Biological Studies in Hawaiian Water-Loving Insects

PART III

Diptera or Flies

B. ASTEIIDAE, SYRPHIDAE AND DOLICHOPODIDAE

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(Presented at the meeting of December 1, 1938)

FAMILY ASTEIIDAE

Stenomicra orientalis Malloch (Plate 14)

Malloch, J. R., Ann. and Mag. Nat. Hist. XX (9), pp. 24–26, pl. II, figs. 8 and 9, 1927 (male and female).

This is a pale yellow, blackish and brown fly, rather slender and measuring up to about two millimeters long (fig. 1). It seems widely distributed over the lowlands to moderate elevations in the Islands wherever suitable conditions for its subaquatic larva occur. The earliest record of its capture is 1908 (O. H. Swezey), on the Islands of Hawaii and Oahu. It has been very generally taken on sugar cane, within moisture-retaining spindles or leaf bases of which the larva probably breeds. More recently, *Stenomicra* has been associated with other kinds of monocotyledonous plants, and data on its biology thereby secured.

This active fly is remarkable for its manner of progression. We usually find it on the upper or inner surface of a long and more or less vertical leaf, as that of sugar cane (*Saccharum*), pineapple (*Ananas*), or hala (*Pandanus*). Here it will run forward, then, facing the same direction, run sidewise or retreat and then advance, so as somewhat to describe the letter U. This erratic behavior may be supplemented by a lifting and lowering of the abdomen, and thus, of the rather long overlapping wings, the whole procedure recalling somewhat the movements of certain tiny chalcidid wasps.

Early in 1932 the writer secured from Mr. O. H. Swezey two *Stenomicra* larvae that were found at the water-holding leaf base of Job's Tears (*Coix lacryma-jobi* Linn, Gramineae) (Proc. Haw'n Entom. Soc., VIII, p. 223, 1932). One adult was reared. Late in 1938, while in the fore hills of Punaluu Valley, Oahu, I chanced upon some young pineapple plants (*Ananas sativus* Schultes, Bromeliaceae) growing among tall grass and weeds. This plant harbors between its inner leaves the early stages of the ceratopogonid midge *Apelma brevis* Johannsen (see Illingworth, J. F., Proc. Haw'n Entom. Soc., VIII, pp. 541–543, 1934). Specimens of these evidently neglected bromeliads were taken, then and later, to the laboratory for examination. Besides numerous larvae and

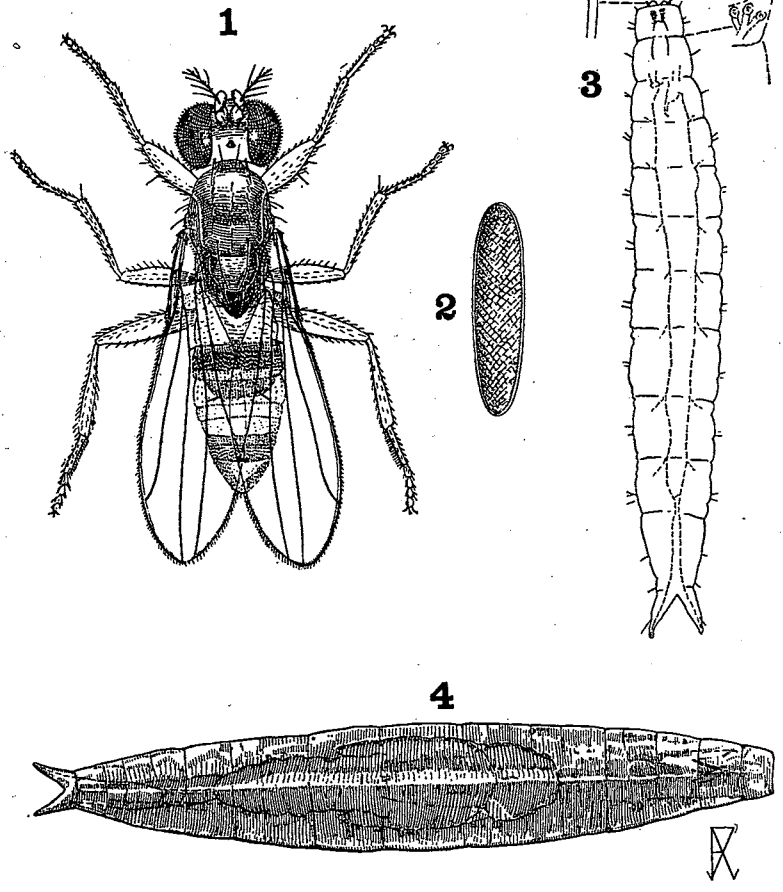
some pupae of *Apelma,* a few larvae of *Stenomicra* were found in the watery fluid usually present between the close-set inner, or near-inner leaves. In January 1939, a few young plants of the screw-pine or hala (*Pandanus tectorius*) that were not yet sufficiently grown to show the spiral-like leaf arrangement, were secured from Manoa Valley, Honolulu, and dismembered leaf by leaf—an unpleasant task because of the sharp marginal spines. The tough outer and more gaping leaf-bases often accumulated quantities of such debris as decaying leaves, portions of guava fruit and wet soil-like materials. Among the small invertebrates found in this environment were a flat sluggish mite, Crustacea, and the larva of our common spotted-wing cranefly *Limnobia perkinsi* (Grims.). As the paler, more close-set inner leaves were reached, coarser debris was excluded and the adhering droplets of moisture were more or less bereft of foreign substances and organisms became fewer. Towards this central portion, in or about the droplets, a few *Stenomicra* larvae were found. More rarely the larva occurred at the rather less favorable leaf bases, well towards the center of the tuft-like head, of the common Ti plant (*Cordyline terminalis* Kunth, Liliaceae). From these few investigations it seems probable that this fly also breeds at the leaf bases of still other plants here and of which several appear suitable.

