows of setulae on the pseudopods and on the last segment. The last segment bears two processes each terminating in a dark, sharply conical hollow spine into the base of which passes a longitudinal tracheal tube (Pl. I, 5). One sometimes may see the larva perforating or pushing apart the leaf walls with these sharply pointed cones, establishing thereby an air connection with its caudal spiracles. The puparium (Pl. I, 2 and 6) though somewhat flattened may cause quite a bulge in the floating leaf in which it rests venter upwards. The pupa shows rather darkly within its air-gilded container. The head end of the puparium may protrude very slightly from the edge of the leaf in which it lies, or the walls of this more or less disintegrating leaf are somewhat agape. Thus the emerging *Hydrellia* fly, pushing off the lid of the puparium by means of a temporarily swelled forehead, readily crawls out and onto the leaf and there completes its development. Its tongue extended downwards, wings pad-like, thickish and wrinkled, the fly assiduously brushes itself with fore and hind legs; the hairs stuck flat on the abdomen soon assume a semi-erect position, the tongue is folded back and the wings attain their full size though remaining pallid for some time. About 18 or 19 days were required for the entire life-cycle, in the single case observed.

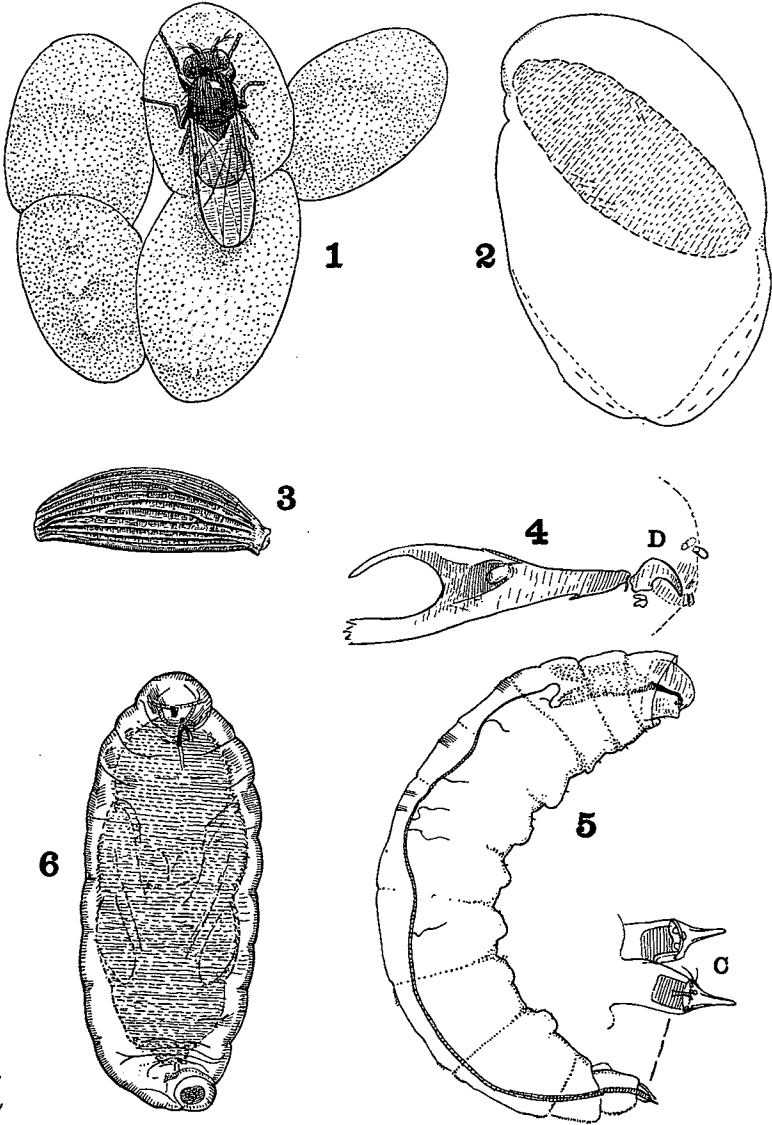
A probable parasite of this tiny fly is *Habrolepis* sp. (Encyrtidae), a chalcidid wasp with prettily spotted wings that appeared in a jar of *Lemna* in which *Hydrellia* was breeding.

This fly has much the same habits as *Lemnaphila scotlandae* Cress., another tiny ephydrid the life-history of which has been studied by its discoverer (Scotland, Minnie B., *The Animals of the Lemna Association : Ecology*, XV, pp. 290-294, 2 figs., 1934). To quote this author regarding the feeding habits of the adult *Lemnaphila*: "As soon as it has spread its wings it begins to eat out characteristic parallel channels in the upper surface of the thallus. This is accomplished by several rows of teeth that can be extended or re-

#### HYDRELLIA WILLIAMSI.

##### Explanation of Plate I.

1. Adult fly on a *Lemna* plant.
2. *Lemna* leaf showing in outline a puparium within.
3. Egg, from the side.
4. Cephalo-pharyngeal skeleton, palps and antenna of larva.
5. Larva, from the side; at C, caudal processes more enlarged. Probably in last instar.
6. Puparium showing pupa within, ventral view. Length 1.8 mm.



tracted within the labellum." This is in keeping with the lapping or scraping method of feeding employed by the Ephydriidae in general.

*Hydrellia williamsi* was first taken on Lemna-covered water at Kanoa, Molokai, on June 1, 1931 (2 specimens). Series of adults as well as life-history notes were obtained from Waianae village and Kukuiala valley, Waianae Mts., Oahu, early in 1936.

A second and larger species, *Hydrellia hawaiiensis* Cresson (Trans. Am. Entom. Soc., LXII, pp. 263-264, 1936) is found on the algal mats largely composed of *Enteromorpha* sp. in a reservoir and cement ditch of Waianae Company sugar plantation. This fly can walk freely upon water. Nothing was learned of its immature stages aside from a few eggs obtained from captive specimens. The egg much like that of *H. williamsi* is yellowish white and ribbed, but is somewhat larger, measuring about 0.53 mm. (Pl. VI, 44 and 45). The wing is shown in fig. 43.

### **Brachydeutera hebes** Cresson. (Plates II and III)

Cresson, E. T. Jr., Proc. Haw'n Entom. Soc., VI, p. 277, 1926.

From shallow, often brackish puddles by the sea to mountain bogs a mile or more above them; in the rain barrel, the water-filled tree hollow, the tiny canyon pool; on such diverse quiet waters as these the stout-bodied, silvery-and-brown *Brachydeutera* fly may be found. In the open sunshine this insect, a trifle smaller than the common house-fly, is readily seen, in the forest's shadows the shining overlapping wings help mark it on the surface of the dark waters.

This adaptable fly is particularly abundant in the lowlands. Here are puddles; shallow, fishless and set in coral basins, sheltered to some extent by the thin foliage of the algaroba tree (*Prosopis juliflora* [Sw.], Leguminosae), so that the bottoms of these puddles are carpeted with leaflets in various stages of decay. In such places *Brachydeutera* often breeds in numbers, sharing its abode with the larva of the night mosquito (*Culex quinquefasciatus* Say), with the bloodworm—larva of the midge (*Chironomus hawaiiensis* Grimshaw)—with minute crustaceans, *Tubifex* worms and other small organisms. On opaque muddy pools near Ewa, Oahu, swarms of hundreds of these ephydrid flies have been seen seeking the scant shadows of half-submerged branches and, if not clinging to some object, hopping forward occasionally when a gust of air threatened to push back their ranks. We have seen adult *Brachydeutera* strung out in more hundreds on scummy water and along wet banks on the shaded side of a ditch impregnated with filter-press mud foul enough to provide a breeding place for the shrill-humming, bee-like drone-fly, *Lathryophthalmus arvorum* (Fabr.). A shaded puddle at the base of a compost heap, the drip from a leaky pipe line, a quart or two of rain water

accumulated in an old, partly sheltered wash-boiler, will often suffice for *Brachydeutera* to go through its rapid metamorphosis. On windward Oahu the adult has been found on standing irrigation water in a low cane field. In the woods and mountains we may find it in detached little pools layered with decaying leaves, and perhaps containing fruits of the guava (*Psidium guajava* L.) and of the candlenut or kukui (*Aleurites moluccana* [L.]), as well as in the kukui tree water-filled hollow, where breed also the commoner day mosquito (*Aedes albopictus* (Skuse)), moth-flies and one or two other Diptera. It persists at higher elevations, and here the fly has been known to reproduce in a gallon kitchen pot half full of water—as the writer observed in a yard on the slopes of Mauna Kea, Hawaii—at an elevation of about a mile. Going higher still, there is a record (August, 1929) of finding several of these flies perched on water in a rain barrel at an elevation of about 6300 feet, on the slopes of Hualalai, Hawaii. At least once (October 5, 1931) the adult fly has been taken riding the waters of Lake Waiau, at an elevation of 13,007 feet above sea-level on the bleak heights of Mauna Kea, our loftiest mountain (13,784 feet). But despite the great adaptability of the fly to various situations, it may be absent from pools apparently well suited to it and where its smaller, less aquatic, and often sun-loving relative, *Scatella*, thrives. Or we may find it plentiful at one time and absent at another.

As *Brachydeutera* rests upon the water (Pl. II, 7), the tarsi or feet of usually all three pairs of legs impress the surface film, but the burden falls chiefly upon the outspread middle pair, since these legs may serve as a fulcrum while the insect lifts and cleans its fore and hind paws or brushes its body; the latter, by the way, is held quite clear of the water. The tarsi are provided on their underside with fine hairs the free ends of which are so bent as to lie more or less for their length upon the surface of the water and thus must form a large buoying-up area (Pl. II, 9). Such hairs bent at their tip were found poorly developed in *Scatella*, an ephydrid less adept than *Brachydeutera* upon the surface of the water. They were noted upon the tarsi of the water-skating dolichopodid *Campsicnemus miritibialis* V.D., but particularly upon *Hydrophorus*. These modified hairs are not present on the tarsi of *Musca domestica*, the common house-fly.

When the water is still, so usually too *Brachydeutera* makes little movement, at least when in small numbers. If disturbed it takes a short, rather elevated flight to a safer place on the water, or alights on the water's edge. At leisure, it may walk on the surface or progress by a very short winged dash. It is not a strong flier.

The fly is easily kept in captivity and, properly cared for, may live for several weeks. It will often remain for a day or more in a

moderately deep uncovered dish partly filled with water and placed by the window. It seems almost forever to be lapping the surface of the water with rapid strokes of its large tongue-like organ or labella which terminates the proboscis (Pl. II, 12). By moving this bilobed labella, its free surface skims the water, gathering by means of incomplete, basally-converging tubes (food channels) or pseudotracheae thereon, materials fine enough to pass through them and thence into the gullet. The large oral cavity houses the proboscis, which folds in and against it and is not then, the place into and through which food passes, the labella being the intake, as we have just seen.

Field-caught *Brachydeutera* may oviposit readily, even when confined in a very small receptacle with water or moist materials. In April 1933, a few eggs were found on dead and partly submerged *kukui* (*Aleurites*) leaves in pools near Honolulu. The eggs (Pl. II, 8) are rather stout, firm-shelled and float well, the blunt, non-micropylar end to the surface. They measure about 0.8 mm. and are mottled brownish. The surface is very finely roughened by what appear to be reticulations which on part of the straighter side are arranged somewhat longitudinally bead-like. The blunted portion towards this side is a thick-margined, pale-dotted subtruncation (Pl. II, 8, upper end; 11). The micropylar end is well rounded, the little button-like micropyle lying in a small shallow depression in the operculum that is marked off externally by an incised line (Pl. II, 10, m; 11, o). The operculum is lifted off through pressure exerted by the larva at the time of hatching. Eggs dissected out of the bodies of several flies numbered from one to more than thirty per fly. In one fly that contained many eggs the majority were soft, pallid and undersized, but about 8 were brownish, firmer and probably fully mature—in fact, one egg enclosed a well developed fly maggot. Well-matured eggs within the uterus have the cap already fully defined. They are extruded from the body, truncated end foremost.

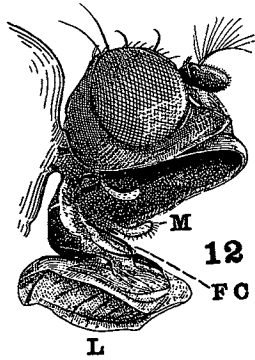
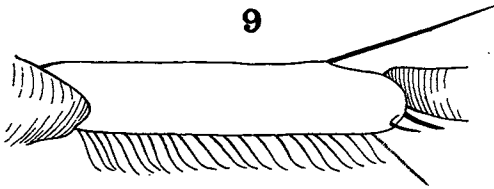
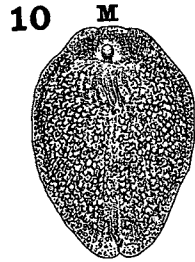
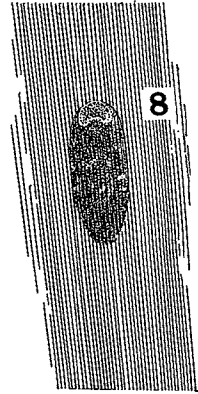
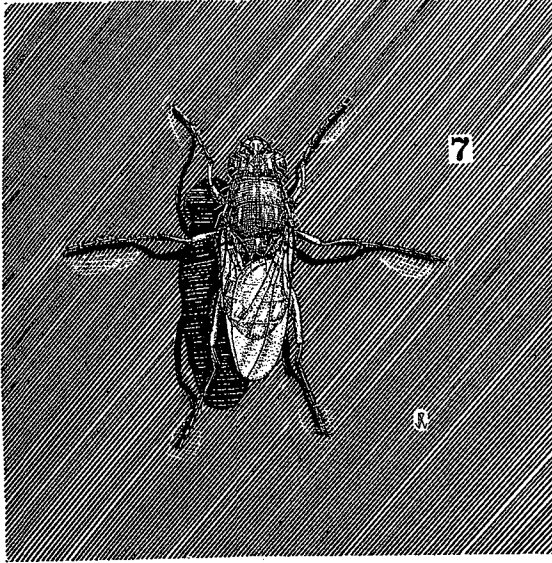
The egg hatches in a day or two, the tail end of the larva sometimes remaining within the shell for a short time. At first the larva is of stubby form and, except for a little of the fore part, has

#### BRACHYDEUTERA HEBES

##### Explanation of Plate II

7. Adult fly on surface of water. Length to extremity of wings 5-6 mm.
8. Egg floating in water.
9. Hind tarsus, third article, from the side to show hairs in profile so bent that their extremity rests lengthwise upon the surface film of water.
10. Operculum of egg showing micropyle M.
11. Egg in outline to show operculum O (fig. 10) that is being pushed up to liberate the larva.
12. Head of adult, side view; FC, food channel; L, labella; M, maxillary palpus.





⊠

a covering of dark hairs, the shorter of these being the more numerous. This vestiture gives it a rather unkempt appearance. Two longitudinal air tubes are visible in the body. These terminate in spiracles mounted on short tubes at the tail end now thrust up through the surface film thereby suspending the larva in the water and permitting it to breathe. At the fore end, the mouth parts are to be seen in motion. Now, the larva brings the head to the surface and swallows a quantity of air visible through the transparent skin as silvery bubbles that accumulate in the alimentary canal and render the insect more buoyant. Sometimes the swallowing of air takes place before the larva is entirely free from the egg shell. In a short while it increases to several times the size of the egg, and, assuming more graceful proportions, is now able to swim with its peculiar precise vertical S-like movement. The head (Pl. III, 15) is small, rather poorly defined, and capable of being withdrawn far into the thorax. It is provided with two simple papilla-like antennae, G, with which it feels about, for it is already a restless and hungry creature that feeds almost incessantly. What might serve as the upper lip bears a sort of mustache, behind which is a dark-colored brush-like apparatus (Pl. III, 14 and 15, (7)); for the lower lip are several rows of short spines with swollen bases (15,(8)). A disc F, seems to represent the maxillary palpi.

Captive specimens nibbled, pecked and particularly scraped the different areas of a dead leaf; they also ate green tissues, tugging with very indifferent success at lateral buds of filamentous algae. A pair of strongly toothed shell-like discs, part of the mandibular sclerites form effective scrapers (13 and 14 (6)). The stomach contents of several large field-caught specimens were examined and, as far as could be determined, consisted mainly of old broken-up plant tissues. In one case there was a nematode worm, and in at least two cases, a clear, crystal-like material. They will swallow the remains of minute ostracod Crustacea. All observations point to a preponderately scavenger habit. The larva (Pl. III, 16) homely and frowsy, feeds most conveniently in water shallow enough to keep its posterior breathing tubes (Pl. III, 16, P. S, and 19) to the surface while it rummaging about, head under water. Where necessity arises however, it comes up from the depths of a couple of inches or so to take air and then briskly descends below. It swims with far less speed than a mosquito larva, and with vigorous movements that seem quite out of proportion to its rather mild progress. These movements are in a vertical plane, the fore part dives down while the tail end makes a backward stroke, the curved posture suggesting somewhat an S. It can also creep about with caterpillar-like undulations of the body, or it may haul itself along the bottom, using the head part only in its progress. In the larger larvae the transverse folds are

better developed on the underside and these, to some extent, serve as pseudopods or false feet. Not always does it live in open water, however, but may lead quite a secretive existence in the thick growth of filamentous green algae in some pool befouled by the leaves and fruits of guava.

A well-fed *Brachydeutera* larva may attain full growth within ten days; poorly fed and unfavorably placed however, it may develop very slowly and indeed not reach maturity at all. There are three instars. When full grown it is still of rather frowzy appearance chiefly because of the short unkempt dark hairs that clothe it none too thickly. Well forward on the thorax and at the posterior end of the body, these hairs are short and thorn-like. It is now about 10 or more millimeters long, according to the degree of extension. The wrinkled tail end when well extruded calls to mind somewhat the proboscis of an elephant, and the short horns bearing the spiracles are in part hair-fringed at their tips (Pl. III, 19), though not to the extent that we find in many aquatic larvae of more primitive flies. Although the anterior spiracular processes (Pl. III, 20 and 21) are well developed in last instar larvae, never do they seem to be in the least extruded from the invagination pocket in which they lie.

The next stage of development, the puparium, when the skin of the larva hardens, the anterior spiracular processes or respiratory siphons are thrust out, and the pupa is formed, is of great interest. It seems that the larva may wander about a bit, creeping caterpillar-like until it finds a place suitable to transform, for I do not think the transformation occurs commonly in the open water, but along its margin or even above it—at any rate the larva soon becomes sluggish, contracts somewhat, and the tail end particularly becomes upcurved. The fore end can bend and squirm after the posterior portion has stiffened, and the head and mouth-parts are still extrusile. On either side of the larval head skeleton within segment 2 of the thorax may be seen a dark rod-like piece<sup>1</sup> that plainly connects behind with a silvered longitudinal air tube. These rods together capable of somewhat pincer-like movement, even when within the thorax, represent the heavily chitinized tips of the respiratory siphons (Pl. III, 20) that are soon to be thrust out. There are still some segmental movements of the thorax. Suddenly, though smoothly, first one then the other siphon is extruded earlike on either side of the glassy, somewhat bilobed head portion. In one case the extrusion of a siphon occupied about 3 seconds. This extrusion seems plainly the result of pressure effected through contraction of the larval skin. These dark-tipped siphons can now be wriggled considerably. At first

<sup>1</sup> In large still active larvae these ensheathed rods are somewhat clublike and studded with pale topped bosses that in the puparium seem to be perforations (Pl. III, 20, S.D.).

they extend parallel pretty well forward but in the end assume the right and left position (Pl. III, 17 and 18) and become rigidly fixed. The puparium becomes, at last, entirely rigid. The dorsum of the thorax is now flattened or even a little concave, and widened as a suboval disc with thickened margins. The body in general retains its furry aspect and is transversely wrinkled (Pl. III, 18). It may be quite buoyant, floating high, back up, or upon its side, being quickly attracted to the sides of a receptacle or nearby object, so that a lot of these puparia thus assembled somewhat suggest a flotilla of small, high-prowed boats. Puparia are also found on top of, or alongside green scum of stagnant little guava-laden pools.