The egg of *Stenomicra* (fig. 2) is long oval, flattened and about 0.65 mm. long. It is dead white and shows a fine cross-hatched sculpture. The very few found in the field had been laid singly and glued for their length to the surface of the leaf quite a distance above its base. The larva (fig. 3) is flattened, and, except for the blackish head skeleton and the gut content, is semi-transparent glassy white. It is provided with some short setae and transverse rows of very fine ventral spines on more or less obvious swellings or pseudopods. The head is retractile, the thoracic spiracles very small and three-fingered and the longitudinal tracheae terminate as spiracles in the forked caudal process. It is quite unable to swim, but when within a droplet of water will move its body in a vigorous undulating manner. It can creep caterpillar-like and, as with certain other subaquatic larvae often swallows air. It appears to be of scavenger habit. When ready to pupate it crawls some distance away from the leaf base, becomes firmly fixed to the leaf, the skin hardens and adds a keel to its otherwise flattened dorsal sur-

STENOMICRA ANGUSTATA

Explanation of Plate 14

1. Adult. Length to tip of wings 2.25 mm. On pineapple plant, Punaluu, Oahu.
2. Egg, dorsal view. Length 0.65 mm.
3. Larva. From base of leaves of pineapple plant. Punaluu, Oahu.
4. Puparium showing in outline the pupa within. Length 5.20 mm. From inner leaf surface of young Pandanus plant. Manoa Valley, Oahu.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face. As the pupa is formed the withdrawn larval head skeleton remains well to the front. The yellowish orange pupa (as outlined in fig. 4) is only about half the length of its container. When about to issue, the fly frees itself from the delicate pupal envelope and, working its way to the fore-end of the scale-like puparium forces apart fissure-like the upper and lower portions of the first one or two segmental divisions and crawls through this opening.

The genus *Stenomicra* is represented by very few species. Malloch (*l.c.,* pp. 23–26, pl. II, 1927) gives a key to the four species, three of which are described as new. *S. angustata* Coquillet was described from Porto Rico; *S. australis* Malloch from Queensland, Australia. The author figures its puparium that was found on a banana leaf and resembles that of our local species. *S. fascipennis* is from Luzon, Philippine Islands.

FAMILY SYRPHIDAE

This extensive family of often large and showy flies is represented in the Hawaiian Islands by only 11 species, all of which are probably recent to very recent immigrants, and several of wide distribution. Five of these 11 species may be considered as passing their larval stages in a more or less watery medium, with a sixth species, *Syritta oceanica* Macq., partial to wet decaying plant tissues, somewhat on the borderline.

Volucella obesa (Fabr.) is a large compact, brilliantly metallic bluish green species. It often breeds in thick foul bodies of water, in rotten cactus stems (Swezey, O. H., Proc. Haw'n Entom. Soc., VIII, 28, 1932), sisal juice (Weinrich, W., *id.,* I, p. 25, 1906), filter press mud (Williams, F. X., *id.,* VIII, p. 233, 1933), etc., while Illingworth (*Id.,* p. 83, 1915, & VII, 252, 1929) found it in living papaya stems as well as in a decayed one. The fly attaches a mass of white eggs to a blade of grass or other suitable object near the source of larval food. Both larvae and pupae have relatively short posterior breathing tubes.

Volucella pusilla Macq. is a more recent immigrant, having first been collected here by J. S. Rosa in 1930. It is smaller than *V. obesa* and chiefly brown and yellow with marked wings. Mr. Swezey found it breeding in decaying stems of *Opuntia* and *Hylocereus* cacti. The writer found larvae of this insect breeding in the liquid of decaying pieces of *Opuntia,* on the summit of Koko Crater, Oahu.

Eristalis tenax (L.) the common drone, or drain fly is a large brownish bee-like species. It is not very abundant in Hawaii, where it favors the cooler elevations. Of this insect, G. H. Verrall (Platypezidae, Pipunculidae, and Syrphidae of Great Britain, London, 1901, on p. 674) comments, as follows: "The common *Eristalis tenax* is essentially the 'Drain Fly' of the whole world, as it has followed all over the world what civilization has considered

its improved sanitary arrangements of drainage, and it has been very interesting to watch the lines of route and the length of time that it has taken to arrive at new localities (*v.* page 508)." Its rat-tailed maggot has a breathing tube that is extrusile for a length of several inches. This species was well known to the ancients. And about two centuries ago R. H. Reamur published his classical memoir upon this fly. For a very readable account, with illustrations of *Eristalis tenax* the reader is referred to L. C. Miall's "The Natural History of Aquatic Insects," 1895: London and New York. Good figures of the early stages of this insect are also found in C. L. Metcalf's "Life-Histories of Syrphidae, V." (Ohio Naturalist, XIII, No. 5, on Pl. V.)

Lathyropthalmus* arvorum (Fabricius) (Plate 15)

Syrphus arvorum Fabricius, Mantissa Insect., II, 335. 16. 1787.

This shrill-humming bee-like fly with black-striped thorax measures up to about half an inch long (fig. 5). It is widely distributed in Indo-Malaya and Australasia. First taken in the Hawaiian Islands in 1900 (Grimshaw, P. H., Diptera, supplement: Fauna Hawaiiensis, III, pt. 2, 1902, on p. 82, as *Eristalis punctulatus* Macq. Honolulu), it is an abundant and conspicuous insect of our lowlands. In the male fly the immense compound eyes meet broadly at the top of the head.

Of the early stages of this insect, F. W. Terry (Hawaiian Forester and Agriculturist, III, 2, 1906, on p. 39, cited as *Eristalis punctulatus*) writes as follows: "The larva is aquatic, living in stagnant and foul water, feeding upon stable refuse or decaying vegetation, around which the female flies may frequently be observed depositing masses of white slender eggs. The whitish larva is maggot-like and semi-translucent, the digestive and other organs being easily visible through the tough skin; it belongs to that type known as "rat-tailed," since it possesses a very long and protusile breathing-tube, which is capable of being extended for nearly two inches; by this means the larva can remain hidden in the submerged mud and continue its respiration unchecked."

It is also known to breed in pineapple and sisal refuse (Bridwell, J. C., Proc. Haw'n Entom. Soc., IV, 360, 1919) and in filter-press mud used in sugar cane fields (Williams, F. X., Proc. Haw'n Entom. Soc., VIII, 233, 1933), in pools rendered foul with decaying guavas, in sewage, etc.