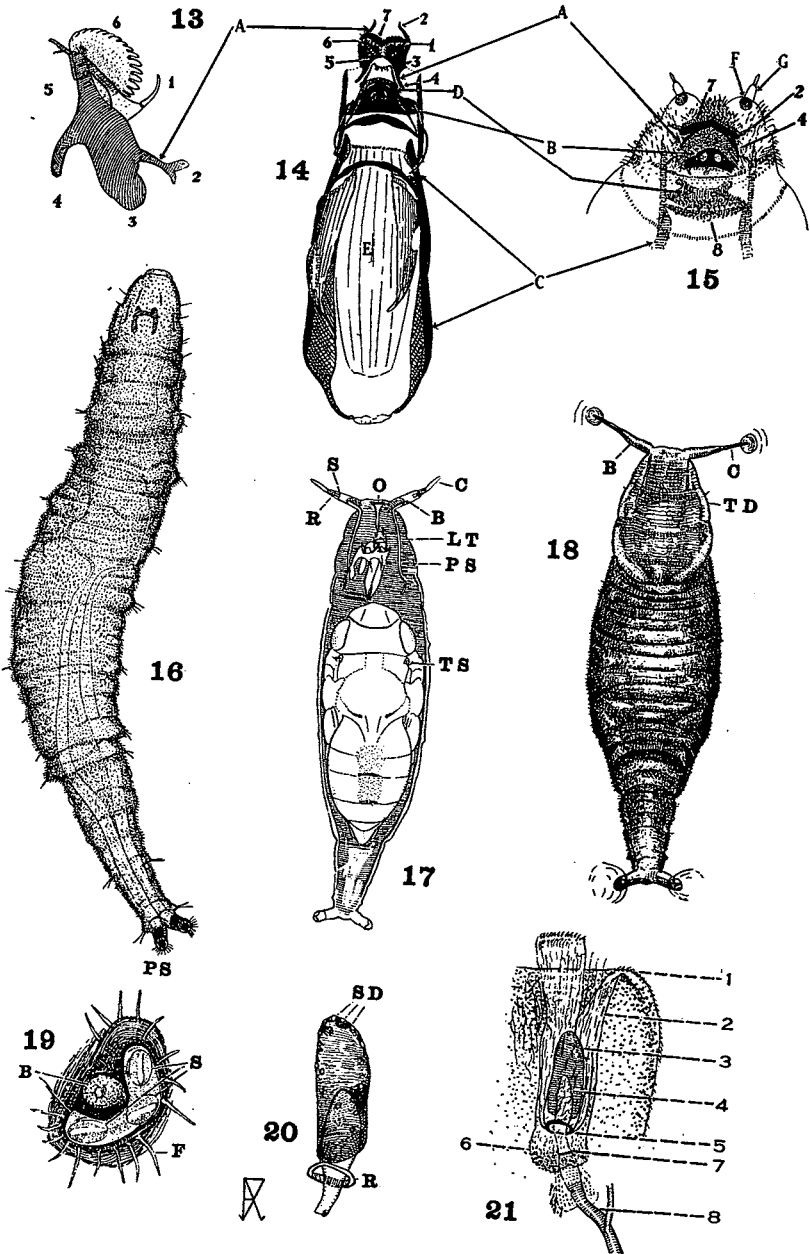
Internal changes continue for some time. Through the integument one sees the larval head-skeleton in movement as it works itself free of the forming pupa to range itself at last along the ventral side of the rigid larval skin, or puparium, seeming to hang from the invagination between the breathing siphons (Pl. III, 17, PS).

If we cut away a portion of the puparium so as to expose the pupa we immediately notice the small size of the pupa as com-

#### BRACHYDEUTERA HEBES

##### Explanation of Plate III

13. Mandibular sclerites, one of pair showing semicircular sawlike scraper 6. The numerals correspond to the same parts in figs. 14 and 15. Last instar, side view.
14. Cephalo-pharyngeal skeleton of penultimate instar larva, dorsal view; E, pharyngeal sclerite. The numerals and letters correspond to the same parts in figs. 13 and 15.
15. Larval head, from beneath; last stage; G, antenna; F, maxillary palpus.
16. Larva, last stage, from above; PS, posterior spiracles.
17. Puparium with dorsal wall cut away to show the pupa; the larval cephalo-pharyngeal skeleton PS that hangs from the oral invagination O; C, chitinized respiratory process; R, annulus or ring; B, basal part of respiratory process; S, break in respiratory tube; LT, longitudinal trachea; TS, pupal spiracle.
18. Puparium, dorsal view; B, basal part of respiratory process; C, chitinized respiratory process; TD, thoracic disc which lifts off at the time of hatching of the adult.
19. One of the two posterior spiracular processes, last instar larva, distal view; B, button or scar from previous moult; F, setulae; S, spiracles.
20. Anterior respiratory process dissected from last instar larva to show the numerous very short spiracular digits, SD; R, annulus or ring.
21. Last instar, still active larva to show invaginated respiratory process of thorax exposed by tearing open the body wall; 1, anterior border of segment 2, at edge of pocket or invagination; 2, basal or membranous part of respiratory process which is everted in the puparium (17 and 18, B); 3, the chitinized respiratory process (17 and 18, C); 4, terminus of longitudinal breathing tube showing its apparently non-taenidial character; 5, ring or annulus (17, R); 6, proliferating? cell band; 7, the point in the tracheal tube where the break or separation occurs at extrusion (17, B); 8, longitudinal tracheal tube extending posteriorly into body.



pared with the length of its container, the puparium. The latter may have a total length of 7-8 millimeters, the pupa scarcely more than half of that length. The new pupa is pale but the eyes darken quickly. The head and tail ends are free from the walls of the puparium, at least in later development, but the intermediate portion quite fills the space along the sides and venter, while dorsally at least for a time, there is a free space. Anteriorly, the puparium is practically all a glistening reservoir of air (or other gas), which explains its great buoyancy. The tracheal tube is interrupted in each respiratory siphon (Pl. III, 17, S), but posteriorly it extends along the flat disc of the thorax and disappears there. On each side of the pupal prothorax above is a large spiracle (T.S.) with part of a silvery tracheal tube visible as leading from it to the interior. These spiracles connect with the air chamber of the puparium. We see then that respiration has been transferred chiefly from the tail end of the larva to the anterior portion in the puparium. The tail end, however, does contain a smaller quantity of air (or other gas) although the tracheal tubes so strongly developed there in the larva seem now broken up and non-functional. A little excreted matter or meconium is present at the tail end of the pupa.

The pupal stage is a matter of a few days. When ready to hatch, the fly pushes up the flattened thoracic disc of the puparium, which hinges up from its base, crawls out and in a short time its wings develop to their proper length and firmness, and it has become a mature insect.

As reared in the laboratory, *Brachydeutera hebes* has a rapid life-cycle. Flies secured March 13, 1932, oviposited almost immediately; some of the eggs hatched March 14; the first puparium was formed during early morning of March 22, while the first adult issued on the morning of March 27; a matter of about 14 days from oviposition to adult fly. Other flies issued March 28 and subsequently. Poorly fed flies in confined quarters, took much longer to transform, or failed to do so. A small experiment indicated that the insect does not pass through dry periods in the puparium. Several dozen puparia collected in their natural environment yielded no parasites. A Californian ephydrid fly (*Ephydra millbrae* Jones) that is common in salt water ponds along a portion of the shore of San Francisco Bay is parasitized by chalcidid wasps which issue from the puparia, (Jones, B. J. Catalogue of the Ephydridae, with Bibliography and Description of new species. University of Calif. Publ. Tech. Bull. Entom., Vol. I, No. 2, pp. 152-198, illustrated, 1906).

The genus *Brachydeutera* was described in 1862 (Loew, H., Monograph North American Diptera I. p. 162) to receive *B. dimidiata* Loew (= *argentata* (Walker)), a species widely distributed

in temperate and tropical America and in Europe. The Hawaiian species was for a time confused with *B. argentata*.

Regarding the habits of *B. argentata*, which is a little smaller than our *hebes*, Dr. L. O. Howard, writes in part as follows (Insect Book, p. 182, 1901): "I have reared *Brachydeutera argentata* . . . from larvae found in a small pool which was strongly impregnated with horse manure from an adjoining manure heap." O. A. Johannsen (Mem. 177. Cornell U. Agric. Exp. Sta. Aquatic Diptera, Part II, 1935) gives a good account with illustrations of *Brachydeutera hebes*.

This genus is represented by a very few species and occurs in the north temperate regions and in the tropics of both hemispheres.

### **Scatella** (Plates IV, V, VI)

These are small compact dusky flies the wings of which are usually spotted with whitish. They are found as a rule in considerable numbers at the margins of brackish pools, of reservoirs, ditches, flumes, on wet boulders along streams, moist to dripping wet banks, etc.; much according to species. What is of interest therefore in the genus is the more or less well-defined habitat of its several species and also their obvious suitability, in some cases at least, in their early stages to their environment. These flies are of a generally rather sluggish disposition; in striking contrast for example, to the restless dolichopodid flies so often found in similar situations. They are fair flyers and if perchance driven upon open water will quickly make their way ashore in hopping flight, not being willing performers upon the surface film. The males are often seen courting the females. One will face her and moving from side to side thus describe little arcs; very frequently he gets immediately behind her, raises and lowers his wings and then mates with her.

The eggs are deposited on wet materials or they may be shallowly submerged. They are whitish, measure from about half to a little more than half a millimeter in length, with a finely reticulate pattern more or less evident. From the apex of the narrower end and extending towards the less curved side is a slightly depressed truncated area that may be strongly margined in horseshoe form (Pl. IV, 28; Pl. VI, 38). When hatching time is near at hand the larva may be seen through the shell as a tightly fitting duskiely segmented creature of undulatory movements. Its forked tail is jammed against the broader end while the blackish cephalo-pharyngeal skeleton shows clearly forward. Soon the well-toothed paired dental process—the anterior hinged part of this skeleton—is observed in downward strokes as it scratches the shell just beneath the obliquely truncated area so that eventually with the aid of pressure a rent is made through which the larva issues (Pl. VI, 39). The larva is covered with spinules, better developed in some species than in others. After the first moult a digitate respiratory organ appears

on each side of the thorax (Pl. VI, 40). Each arm of the forked posterior terminates in a cap provided with spiracles and palmate hairs, or hooks (Pl. VI, 41, 42 and 37; Pl. V, 32A). Segmental abdominal swellings serve in a measure as pseudopods, for the larvae are creepers along wet and often algal-covered margins, in thinly water-sheeted banks, etc. They feed by an almost incessant down-scraping movement of the head end. They are comparatively helpless in deep water but, as observed in *Scatella bryani* Cress. rendered buoyant by swallowings of air, they may be able to progress slowly by withdrawing head and tail beneath the surface film and then by rather slight bendings of the body, roll over and over somewhat barrel-like. There are, I believe, three larval stages. The puparia are naturally found in about the same situation as the eggs and larvae. They are often more or less distorted (Pl. V, 34) and rest dorsal side uppermost (Pl. V, 30). The adult hatches by forcing up hinge-like the flattened disc of the thorax. Both larvae and puparia as far as known, offer specific characters.

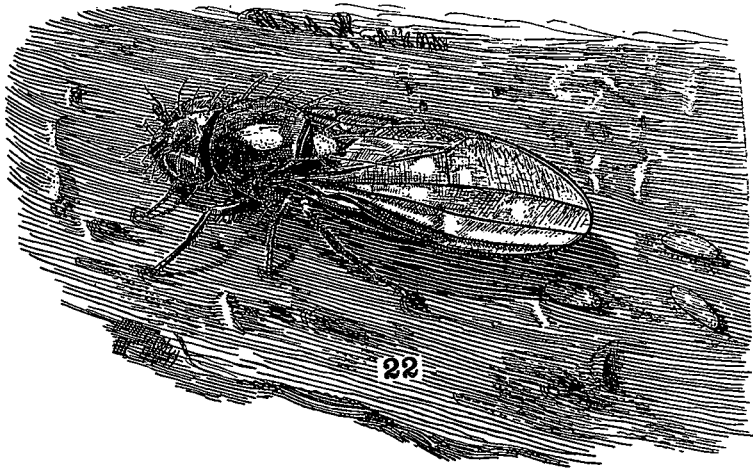
At, or very near the seashore we find *Scatella terryi* Cresson and *Scatella sexnotata* Cresson (Proc. Haw'n. Entom. Soc., VI, pp. 275-6, 1926). *S. terryi* is of a general brownish-olive opaque color, the wings five-spotted and the mesonotal setulae not well developed. The type is from Wawamalu Beach, near Koko Crater, Oahu (E. H. Bryan, Jr.). Others have been found on tide rocks at Waianae, Oahu. The writer knows nothing of its early stages. *S. sexnotata* (Pl. IV, 23), 3-3.5 millimeters long of opaque appearance, wings six-spotted and the notal and fore-femoral bristles well developed, is an abundant and widespread maritime species in the Hawaiian Islands. It favors stagnant saline pools—such as are formed by particularly high tides—marshes, and mudflats that often glisten with salt crystals. In these areas frequently encompassed by such succulent plants as *Batis maritima* Linn. (Batidaceae) or *Herpestis monniera* H. B. K. (Scrophulariaceae) its most obvious insect associates are likely to be the water-boatman bug *Trichocorixa blackburni* (White), the large dolichopodid fly *Hydrophorus pacificus* V.D. and a little borborid fly of the genus *Leptocera*. This *Scatella* also occurs on tidal flats, wet beach sand and tide rocks and has been

#### SCATELLA

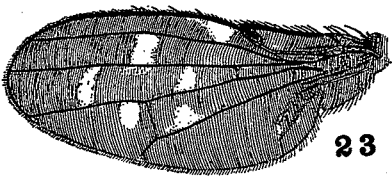
##### Explanation of Plate IV

22. *Scatella oahuense*, resting on a boulder over which a very thin sheet of water is flowing. To its rear may be seen three eggs. From head to extremity of the wings the fly measures 4.05 mm. Honolulu.
23. *Scatella sexnotata*, wing. Mud flats, Waialua, Oahu.
24. *Scatella oahuense*, wing. Honolulu.
25. *Scatella bryani*, wing. Green Lake, Kapoho, Hawaii.
26. *Scatella hawaiiensis*, wing. Honolulu.
27. *Scatella warreni*, wing. Lulumahu stream, near Honolulu.
28. *Scatella bryani*, egg. Length 0.48 mm.

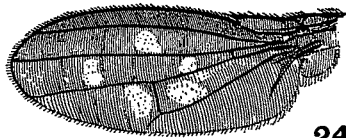




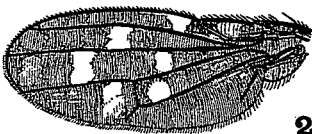
22



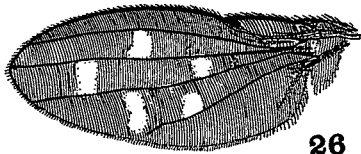
23



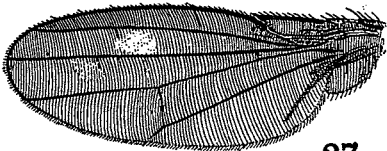
24



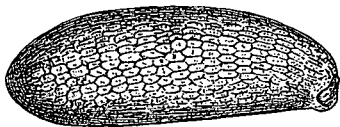
25



26



27



28

observed at reservoirs near the sea that more properly belong to the domain of *Scatella bryani* Cresson (1926), which, however, may in turn invade saline flats. The eggs are about 0.65 mm. long and rather well sculptured. The larvae bear four fans or palmate hairs on each caudal process, throughout their existence. The puparia seem usually to have the tail end well curved upwards. *Scatella bryani* is our smallest species. It is about 2 mm. long and has six well-marked wing spots (Pl. IV, 25), a seventh spot being more or less apparent in this (and other) species basally in the costal cell. It is found in many lowland situations usually where there is standing water—lakes, lily ponds, reservoirs, overflow areas, stagnant ditch and sewer water, gutters, etc. The egg is about 0.48 mm. long, well reticulate and rather stout (Pl. IV, 28). The larvae have caudal palmate hairs as in *sexnotata*. This species is particularly easy to rear in moist decaying algae such as are accumulated along the margin of reservoirs. What appears to be a dusky form of *S. bryani* was taken at an altitude of between 5000 and 6000 ft. at small exposed water pocket in a limb of an *Acacia koa* Gray (*Leguminosae*) tree on Mauna Kea, Hawaii. The type of *S. bryani* was described from Awaawapuhi, Kauai (E. H. Bryan, Jr.)

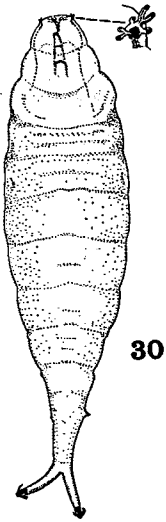
Now, if we leave the open lowlands of Oahu and explore its valleys and canyons where the water runs clear between boulders, as a thin sheet over a slope, or merely oozes from some trailside bank, at least three additional species of *Scatella* will be found, for much additional study is needed on this more upland assemblage. Two of these species, *S. hawaiiensis* Grims (1901) and *S. oahuense* n. sp. often occur intermingled. The third, *S. warreni* Cresson (1926) may also be in company with one or possibly both of the two others, and frequently with the canacid fly *Procanace nigroviridis* Cresson, of rather similar habits. *S. hawaiiensis* (Pl. IV, 26; Pl. V, 35) differs from *S. oahuense* (Pl. IV, 24; Pl. V, 36) chiefly in its much larger postvertical bristles, better defined wing spots and more sinuous veins. From a standpoint of habitat I have been unable thus far to separate *S. hawaiiensis* from *S. oahuense*, and indeed, up to the present time they seem not to have been recognized as two species.

## SCATELLA

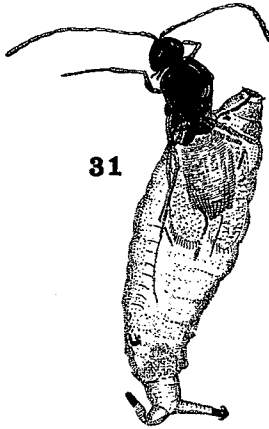
### Explanation of Plate V

29. *Scatella hawaiiensis*, or *oahuense*, last larval stage.
30. *Scatella bryani*, puparium, dorsal view. Length 3.9 mm.
31. Figitid wasp that has died in issuing from the puparium of *Scatella hawaiiensis*, or *oahuense*. Puparium about 3 mm. long.
32. *Scatella hawaiiensis*, or *oahuense*, puparium. Length 4.1 mm. At A is shown, more enlarged, one of the four palmate hairs of the caudal spiracular processes of a *Scatella* larva.
33. *Scatella oahuense*, first stage larva.
34. *Scatella warreni*, puparia. All are to same scale. Secured among algae and diatoms along the margin of a swift-water cement ditch, Waianae, Oahu.