The egg is whitish, rather elongate and adorned with tiny oblong areas (fig. 8). The micropyle is at the narrower end. It measures about 1.35 mm. In a few days it hatches, the larva being immediately of much greater apparent bulk than its recent container (fig. 9). There are short bristles at the head end and very sparse

* *Lathyropthalmus* (Mik, J. Wien Entom. Zeitg., 16, pp. 114–115, 1897) is regarded by Mik and some others as a subgenus of *Eristalis*.

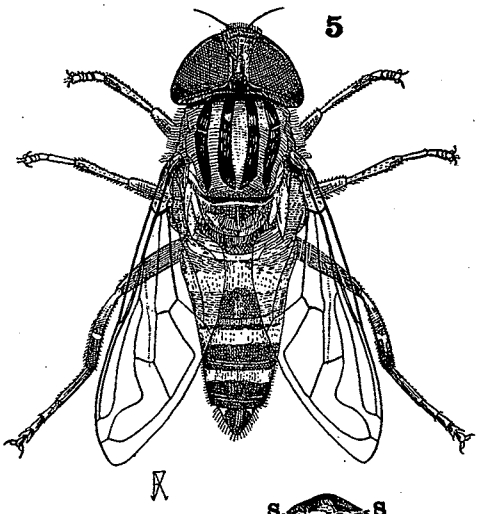
fine hairs rather generally, on the body. The short though obvious antennae are situated above the generous mouth and seven pairs of hook-armed pseudpods, the first pair well forward, are present on the underside of the body. The silvery longitudinal tracheae, swollen reservoir-like near their middle length lead into the telescopic breathing tube that terminates in spiracles. As the larva increases in size and moults it assumes a more hirsute and transversely wrinkled appearance, and a pair of short dark horn-like spiracles appear at the head end. Full fed, it may be 20 mm. long exclusive of the tail that is extrusile to 50 mm. or more (fig. 11). Well behind the functional anterior spiracles and approximately above or opposite the second pair of prolegs is a pair of ringed circular areas. Here in the puparium will protrude the larger pair of thoracic horns or spiracles. The rather thick basal portion of the tail is wrinkled, hairy, and even papillose; beyond, it becomes more slender and bears many fine spinules, and finally it terminates as a thread like tube wherein two longitudinal tracheae are plainly visible. These lose their tracheal character just before the extremity of the tube. The extremity is surrounded by 8 short-fringed hairs above the base of which are the spiracles or breathing pores (fig. 7, SS). These fringed hairs form a coronet that rests upon and depresses somewhat basin-like, the surface film of water and exposes the spiracles to the air.

The *Lathyropthalmus* larva is hardly able to swim, and when lifted out of its liquid environment is about as flabby, I should imagine, as a stranded whale, though not as helpless. It can, however, creep along with caterpillar-like undulations. When time for forming the puparium is at hand the larva seeks firmer ground, in captivity crawling well up or out of a jar. Now the skin soon hardens, darkens and contracts into a leathery case from the fore end of which, horn-like, the two pairs of respiratory processes, connecting within the tracheae, will protrude (fig. 10). In two out of six puparia formed under laboratory conditions only the more anterior or smaller pair of respiratory processes were formed. In issuing, the fly pushes off the fore end of the puparium.

LATHYROPTHALMUS ARVORUM

EXPLANATION OF PLATE 15

5. Female fly. Length 12.5 mm.
6. Puparium, from side. Greatly enlarged.
7. Extremity of respiratory tube of last stage larva showing tail coronet, that consists of 8 fringed hairs. S.S., spiracles. The two tracheal tubes are represented by broken lines. Greatly enlarged.
8. Egg and detail of its sculpture. Length 1.35 mm.
9. Larva in first stage, side view. G, anal gills. Greatly enlarged.
10. Pupa, with all but the anterior end (A) of envelope or puparium removed, the rest being represented by broken lines. T.T., tracheae leading from the respiratory horns. Length of pupa 8.8 mm.
11. Group of last stage larvae with their respiratory processes so extended as to reach the surface of the water. These tubular processes measure about 2 inches. Enlarged.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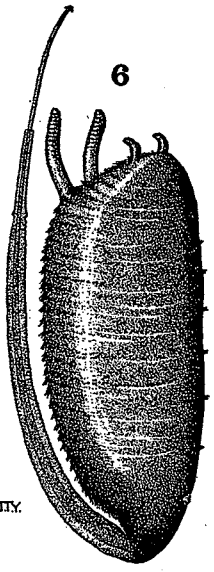
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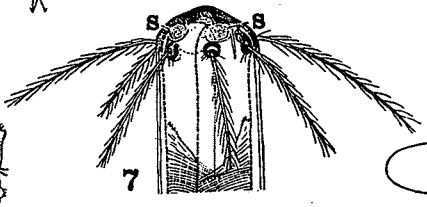
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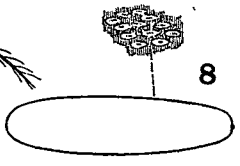
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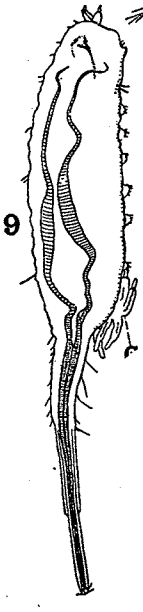
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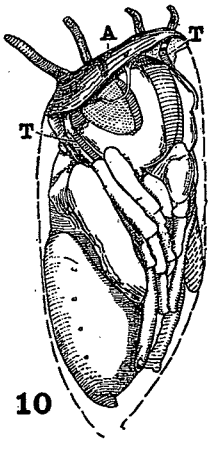
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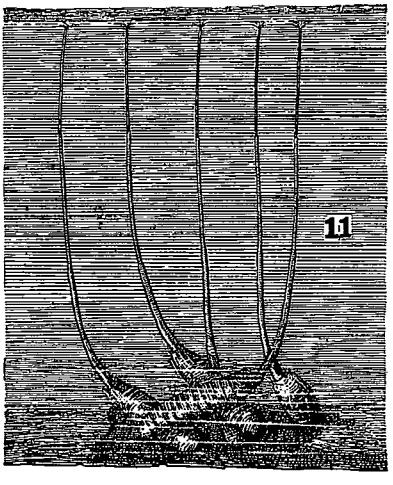
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An ichneumonid wasp, apparently of the genus *Phygadeuon,* has been reared from the puparium of this syrphid found in filter-press mud near Hilo, Hawaii. (Williams, F. X., Proc. Haw'n Entom. Soc., VIII, p. 233, 1933.)