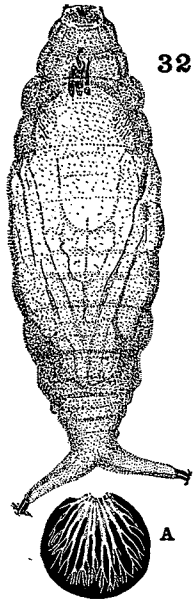
29



30



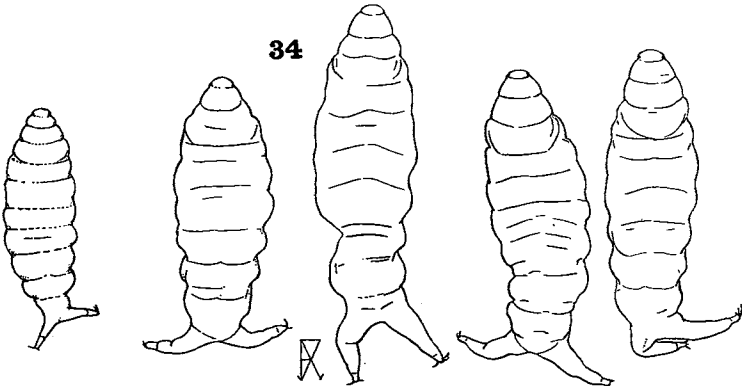
31



32



33



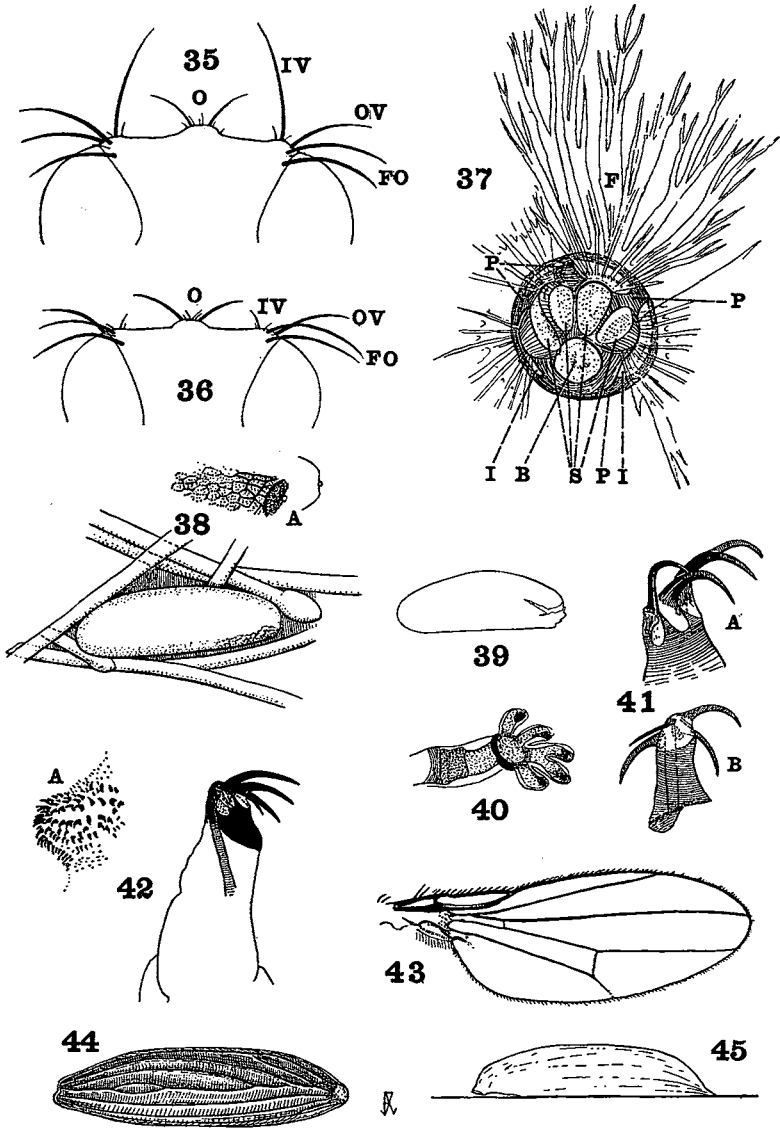
34

Both are well distributed on Oahu. *S. oahuense* has also been taken on Hawaii at an altitude of about 5200 ft. and on Haleakala, Maui, above 8,000 ft. *S. hawaiiensis* was described from specimens collected at 2000 ft. on Mt. Kaala, Waianae Mts., Oahu. The two species may be very conveniently found at moderate elevations behind Honolulu. Here one, or perhaps both may be seen, where the water as a mere sheet flows over a boulder, clinging in midstream to some tiny barely submerged bit of moss, algal or diatomaceous growth. And here also in this very shallow water may sometimes be found the delicate white eggs (Pl. IV, 22). A thriving colony of *S. hawaiiensis* was located at an oozy leak on the side of a large wooden water tank on the lower slopes of the Waianae Mts. All stages were represented in the green and brown scummy material nurtured by this leak. In addition, a plain gray *Psychoda* fly was breeding here. The *S. hawaiiensis* eggs were rather stout of form and well sculptured as in *S. bryani*. Like *S. sexnotata* and *bryani* this species from the beginning is provided with four palmate hairs surmounting each caudal spiracle-bearing process. The larva of *S. oahuense* on the other hand in the first instar has four curved thorns surmounting these two processes. One of these thorns is much weaker than the others (Pl. VI, 41B). They are replaced in the following instar by regulation palmate hairs. Fig. 32A shows the structure of one of these hairs, while fig. 37 gives a bird's-eye view of the spiracles, etc., at the extremity of one of these caudal processes.

#### SCATELLA AND HYDRELLIA

##### Explanation of Plate VI

35. *Scatella hawaiiensis*, female, upper front portion of head to show principal bristles; O, ocellar; I. V., inner vertical; O. V., outer vertical; F. O., fronto-orbitals.
36. *Scatella oahuense*, female; upper front portion of head; lettering as in fig. 35.
37. *Scatella*, larva; apex of one of the paired caudal processes to show spiracular disc; S, spiracles; B, button or moult scar; P, pillars; F, fan-like palmate hair arising from interval or membranous area, I.
38. *Scatella hawaiiensis*, or *oahuense*; egg among algae; A, showing micropyle and sculpture. Egg length 0.55 mm.
39. *Scatella hawaiiensis*, or *oahuense*; hatched egg.
40. *Scatella hawaiiensis*, or *oahuense*, last stage larva; thoracic respiratory process.
41. *Scatella warreni* (A) and *Scatella oahuense* (B); first stage larvae; extremity of one of the two respiratory processes. The spiracles are situated at the base of the hooks in the membranous area. In A, the hooks are present throughout the larval instars—and in the puparium; in B they are present only in the first larval instar, being replaced at the first moult by regulation palmate hairs. Drawn to same scale.
42. *Scatella warreni*; one of the pair of caudal larval processes, showing strongly developed hooks. At A, is one of the larval pseudopods.
43. *Hydrellia hawaiiensis*, wing.
44. *Hydrellia hawaiiensis*, egg, from above. Length 0.53 mm.
45. *Hydrellia hawaiiensis*, egg from side.



Probably the most water-loving of our *Scatella* is *S. warreni* Cresson (1926). It favors swift flume and ditch waters, rushing streams, waterfalls and the cool water-sheeted banks of uplands. It has rather long dusky wings with indications of one or more pale spots. It varies much in size and, as the smallest forms are often associated, there may be really more than one form involved. In the same environment one finds the sooty canacid fly with green and gold eyes as well as the erratic *Telmatogeton* midge that in its wild coursing over dripping boulder and wave-washed flume margin not infrequently collides with these staid little water-lapping flies. *S. warreni* was found particularly abundant and in almost pure colonies along the Kalihi Valley stream, Honolulu. Here also, barely submerged were seen its delicate white eggs. The larva is more strongly setulose particularly as regards the pseudopods than are the other species we have considered (Pl. VI, 42A). Furthermore, the paired caudal processes are provided in all the instars with four grapple-like hooks (Pl. VI, 41,A; 42). These hooks curve ventrally and together with the backwards-pointing thorns on the pseudopods make for a secure anchorage in the algal and other growth in the often strong wash or current of its environment. This fly then, and some others are quite at home along ditches and flumes. A cement-lined ditch passing into an iron flume, in the heated Wai-anae lowlands, carries clear swift-flowing water from the steep slopes of Mt. Kaala almost overshadowing it, to the sugar cane fields. And from these cool forested slopes have descended several of the water-frequenting insects. *Scatella warreni* and *Procanace nigro-viridis* are both present busily lapping up moisture, and the puparia, often of rheumatic aspect (Pl. V, 34), of the former are likely to be found, sometimes more or less imbedded in the water-washed margin of scummy growth. *Dasyhelea hawaiiensis* Macfie, a tiny ceratopogonid midge is also here, but most obvious is the active *Telmatogeton abnormis* (Terry), its dark olive green larva being a lover of highly oxygenated water. A psychodid fly breeds along the flume margin and *Scatella bryani* present aside in a tiny leak puddle passes its early stages also in the upper portion of this marginal band of algae. On the Island of Hawaii V-shaped or square wooden flumes carry water from the uplands. The current often attains great velocity and small waves wash the margins. Here also is *Scatella warreni* placidly sitting alongside the rushing water. *Telmatogeton torrenticola* (Terry) much larger than the Oahuan species races along the water's edge, now and then to be caught in the current and borne downstream but soon gaining shore, persists in its advance. Others rest quietly in small groups and here and there a female is laying her cluster of eggs. The adaptable crane fly *Limonia grimshawi* Alexander breeds in the algae a little above the water line. Well up in the mountains behind Honolulu I have observed *Scatella warreni* freshly issued from the puparium, its wings still

wrinkled and stubby, floating down from a little rapids into a shallow pool and thence at last to shore. On the surface of this pool a number of dusky *Campsicnemus miritibialis* V. D. (Dolichopodidae) flies were skating with great rapidity, on the lookout for prey which in this case appeared to be mainly the little green *Tanytarsus* midge, itself freshly hatched and afloat. W. A. Warren (Proc. Haw'n. Entom. So. III, 25, 1913) published some interesting notes on *S. warreni*. He observed freshly issued flies floating in a flume in Honolulu and, upon further investigation, found larvae and pupae in the masses of algae. These early stages he describes briefly.

Flies of the genus *Scatella* have a number of enemies. Among these are the nymphs of certain of our damselflies (*Megalagrion*) that frequent dripping wet banks and boulders. These may devour both adult and young *Scatella*. Quite frequently the puparia have a large perforation, the emergence hole of a figitid wasp, examples of which are often seen exploring in their tedious manner the moist habitations of *Scatella* larvae, into which they thrust their ovipositors. Figure 31 shows one of these wasps that failed to completely issue from a puparium of *S. hawaiiensis* or *oahuense*. Figitids are also to be seen about the briny mud of maritime swamps, home of *Scatella sexnotata*. The Figitidae are fairly numerous in the Hawaiian Islands. Some are well known as parasites in dipterous puparia. Their classification is in a rather unsatisfactory state.

**Scatella oahuense** n. sp. (Fig. 24, wing; 36, dorsal bristles of head; 33, larva, first instar; 41 B, caudal hooks first stage larva.)

Female, holotype—Head and thorax shining black above, becoming somewhat brownish pollinose at side and below; abdomen also brownish dusted. Wings infuscate, with five whitish spots only moderately distinct; veins only slightly undulating at these spots. Inner vertical bristles weak; mesonotal setulae sparse; three well developed dorso-centrals and one strong pair of acrosticals. Fore femora with a few moderately strong post-flexor bristles. Length 2.8 mm.

Male, allotype—Like the female.

Resembles *S. hawaiiensis* Grimshaw, from which it differs chiefly in its quite small inner vertical bristles. The wing spots are less distinct and the veins scarcely undulating at these spots.

Type: Female; Hering Valley, Tantalus, Honolulu, March 6, 1937. Wet bank (F. X. Williams).

Allotype: Male; Pauoa Side of Tantalus, Honolulu, February 25, 1937. Wet bank (F. X. Williams).

Paratypes: 12 females and 6 males. Tantalus, Upper Manoa Valley, Honolulu, Waikane, Kaluanui Valley, and Mt. Kaala, Oahu, 1936 and 1937. (F. X. Williams).

Holotype and allotype in collection of Hawaiian Entomological Society; two male and two female paratypes deposited in B. P. Bishop Museum.

An abundant species. Occurs also on Maui and Hawaii.

**Canace nudata** Cresson. (Plate VII, 47, 51, 52).

Cresson, E. T. Jr., Trans. Amer. Entom. Soc., 52, pp. 257-258, 1926. (California).