I am indebted to Mr. F. K. Lee, manager of the anti-mosquito league here, for specimens of the larva of this fly as well as for considerable other aquatic material.

Lathyropthalmus aeneus (Scopuli) is bronzy black with several thin gray thoracic stripes. It was first recorded here in 1919 by H. T. Osborn (Proc. Haw'n Entom. Soc., IV, pp. 329, 339, 1920) from a dead specimen taken at a window by O. H. Swezey. It is widely distributed in Europe and in North America. Little or nothing seems to be known of its early stages here. In Ohio, C. L. Metcalf has worked out the life-history and given excellent illustrations of its various stages. (The Ohio Naturalist, XIII, No. 5, on pp. 84–89, and pl. IV, figs. 149–150, pl. V, figs. 145–148, 1913.) The larva which has a breathing tube capable of considerable elongation, occurred in sewage, and, "These larvae can progress through the water by undulatory constrictions of the body, or creep over submerged or exposed objects by the aid of their prolegs" (p. 87).

Trichogramma japonicum Ashm., a minute parasitic wasp imported from Japan has been bred by D. T. Fullaway from eggs of one of our larger syrphids. These eggs suggest those of a *Lathyropthalmus.* The eggs were found on a rice stem (Proc. Haw'n Entom. Soc., IX, 373, 1937).

FAMILY DOLICHOPODIDAE

This large family of carnivorous flies comprising about 100 described Hawaiian species nearly all of which appear to be native insects has only recently been given much attention. Most of the species are described from the Island of Oahu, and when the other large Islands of the Archipelago have been adequately explored for these insects their number might well be doubled. The Dolichopodidae are often, or perhaps usually, metallic green, blue or bronzy flies, though many of the Hawaiian species are relatively dull colored. Their ecology, or relation to environment, is of great interest. Some of our species have a wide range while others have a very specialized habitat. The two species of the Hawaiian genus *Emperoptera* have undeveloped wings and are thus unable to fly though active jumpers. Dolichopodid larvae are carnivorous, cylindrical tapering at the poorly developed head and nearly truncate at the lobed posterior end. A cocoon is formed. The pupae have well developed often very long thoracic respiratory processes.

Certain species may be classified as definitely beneficial. The larva of *Medetera* has been found attacking beetle borers. An excellent account of such a species is that by Donald De Leon entitled

"A Study of Medetera aldrichii Wh. (Diptera, Dolichopodidae), a Predator of the Mountain Pine Beetle (Dendroctonus monticolae Hopk., Coleo-Scolytidae)" (Entom. Americana, XV, pp. 59–92, 4 pls., 1935).

The adults of several species of the genus *Dolichopus* are sometimes effective destroyers of mosquito larvae and pupae, as observed by S. C. Bishop and R. C. Hart (Notes on Some Natural Enemies of the Mosquito in Colorado; Journ. New York Entom. Soc., XXXIX, pp. 151–157, 1931). These two authors also refer to Howard, Dyar and Knab in, The Mosquitoes of North and Central America and the West Indies, I: 170, 1912, where they ". . . record the capture in Panama, of mosquito larvae by flies of the family Dolichopodidae but the species involved were not determined."

Dolichopodidae are among the numerous kinds of flies captured by our Hawaiian crabronid wasps. For example, *Melanocrabro discrepans* Giffard of the Island of Kauai has been found storing its tunnel in a tree stump with a submetallic greenish dolichopodid, evidently a new species of the genus *Eurynogaster*.

The principal systematic papers on Hawaiian Dolichopodidae are chiefly of recent date. The earlier descriptions are mainly by P. H. Grimshaw in Fauna Hawaiiensis, III, Pt. 1, and III, Pt. 2 (Suppl. to Diptera), 1902; *Dolichopus exsul* was described by J. M. Aldrich in Proc. U. S. Nat. Museum, 61, No. 2446, 1922, on pp. 15 & 16; P. H. Timberlake, in Proc. Haw'n Entom. Soc., V, 190, 1923, lists several genera and a species; J. R. Malloch describes several species, of *Campsicnemus* from Oahu and gives a key to the Hawaiian species of that genus in Stylops, I, pt. 6, 1932, on pp. 121–124; M. C. Van Duzee, in Proc. Haw'n Entom. Soc., VIII, pp. 307–357, Pls. 22–25, 1933, monographed the Hawaiian Dolichopodidae, describing two new genera and many new species; finally, Abbe O. Parent described one new Hawaiian genus and several new species in Mem. de la Soc. Nationale des Sciences Naturelles et Mathematiques de Cherbourg, Tome XLI, pp. 257–308, Expl. of plates and Pls. 67–79, 1934; other papers by Abbe O. Parent are: Dipteres Dolichopodides, Espèces et Localités. Bull. et Ann. de la Société Entom. de Belg., LXXVII, pp. 125–148, 1937; Quelques Dipteres Dolichopodides de Iles Hawaii, Konowia, XVI, Pt. 1, pp. 67–84, 17 Figs., 1938; Idem, Pts. 3 & 4, pp. 208–219, 14 Figs., 1938, and Proc. Haw'n Entom. Soc., X, 2, pp. 225–249, Figs. 1–42, 1939. Many new species are described in these papers. Some other contributors to the knowledge of Hawaiian Dolichopodidae are: E. H. Bryan, Jr., in A Review of the Hawaiian Diptera, with Descriptions of New Species, Proc. Haw'n Entom. Soc., VIII, pp. 399–468; F. X. Williams, Proc. Haw'n Entom. Soc., X, pp. 120–129, 2 pls., 1938; E. C. Zimmerman, Proc. Haw'n Entom. Soc., X, pp. 145–148, 1938 (Emperoptera from Maui (Diptera, Dolichopodidae)).

A brief review of the Hawaiian Dolichopodidae is given by Dr. R. C. L. Perkins, in Fauna Hawaiiensis, I, Introd. on p. clxxxiii, 1913.