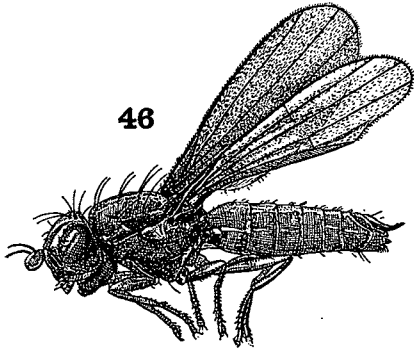
This is the quiet dusky little fly that under favorable conditions literally swarms on the tidal rocks of our sea-coasts. Engaged in the customary ephydrid habit of lapping up moisture, for dear life it would seem, it is nevertheless fully alert to the oncoming wave that it evades by a quick upward flight and forthwith settles again upon the dripping rock. *Canace* then is one of several species of Diptera that help animate this narrow belt of land and sea. Quite likely to be the most conspicuous of these other flies is the dolichopodid *Cymatopus acrosticalis* Parent (1937), almost constantly on the move as it forages for some larva or other delicate organism made available by receding waters. On occasion, certain midges of the genera *Clunio* and *Telmatogeton* may draw attention by reason of their great activity. And finally in the upper tidal zone and beyond, a tiny *Dasyhelea* midge may be seen singly or in little swarms. *Canace* is not always at the edge of the surf but occurs also about certain pools more or less out of reach of ordinary tides. One such at Hanauma Bay near Honolulu, was very shallow and rested upon a thin layer of volcanic mud in places more or less bound together felt-like by algae etc. and that curled or flaked up where exposed to air. The whitish eggs (Pl. VII, 47) which *Canace* was induced to lay on some of this material showed a very fine reticulate structure, and a slightly granulate protuberance at the narrower end. They measured about 0.4 mm. long. Sometimes one finds a *Canace* larva more or less imbedded in some of this wet felt-like material. It is active but quite unable to swim. A large specimen may be 5 mm. long. It is covered with fine spicules with a rather sparse assortment of stout erect spines of considerable size on the back, which bears also fine very close granulations appearing almost plate-like. A grouping of tiny plates rather than granulations is present on the fore part of the thorax above. The anterior respiratory processes are very well developed. Posteriorly the paired longitudinal tracheae terminate separately as approximate spiracles in a single tube-like extension of the body (Pl. VII, 52). The underside of the *Canace* larva is relatively unarmed save for the extrusive anal proleg that is provided with a number of strong anteriorly-curved

## CANACINAE

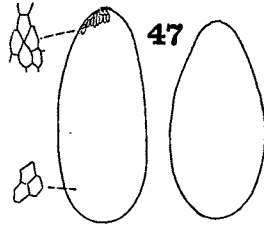
## Explanation of Plate VII

46. *Procanace nigroviridis*, female.
47. *Canace nudata*, eggs. Length 0.41 mm.
48. *Procanace nigroviridis*, puparium, ventral view. Length, 2.3 mm. At A, is the thoracic respiratory organ of the larva.
49. *Procanace nigroviridis*, wing.
50. *Procanace nigroviridis*, labella terminating the proboscis, from the side.
51. *Canace nudata*, puparium, from the side.
52. *Canace nudata*, larva, from the side.

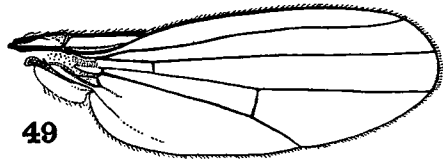




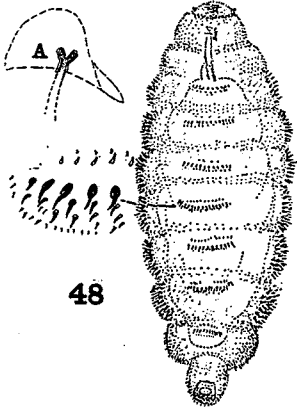
46



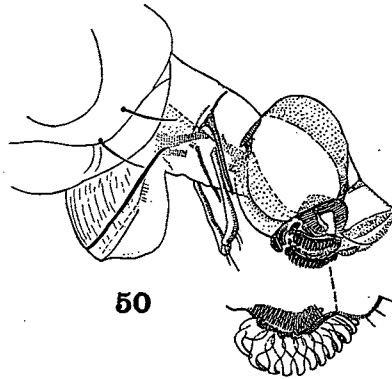
47



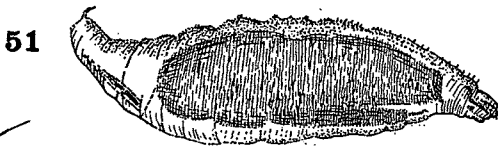
49



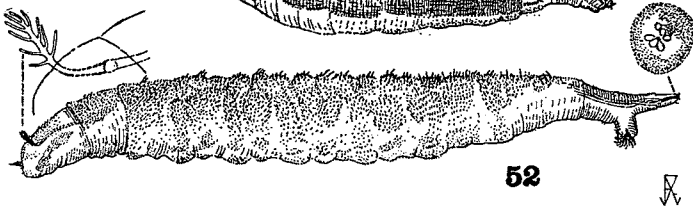
48



50



51



52

hooks that indicate good powers of anchorage. The puparium (Pl. VII, 51) is stout and rather curved at each extremity, with the larval respiratory processes somewhat reduced. It also may be more or less imbedded in the wet substratum. The larva is saprophytic or perhaps a feeder on living algae as the sometimes green matter in its intestines suggests.

*Canace nudata* is not peculiar to the Hawaiian Islands since it occurs on the Pacific Coast of North America, and extends at least as far as Wake Island, 19° 15' N, 166° 30' E, towards the coast of Asia.

**Procanace nigroviridis** Cresson. (Plate VII, 46, 48, 49, 50).

Cresson, E. T. Jr., Proc. Haw'n Entom. Soc., VI, pp. 277-278, 1926.  
(Described from Awaawapuhi, Kauai 1922, E. H. Bryan Jr.—Collector.)

This fresh-water species superficially resembles *Canace nudata* of the sea-shore. It measures from about 2.5 to 3 mm. long and its somber coloration is relieved somewhat by the golden green eyes and a greenish shade on the front and top of the head. It is partial to canyon and mountain streams and to swift-water flumes, being often in company with *Scatella warreni* and to a less extent with the spotted wing species. It probably occurs on all the major islands but thus far seems to have been collected only from Kauai, Molokai and Oahu. On Molokai and Oahu it has been taken on wet stream boulders up to an altitude of about 2000 ft. Its habits are much like those of *Canace* and of *Scatella*. Courting scenes are about similar—the male very alert, wings outspread like a soaring bird faces his prospective mate that with apparent unconcern may be lapping up moisture or slowly moving forward; he makes little sudden moves, lowers his wings slightly or suddenly follows close behind her; to be accepted or rejected. Eggs as dissected from the body of the fly greatly resemble those of *Canace nudata*. They measured about 0.4 mm. long, with a low blunt apical process and a finely reticulate pattern. The larva which was but rarely taken, lives among scum, algal and other fine growth on wet rocks etc., as with its *Scatella* associates. It is a curious broad fusiform rather ventrally flattened creature, covered with very short dark spicules except on the underside. In addition to this armament, most of the abdominal segments bear on the lower part of their side a number of stout erect slightly curved spines, while across the middle of the underside are seven segmental bands of generally backward-pointing spines. Finally, an anal pseudopod is provided with strong procurved spines much as in *Canace*. The two respiratory processes of the thorax are bifurcate while a single retractile anal tubular process forms the terminus of the paired longitudinal tracheae ending in spiracles. The larva is sluggish and seems unable to swim. The puparium (48) much resembles a short stout larva. Both appear well suited for anchorage among low growth, etc. in running water.

## FAMILY ANTHOMYIIDAE

This family is well represented in the Hawaiian Islands where it reaches its greatest development in the genus *Lispocephala* with 38 described species and many more sure to be discovered. Some of these are of considerable size. They are most abundant in the moist upland forests. Some have the habit of perching on the downbent end-portion or the underside of the leaves of shrubs—and also, to quote Dr. R. C. L. Perkins (Fauna Hawaiensis, Introduction, p. clxxxvii, 1913) in referring to these flies under the name *Coenosia*: “The larger ones may sometimes be seen in some numbers on the trunks of trees, having a bold appearance, as they stand ready to dart off after some other insect”. Perkins and others have found species of this genus stored in the nests of our fly-catching crabronid wasps. The damp-woods species probably breed among wet debris and mud, in decaying plant tissues (banana stems, etc.) and perhaps at the leaf bases of certain plants. Those *Lispocephala* that patronize wet boulders along streams, or dripping mossy banks are in some cases at least, semi-aquatic. Our common *Lispa metatarsalis* Thom. is chiefly a lowland insect frequenting reservoirs, ditches, mud flats, etc. A number of exotic genera of anthomyiids frequent water. Of considerable interest are certain forms referred to by Tillyard on page 374 in his *Insects of Australia and New Zealand*, 1926, as follows: “A striking group of genera are the predatory flies, called ‘cannibal flies’ in New Zealand, which are found resting on rocks in or near running streams, and which fly up and seize other insects (especially Mayflies) and suck them dry; these belong to the genus *Trichophticus*, and are also found in Tasmania.”

Some of the Anthomyiidae are decidedly beneficial insects. Thus P. Tate (*Parasitology*, XXVII, pp. 556-560, 8 figs., 1935) found the larva of *Phaomia mirabilis* Ringdahl preying upon mosquito larvae at Cambridge, England. The very active *Phaomia* larvae were able to rapidly encircle their prey. Records of the predacious habits of adult Anthomyiidae are numerous. A good summary and list of references of these is given by B. M. Hobby (*Entom. Mo. Mag.*, LXX, pp. 185-190, 2 figs., 1934) who also figures the mouth-parts of several species to show adaptation for the capture of prey. Of considerable interest here is the account by W. A. Lamborn (*Bull. Entom. Res.*, XI, pp. 279-281, 1920) of “The habits of a dipteran predaceous on Mosquitos in Nyasaland.” The fly involved, a species of *Lispa*, grasped larvae, pupae and emerging adults and also crippled adults, from the surface of the water.

Previous records of *Lispa* preying on mosquito larvae are those by J. Mitford Atkinson (*Jl. Trop. Med.*, XII, 1909, pp. 255-6) and by Howard, Dyar & Knab (*Mosquitos of N. America*, I, 1912, p. 170).