Among the American papers on the early stages of Dolichopodidae are: Malloch, J. R. A preliminary classification of Diptera, exclusive of Pupipara, based upon larval and pupal characters, with keys to imagines in certain families; Part I. Illinois State Lab., Nat. Hist. Bull. 12 (1915–17), 161–410, 1918; Johannsen, O. A., Cornell Univ. Agric. Exp. Sta., Aquatic Diptera, Pt. II. Orthorrhapha—Brachycera and Cyclorrhapha; Mem. 177, pp. 1–62, Pls. I–XII, 1935. Other references are found in the text.

Campsicnemus Walker (Plate 16)

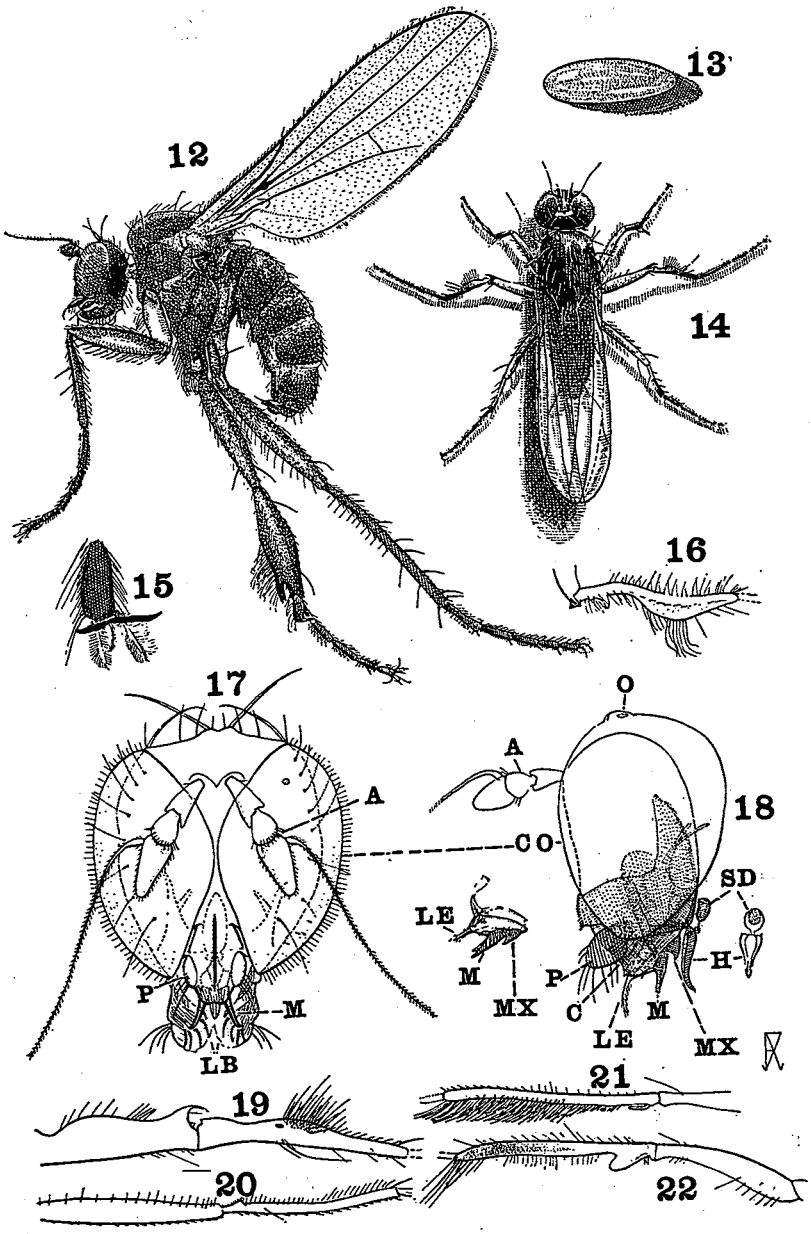
Walker, Insecta Brittanica, Dipt., I, 187, VI (1851).

The widely distributed genus *Campsicnemus* thus far includes about 50 Hawaiian species or over half of our described Dolichopodidae. These consist of mainly dull-colored flies (the top of the head is often of a metallic hue) representing several different forest environments. Many species occur on paths or on the leaf-littered forest floor, others walk or skate upon the surface of puddles or stream pools, others still are found on the leaves of plants where they may be exposed to sunlight. Finally, in very humid regions a small number patronize the stems of bananas (*Musa*) and of other plants. Of those found on the forest floor nearly all are brownish, some few being in part whitish while one or two are practically all whitish. Those on the surface of the water are brownish to black, the several associated with high lights and green leaves are in great measure metallic green or bluish. A few brown or more or less brilliant species may be found on the stems of plants. Much further study, however, on these insects is needed to more accurately establish their ecological relationships.

CAMPSICNEMUS

Explanation of Plate 16

12. *Campsicnemus miritibialis,* male—Oahu.
13. *Campsicnemus* sp., egg of a water-riding species. Length 0.46 mm. Oahu.
14. *Campsicnemus williamsi,* male. Length to tip of wing, 4 mm. Oahu.
15. *Campsicnemus miritibialis,* last tarsal joint.
16. *Campsicnemus sinuatus,* mid-femur. Nauhi, Hawaii.
17. *Campsicnemus* sp., head. Oahu.
18. *Campsicnemus* sp., head, side view, with labella removed.
    Explanation of Figs. 17 and 18: A, antenna; C, clypeus; CO, compound eye; H. hypopharynx; LB, labella; L-E, labrum-epipharynx; M, mandibles (these can move laterally); MX, maxillae; O, ocelli; P, maxillary palpus; SD, receptacle of salivary glands.
19. *Campsicnemus williamsi.* Male, mid femur. Oahu.
20. *Campsicnemus grimshawi.* Male, mid femur. Nauhi, Hawaii.
21. *Campsicnemus* sp. Male, mid femur. Nauhi, Hawaii.
22. *Campsicnemus gloriosus.* Male, mid femur. Oahu.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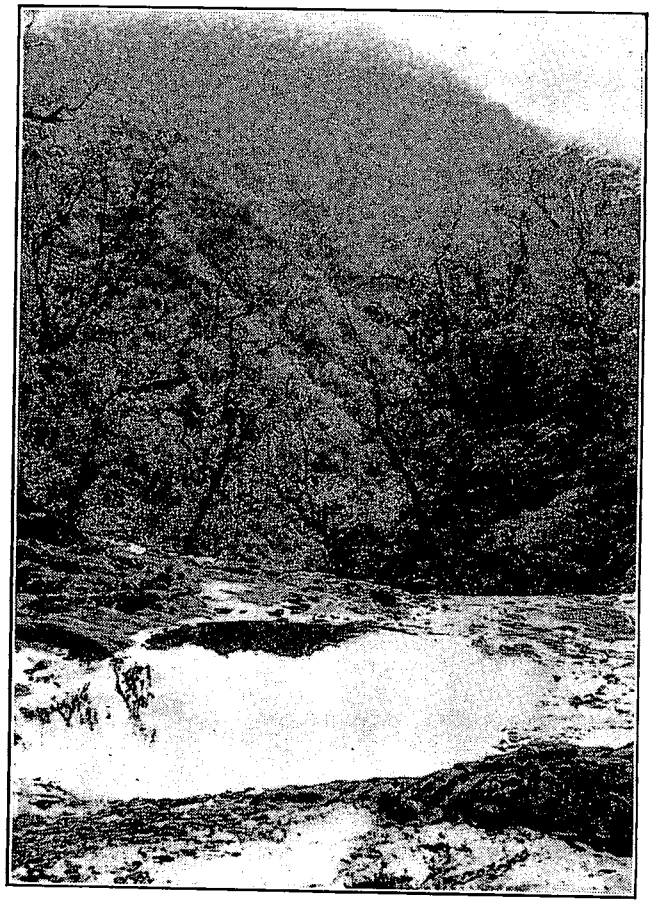
In the Proceedings of the Hawaiian Entomological Society, VIII, on pp. 307–309, 1933, in the preface to an extensive paper by M. C. Van Duzee on "New Dolichopodidae from the Hawaiian Islands," I have given a short account of some of the habits of a few *Campsicnemus*. Since then I have added but little relative to these numerous flies. As usual, the observations that follow have been made chiefly on the Island of Oahu.

At least 16 species of Hawaiian *Campsicnemus* are known to disport themselves upon the surface of water. Such waters include mud puddles, canyon pools and the quieter parts of streams. None appear to have been found here on lowland reservoirs nor yet on brackish waters. Proficiency upon the surface film varies with the species. Some, standing rather high on their legs walk briskly on or run over the water, readily turning about when something attracts them from the rear, others travel more quickly, while the most adept of all skate, with middle legs more extended, with a speed that is hard to follow. Progress is commonly aided by a flick of the wings or even a short flight. In general, I would state that the less skilful water-riders occur upon mere puddles and little, more or less disconnected pools—or failing these temporarily, are content with wet ground, while the accomplished skaters are found upon the more permanent streams. In the first group at least, there are often two species found upon the same little body of water. One of these is almost sure to be the small *C. gloriosus* V. D. (fig. 22; mid femur and tibia). And in this group I have occasionally seen a *Campsicnemus* fly overtake the young of the common little water-running bug *Microvelia vagans* (White) but never seriously to attack it. The larger collembolous insects often found upon the water seem generally to be pursued in vain. Insects like some of our native psyllid bugs, *Trioza iolani* Kirk., for example, may fall and drown in the water and are then fed upon by the flies. Hence, their food may consist largely of non-aquatic insects and is to that extent of an accidental nature. But in the second group the flies are larger and swifter; collembolous insects too large for the smaller *Campsicnemus* flies often fall a victim to them and, in addition, a more natural and dependable source of food is to be found in the several species of midges that breed in the more permanent streams. At Nauhi, Hawaii, situated about a mile high on the slopes of Mauna Kea, *Campsicnemus tibialis* V.D. moves quite skilfully over the surface of pools of the little stream there. This species also occurs at much lower levels. *C. bicoloripes* Parent, of Oahu, is found rather widely distributed at 2000 feet elevation, or less along the Koolau Range. It is a dark vigorous species that skates swiftly in areas often in the shelter of boulders and where also there may be a perceptible current. Such a habitat is the Kaluanui stream. It was found also on small pools that constituted the very headwaters of a little stream flowing into Manoa Valley. At Kokee, Kauai, at an elevation of

over 3000 feet *C. nigricollis* V.D. is a fine performer upon mountain streams. This insect was first collected by H. T. Osborn in 1919.

Thus far not found on the windward side of the Koolau Mountains, Oahu, but observed only on some of the streams in the immediate vicinity of Honolulu, is *Campsicnemus miritibialis* V.D. This is a relatively large dusky species that measures up to nearly 3 mm. in length of body (figs. 12 and 15). Because of his greatly thickened, spurred and tufted mid-tibiae, the male may be recognized even as he courses swiftly over the surface of the water. This fly is by far the best performer of all the water-loving *Campsicnemus* observed on Oahu. The only other aquatic insects that may exceed it in swiftness are the large erratic *Telmatogeton* midges that half fly and half run over the water. Employing the middle pair of legs and aided also by the shining flicking wings *C. miritibialis* propels itself in sometimes almost invisibly swift and graceful gyrations. It is also capable of leaping in the air a short distance. Very often it courses over a more or less restricted beat—frequently the head of a little pool where there may be a gentle current. When one fly encounters another on such a beat there is usually an extremely rapid though brief scuffle. Sometimes the flies occur in rather loose crowds of perhaps two or three dozen, and then moving less swiftly, two or three specimens may be captured at one time by quickly placing a wide-mouth jar over them. Even inclement weather, such as often prevails in the mountains, may not altogether prevent their activities. In numerous field studies I located a number of "roosts" where these flies habitually retired. A fly swiftly approaching a certain rock ledge or depression in a steep dripping bank, would run up the slope a few millimeters, or reach it by a low heavy flight, and then usually turn head downwards. Both sexes were thus to be found, including individuals that were consuming their prey. Flies that I disturbed would dash away wildly, often to return at the same quick pace. I have in mind a tiny bayou of a pool in the Lulumahu stream at an altitude of about 1750 feet. Part of this shallow pocket was bounded by a rocky vertical wall some three or four inches high. Here over a period of several years this water-skater was observed roosting. The pool (Text fig. 1) situated just above a 30-foot waterfall was fed at one side as well as at the far end by a gentle and very shallow flow over sloping rock. Subaquatic moss, and green and brown algae were prominent on this rock slope, and numerous *Scatella* flies (Ephydridae) and green *Tanytarsus* midges and dusky little *Dasyhelea* ones bred in this medium. *Campsicnemus* patrolled the placid water below, sometimes lazily maintaining themselves against the wind or slight current or moving swiftly over the surface. Occasionally a *Scatella,* newly hatched, quite lacking in energy and with wings still in a crumpled undeveloped condition, would float onto the pool from the rocky slope. The alert *Campsicnemus* stationed towards the inflow appeared to heed this help-