**Lispa metatarsalis** Thomson. (Plate VIII).

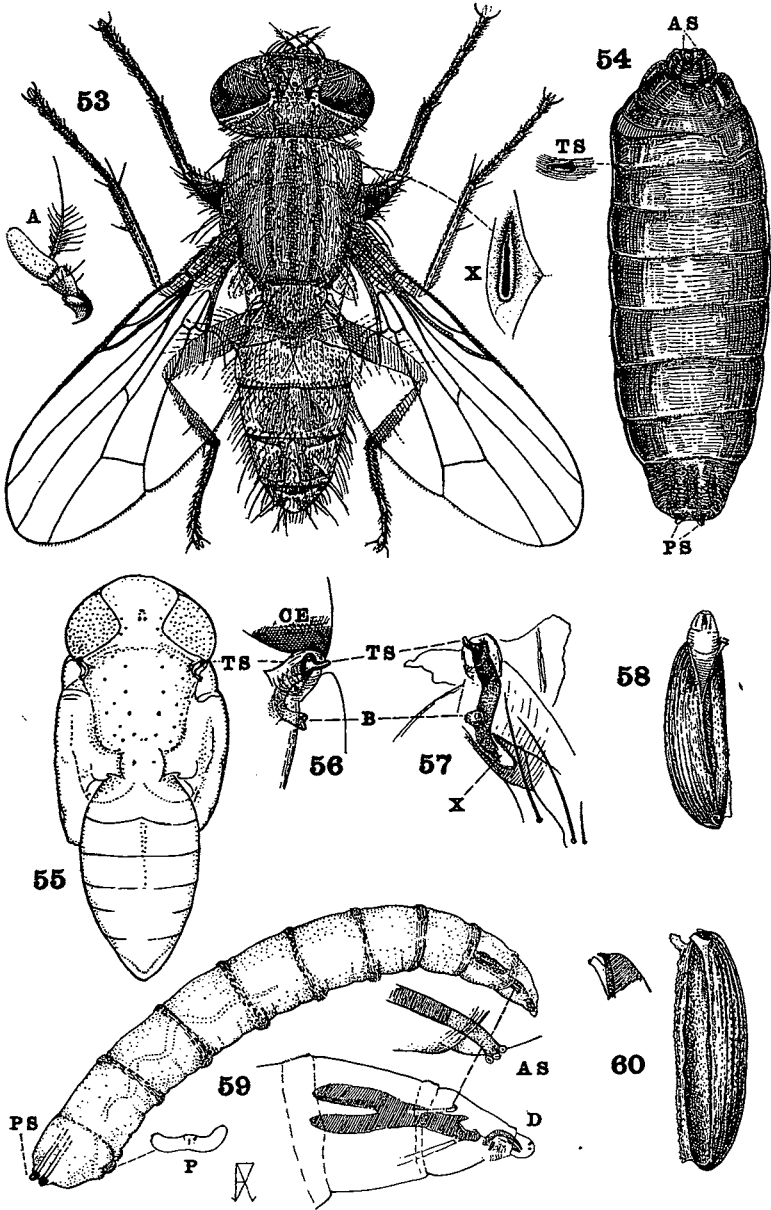
Thomson, C. G.: Voyage de "l'Eugenie", Insects, p. 562, 1868.

Stationed alertly upon masses of green algae that blanket-like overlie portions of lowland reservoirs and are accumulated along their banks, found likewise on muddy shores of marshes, sometimes saline, more rarely extending its range to sluggish portions of small mountain streams, and more rarely still to highland ridges, *Lispa metatarsalis*, a pale gray-brown carnivorous fly of ordinary appearance and solitary habits claims a place among our semi-aquatic insects. In size it is somewhat less than our common housefly, but its markings are more obscure and moreover it has the habit of keeping its wings one quite overlapping the other over the back. It is a strong flyer and, being usually on the lookout for something to eat, may often be seen walking in a brisk, aggressive manner towards some small insect that has attracted its attention. Thus the tiny moth fly, *Psychoda alternata* Say falls a prey to *Lispa*, and I have also seen it capture with the help of its fore paws the little phyllomyzid fly, *Milichiella lacteipennis* Loew on the window pane of a veranda. A favorite resort of these insects at Waianae, Oahu, was along the vertical sides of a cement ditch set to the level of the ground and containing at the time—April 1936—about a half inch of gently flowing or standing water well margined and layered with the bright green algae, of which a ribbon-like *Enteromorpha* sp. was the most conspicuous. Here *Chironomus hawaiiensis* Grims. was breeding in some numbers, with *Psychoda* and two Ephydriidae, *Scatella bryani* Cress. and *Hydrellia hawaiiensis* Cress. also common. *Lispa metatarsalis* was likewise numerous on rockwork bordering a neighboring reservoir, newly filled, and teeming with *Chironomus* and tiny Crustacea. *Lispa* does not seem to rest or travel upon water. When confined in a tube supplied with some mud or algae this ravenous insect would sometimes quite readily deposit

## LISPA METATARSALIS

## Explanation of Plate VIII

53. Adult fly, male. Length 6 mm. The wings are naturally held one overlapping the other over the back. A, antenna; X, prothoracic spiracle.
54. Empty puparium. Length 5.8 mm. AS, tiny buttons indicating prothoracic spiracles of larva; TS, prothoracic spiracle of pupa that is exserted through the 4th segment of the puparium; PS, posterior spiracles.
55. Pupa, dorsal view. TS, prothoracic spiracle.
56. Spiracle of fig. 55 more enlarged. B, supplementary spiracle; CE, compound eye.
57. Spiracle of fig. 56 more or less dissected out to show the somewhat imbedded prothoracic spiracle, X, of the adult. See also X, fig. 53.
58. Egg with the larva hatching from slit at upper end.
59. Larva about two-thirds grown, dorso-lateral view. Length 8 mm. AS, anterior spiracles; D, side view of anterior portion to show head skeleton; P, anal plate; PS, posterior spiracles.
60. Egg, with flap end in lateral profile. Length about 1.5 mm.



its rather curiously shaped, seed-like, dull olive brown eggs. These measure about a millimeter and a half in length and, except for a wide gently rounded, well flanged area, are longitudinally ridged. Some eggs that I had placed in water hatched within 24 hours, the larva issuing from a slit formed at the flap-bearing end of the shell (Pl. VIII, 58). This freshly hatched larva seems incapable of swimming; it is, however, provided with a longitudinal tracheal system—already well silvered—extending from the tiny anterior stigmata to the larger caudal pair. Low prolegs are already present.

The larvae were kept in a small dish partly filled with water containing also a mass of filamentous green algae. Although capable of remaining completely submerged for a considerable period, they stayed habitually close to the surface, caudal spiracles exposed to the air. At large, *Lispa* larvae were found in masses of algae bordering small, more or less stagnant pools, under wet shore debris, etc., to altitudes of about 1000 feet. They occurred also among debris and decaying organic matter accumulated at the leaf bases of the ieie vine (*Freycinetia arborea* Gaud., Pandanaceae)—as noted near the summit of Awawaloa, Koolau Mts., at an elevation of about 2400 feet. No doubt they devour various larvae particularly those of nematocerous flies, and readily fed upon "blood-worms" (*Chironomus*) that so frequently share the same environment. As the *Lispa* larva grows it assumes a distinctly yellowish color and finally attains a length of 10 mm. or more, presenting a tapering fore end and a thick club-like posterior one, whence the short hair-fringed stigmata protrude. The mouth hooks (Pl. VIII, 59D) are simple and slender, the anterior spiracular processes (Pl. VIII, 59, AS) are 3-lobed, quite small and protrude obliquely forward from the posterior part of the first thoracic segment. Fine parallel spinulate ridges girdle the anterior part of segments 2-9, the development being generally less on the sides. Such transverse ridges are also present on the fore part of segment 1, while ventrally on 5-9 they are well developed on the paired swellings or pseudopods. On segment 10 there is a well developed mid-ventral pad, immediately behind which is the chitinized anal plate (Pl. VIII, 59, P). In a reared specimen the larval stage occupied about two weeks.

The formation of the puparium (Pl. VIII, 54) and within it later, of the pupa (Pl. VIII, 55), are of considerable interest. The puparium is really a pupal case and is the contracted, hardened and darkened skin of the larva, larval structures remaining more or less visible. The anterior 3-digitate larval spiracles for example—soon to lose their respiratory connection—become reduced and probably non-functional with their replacement in the pupa by a pair of conical spiracular processes (Pl. VIII, 54-57, TS) pushing through dorso-laterally on segment 4 of the puparium. The point at which

these processes are to be thrust out up to their broadening base is indicated by a small pale spot. This spiracular extrusion did not take place—as observed—for more than 24 hours after the puparium had been formed. These little processes show a number of tiny oval slightly convex transparent dots, probably air pores, and clearly connect with the tracheal system of the pupa now formed. Posterior to them but arising from the same tube is a far less chitinized short bifurcate process (Pl. VIII, 56 and 57, B) each arm of which bears a considerable number of very short pale fingers. This process seems not quite to reach the surface of the pupa. It appears likewise to be respiratory in character. The pupa fits rather snugly within the puparium. It matures in a few days, the fly emerging by pushing apart by means of its temporarily swollen forehead a portion of the anterior end of the puparium. The provisional prothoracic spiracular apparatus (TS and B) of the pupa is shed off the longitudinal trachea at the point where the large prothoracic spiracle (Pl. VIII, 53 and 57, X) of the adult is formed.

This fly has been taken on the Islands of Oahu, Molokai and Hawaii. It probably has a much wider distribution in the archipelago.

### *Lispocephala fusca* Malloch. (Plate IX)

Malloch, J. R., Proc. Haw'n. Entom. Soc., VII, No. 1, p. 85, 1928 (male and female).

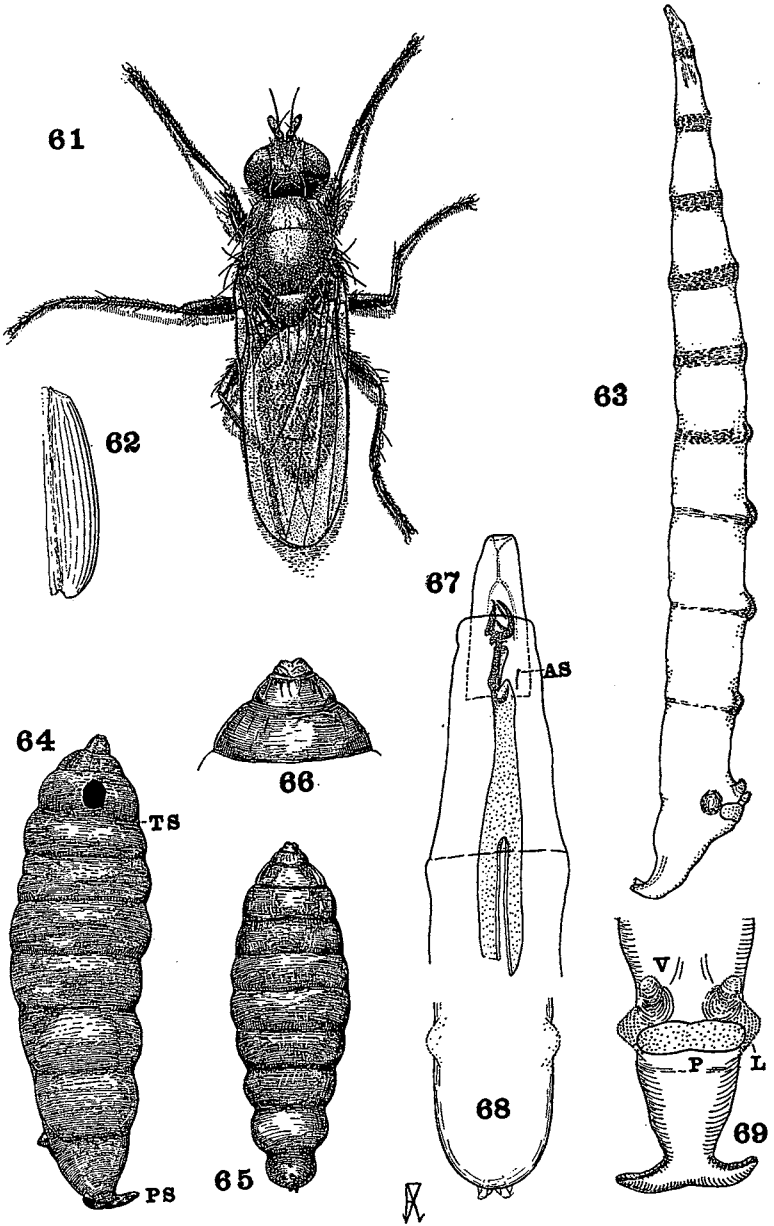
This alert, chiefly sooty brown fly of nearly the size of the common housefly ranges along our watercourses from a few hundreds of feet above sea-level to far into the mountains. It is found on the Island of Oahu where it inhabits both the Koolau and the Waianae Ranges.<sup>1</sup> Its apparent scarcity may be accounted for to some extent by a specialized habitat—the steep and even overhanging, usually wet surfaces of boulders alongside little cataracts or rapids. On such a background, often in the shadows, it may not be easily dis-