TEXT FIG. 1. Pool along the Lulumahu Stream, Koolau Mts., Oahu at an elevation of about 1750 ft. This pool is just above a 30-ft. waterfall and is much favored by the dolichopodid fly, *Campsicnemus miritibialis*.

less insect little or not at all—according to my very few observations. But *Tanytarsus*—the pupal shells of which were common among the algae—though developing with great rapidity and soon taking wing, very frequently alighted once or twice at short intervals, and thus progressing down current was sometimes carried on to the pool and there immediately seized, before it could essay another flight, by its dusky enemy. *Campsicnemus miritibialis* bears this prey in its mouth, feeding while skating swiftly or, retiring to a roost, consumes it at leisure. Similarly, in the rocky bank of an upper pool several little depressions glistening with water might

harbor individuals that were merely resting or consuming *Tanytarsus* midges. The tiny ceratopogonine fly, *Dasyhelea hawaiiensis* Macfie and certain insects that fall into the water are also devoured by this fly. Near the base of a waterfall in Manoa Valley, the rather large and active springtail *Salina maculata* Folsom, leaping or falling into the water were often, after a considerable chase, captured and eaten by *C. miritibialis*. It seems ever on the lookout for prey, and even passing air bubbles may be examined.

Thus far, the early stages of this dolichopodid remain unknown. Fine algae and other plants were scraped off its roosts and examined. Very fat-bodied females frequently rested on wet rocky concavities from a few millimeters to several centimeters above the water line, but no ovipositions were seen. Such flies were also confined in tubes or jars provided with wet algae, etc., with negative results. Dissections showed that turgid females did contain many eggs. Apparently well developed eggs much resemble those of smaller water-riding *Campsicnemus* (fig. 13), or of the arboreal *C. fumipennis* Parent, and measured 0.5 mm. long. A single very young larva with posterior armaments much like those of first-stage larvae of *Eurynogaster minor* Parent, was dissected out of fine algae secured from a tiny water-saturated cave along the Lulumahu stream (Text fig. 2) and where only *C. miritibialis* was observed

TEXT FIG. 2. Lulumahu Stream at about 1750 ft. Where the dripping wet rock bank touches the water and a little to the left of the middle of the picture is an indention or tiny shallow cave, a favorite roost for *Campsicnemus miritibialis*.

roosting. Early in February, 1939, "traps" consisting of metal screen bags filled with algae, old vegetation, etc., were fastened against several "roosts" so as to be partly submerged, along the above stream. When visited more than two months later these bags had been swept away in winter floods. It is hoped that eventually the life-history of this interesting fly will be worked out. This has been done to some extent for the genus with *C. fumipennis,* patron of banana stems (Proc. Haw'n Entom. Soc., X, pp. 120–126, Pl. X, 1938).

I have a single record of rearing *Campsicnemus gloriosus* (Proc. Haw'n Entom. Soc., VIII, pp. 308–309, 1932). Females were induced to lay their smooth long-oval, pale brown eggs on wet cotton stoppers. But other females were enclosed in a jar containing very wet mud, moss and plant stems harboring such animal life as tiny worms and copepod Crustacea, this material being from a locality some distance removed from that in which the flies were captured. Over five weeks later a male *C. gloriosus,* probable progeny of one of the enclosed females issued from the mud.

The following is a list of Hawaiian *Campsicnemus* known to frequent the surface of water:

C. bicoloripes Parent. Koolau Mts., Oahu.
C. concavus V.D. Koolau Mts., Oahu.
C. crinitibia V.D. Waianae Mts., Oahu.
C. gloriosus V.D. Oahu.
C. grimshawi V.D. Nauhi, Hawaii, 5000 ft.
C. miritibialis V.D. Koolau Mts., near Honolulu, Oahu.
C. nigricollis V.D. Kokee, Kauai Mts.
C. obscurus Parent. East Molokai Mts.
C. obtusus V.D. Mt. Kaala, Oahu.
C. octosetosus V.D. Kahana, Oahu 2000 ft.
C. simplicipes Parent. East Molokai Mts.
C. sinuatus V.D. Nauhi, Hawaii, 5000 ft.
C. spinitibia V.D. Nauhi, Hawaii, 5000 ft.
C. tibialis V.D. Nauhi, Akaka Falls, Hawaii.
C. williamsi V.D. Oahu, both ranges.
C. sp.?. Nauhi, Hawaii, 5000 ft.

Further collecting will probably more than double this number.

Of other genera of Hawaiian Dolichopodidae that frequent wet places are two very adaptable, more or less metallic greenish species, namely, *Dolichopus exsul* Aldrich and *Syntormon distortitarsis* V.D. Both may range from near the seashore to well into the mountains. *Dolichopus exsul,* one of the apparently few tropical species in a large and widespread genus occurs abundantly along ditches, streams, muddy trails, leaky garden faucets, etc. Some of its family associates are *Syntormon* and *Chrysotus* spp. *Dolichopus* restlessly explores pool margins, etc., and occasionally alights on a floating mass of algae. The larva is semi-aquatic and has been found in the muddy soil about a leaky faucet. *Syntormon distortitarsis* is likewise very common and apparently well distributed over

the Archipelago. The male has the habit which rather easily identifies the species, of poising a short distance in the air before the alighted female and finally of darting down at her. Both *Dolichopus* and *Syntormon* seem generally to inhabit rather open sunny places, and are thus not associated with many of the native species, as some of the often brilliantly colored flies of the endemic genus *Eurynogaster,* that patronize shady and even quite dark places along springs. The tiny dolichopodids of the genus *Chrysotus,* of which perhaps *C. pallidipalpus* Van Duzee is the most abundant on Oahu, frequent stream sides, wet rocks, and trails, low herbage, leaky faucet areas, and occur also in greenhouses. *Chrysotus* are of metallic coloration, and the males at least in some species, have greatly developed maxillary palpi which hang down like pale curtains from the head.