## LISPOCEPHALA

### Explanation of Plate IX

61. *Lispocephala fusca*, female. Length to tip of wings 6.4 mm.
62. *Lispocephala fusca*, egg, side view. Length, 1.2 mm.
63. *Lispocephala fusca*, larva in last instar, side view. Length 11.5 mm.
64. *Lispocephala fusca*, puparium, dorsal view. At the anterior end is the emergence hole of a parasitic chalcidid wasp. TS, one of the thoracic spiracles of the pupa; PS, posterior spiracles.
65. *Lispocephala kaalae* n. sp. puparium. Length 5.1 mm.
66. *Lispocephala kaalae* n. sp. Anterior end of puparium more enlarged.
67. *Lispocephala fusca*, anterior extremity of larva from side to show pharyngeal skeleton. AS, anterior spiracle.
68. *Lispocephala kaalae* n. sp., posterior extremity of larva, from beneath.
69. *Lispocephala fusca*, posterior extremity of larva, from beneath to show anal plate, P; last pair of pseudopods; V, ventral and L, lateral tubercles.

<sup>1</sup> The same or very closely related species occur on some of the other Islands.





cerned. A flick of the wings will sometimes reveal its presence. The writer recalls an especially good catch of these flies—three females and seven males—the result of three hours' intensive search one morning in late September 1937, along a half-mile stretch of the Waihi-nui Creek, Manoa Valley, Honolulu. My collections indicate that the female is generally the more rarely seen. Along the Kaluanui Stream at an altitude of 2,000 feet or more in the Koolau Mountains, *Lispocephala fusca* shares its habitat with a large brilliant green dolichopodid fly, as yet undescribed, while along a spring on the cool heights of Mt. Kaala, Waianae Mts., we find it associated with the rather similar though smaller *Lispocephala kaalae* Williams, and with *Eurynogaster minor* Parent and several other brilliantly metallic-colored but smaller dolichopodids of the same genus.

*Lispocephala fusca* often remains perched upon its steep boulder for a considerable time. Sometimes its wings rest one quite overlapping the other; more frequently perhaps, they are in a slightly separated position so that their apices each form a lobe. Other species commonly hold their wings somewhat expanded as in our common housefly. It can turn about very quickly and seems ever on the lookout for prey. However, little is known about its feeding habits. When confined in a vial with a smaller fly, it may catch and feed upon it. Sometimes it makes a short though futile dash at the little ephydrid flies that often swarm on wet boulders. On a large boulder within the draft-borne spray of an immensely lofty waterfall on the large Island of Hawaii, *Lispocephala* near *fusca* was once observed attempting to overcome *Telmatogeton torrenticola* (Terry) a sooty black chironomid fly of considerable size. Some of our species have long been known to be carnivorous (see Perkins, R. C. L., Fauna Hawaiiensis, I, Part VI, p. clxxvii, 1913).

Eggs, larvae and puparia of *Lispocephala fusca* were secured, although no flies were reared. The fly sometimes oviposited in captivity. The egg (Pl. IX, 62, side view) is dead whitish, subcylindrical. It is longitudinally ribbed except on one side where it is flattened, gently keeled and bears a fine reticulate pattern. There are strong flanges that project as lobes somewhat beyond the body of the egg. It thus much resembles the egg of *Lispa metatarsalis* which, however, is dull olive brown.

A few large larvae, some good puparia and a considerable number of hatched puparia were found on steep Mt. Kaala, Waianae Mts., at an elevation of about 3,600 feet, where a spring, well sheltered by the huge roundish leaves of the *apéapé* (*Gunnera petaloidea* Gaud., Haloragidaceae) and by other leaves furnished the proper environment. Fine matted roots from nearby plants, and moss or liverworts holding accumulations of mud and over or alongside which a thin sheet of clear water steeply flowed, yielded this *Lispocephala* material as well as puparia of *Scatella* and larvae of *Doli-*

chopodidae and of a chironomid. The well-grown pale yellowish larva of *Lispocephala fusca* (Pl. IX, 63) with its almost needle-pointed retractile fore part measures 11 millimeters—more or less—in length. The paired mouth-hooks are simple, the prothoracic spiracles (Pl. IX, 67, AS) very small, most of the segments transversely striate anteriorly; ventrally there are paired setulose protuberances or pseudopods on the abdominal segments, the pair just anterior to the anal plate being particularly well developed (Pl. IX, 69, V). On each side of the anal plate is a spinulate subconic process. The puparium (Pl. IX, 64) is brownish and retains, in a more or less suppressed manner, some of the characters of the larva. As in the puparia of certain other Diptera (*Scatella*, *Brachydeutera*, etc.) it may often be unduly bent or otherwise distorted evidently, however, to no disadvantage. The thoracic spiracles of the pupa protrude through the puparial integument as small dark points (Pl. IX, 64, TS). The pupa is considerably shorter than the puparium, lying well forward within it. I was unable to hatch any puparia in the laboratory, but a puparium containing a male fly nearly fully developed showed it to be *Lispocephala fusca*.

The fly is sometimes parasitized in its early stages by a chalcidid wasp parasite of the family Spalangidae. In fig. 64 is shown the fly puparium with a perforation near the anterior extremity through which two of these little wasps issued.

*Lispocephala kaalae* n. sp. (text fig. 1) was found associated with *L. fusca* on Mt. Kaala but appears rarer. It also is a dusky species but considerably smaller. The slightly yellowish larva has the posterior end well rounded with the spiracles mounted on short processes (Pl. IX, 68). The puparium likewise has these processes quite short.

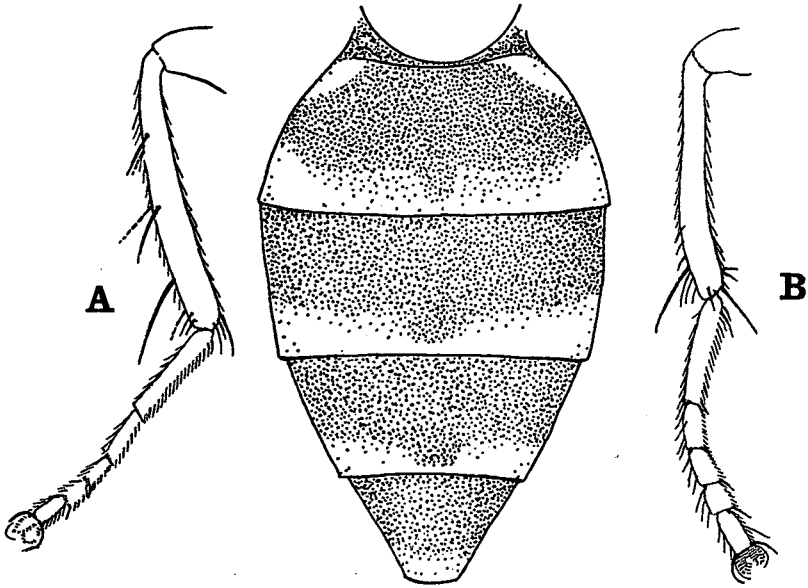
The Hawaiian species of the genus *Lispocephala* have been monographed by Dr. J. R. Malloch (Proc. Hawaiian Entomological Society VII, pp. 67-89, 1928).

***Lispocephala kaalae* n. sp.** (Text fig. 1, dorsum of abdomen of female paratype, to show pattern; A, tibia and tarsus of left posterior leg, posterior view; B, tibia and tarsus of left anterior leg, posterior view).

Female.—Head pollinose as follows: frons, vertex and occiput in part golden brown; face grayish white, parafacials pale brown; cheeks grayish white, some brown at vibrissal angles; antennae and arista black; palpi fuscous, brownish at base. Thorax brown dusted above, generally pale gray dusted elsewhere. Abdomen dusky brown above and extending laterally on 2-4; pale gray dusted on apex of 1-3, rather obscurely on apex of 4, also on each side above at base of 1; elsewhere pale gray. Legs pale gray, but knees brownish; tarsi with brownish tinge. Wings slightly smoky. Calyptrae whitish. Halteres yellow.

Frons at vertex about one third of the head width, triangle extending to frontal lunule; arista pubescent on basal half. Anterior presutural pair of dorsocentral bristles about half as long as posterior pair; both pairs of intra-alars

present. Abdomen not strongly bristled. Mid tibia with a median posterior bristle; hind tibia with three anterodorsal and three posterodorsal bristles, pre-apical dorsal bristle somewhat less than the length of metatarsus. Length 4.1 mm.



Text Fig. 1

Type: Mt. Kaala, Waianae Mts., Oahu, 3600 ft., Sept. 7, 1936 (F. X. Williams); paratypes: one female, same data, and one female issued ex puparium from wet moss of bank of *Gunnera* spring, Mt. Kaala, 3600 ft., July 13, 1933 (F. X. Williams). Type and one paratype in the collection of the Hawaiian Entomological Society. One paratype deposited in the B. P. Bishop Museum.

Related to *L. fusca* Malloch, running down in his key to couplet 19 a. Differs from *L. fusca* chiefly in its smaller size, shorter head, gray-banded abdomen, generally pale gray dusted body, and generally more feeble chaetotaxy.