Finally, a single rather stout-bodied, rather spiniferous little dolichopodid larva was secured from between the moist leaf bases of the *ieie* vine, *Freycinetia arborea* Gaud; (Pandanaceae), at Palikea, Waianae Mountains, at an elevation of about 3000 feet.

Eurynogaster Van Duzee (Plates 17, 18 and 19)

Van Duzee, M. C., Proc. Haw'n Entom. Soc., VIII, pp. 339–340, Figs. 68–74, 1933.

The flies of this Hawaiian genus are usually upland or forest species. The ones that occur along streams, waterfalls, wet boulders bordering rapids, at springs and dripping wet banks are largely brilliant blue, green or coppery, while those frequenting the forest floor or trails and often the leaves of plants, are of duller hues. As far as known, the first of these two groups have aquatic or semi-aquatic larvae, and these will be considered here.

If we ascend the slopes of rugged Mt. Kaala, highest summit in the Waianae Range, Island of Oahu, the trail follows a narrow wooded ridge that at an altitude of about 3500 ft, and well within the cloud zone, passes over a wall of rock, cleft immediately to the right by a precipitous gully containing a small though perennial flow of cool clear water. This spring is well shaded by the giant roundish leaves of *apeʻapeʻ* (*Gunnera petaloidea* Gaud., Haloragidaceae) (Text fig. 3), *olona* (*Touchardia latifolia* Gaud., Urticaceae), *Cyrtandra* and other large-leaved plants. It extends back for some distance, where the lessening gradient permits muddy soil to accumulate along its small flows and pools and to form boggy areas. Much of this stretch is in the semi-gloom. Little rocky banks (Text fig. 4) exposed here and there to sunlight are bright with dripping or sheet-like water, saturated algae, liverworts, moss, brown diatoms, fine soil-like debris, etc.

Six species of *Eurynogaster* were found closely associated with this spring, as follows: *E. apicenigra* Parent; *E. obscurifacies* Parent—rarest and the least shining metallic—; *E. luteihalterata*

TEXT FIG. 3. *Apéapé* (*Gunnera petaloidea* Gaud., Haloragidaceae) growing in a boggy area at an elevation of about 3500 ft., in Mt. Kaala, Waianae Mts., Oahu.

Parent; *E. minor* (Parent)—the largest—; *E. nigrohalterata* Parent; and *E. viridifacies* Parent, the most abundant.

My observations on the ecology of these flies are very fragmentary, and I think that a more extended study on them would reveal that each species has a more or less special station or habitat, bearing on the amount of high light, gloom, relation to water flow, slope, materials, etc. *E. minor,* for example, appears to favor the steep banks with patchy high lights (water, etc., reflections), others seem to prefer obscurity, and *E. apicenigra* and *viridifacies* may also be seen in the sunlight on the large leaves of *Touchardia* that helps shade their watery environment.

TEXT FIG. 4. Dripping wet bank on Mt. Kaala, Oahu. The elevation is about 3500 ft. Portions of two Apeape leaves (the left withered) appear in the upper part of the picture; while at the far right are a few leaves of *Olona* (*Touchardia latifolia* Gaud.; Urticaceae). Six species of *Eurynogaster* are among the water-loving flies occurring along this spring.

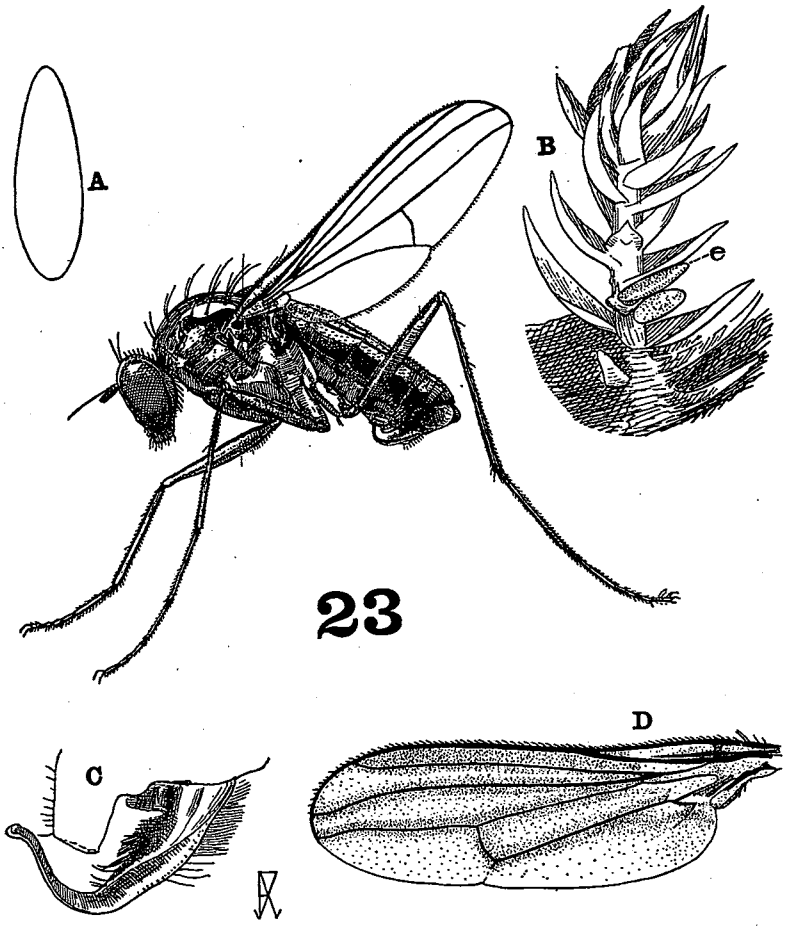
A little of the life-history of *E. minor* is known. This large species (fig. 23) is about 4 mm. long, metallic green with some blue and coppery, and iridescent wings. The arista of the antennae has a slightly club-shaped appearance due to the fine close-set ciliae at its distal end. Though brilliant, it is not conspicuous as it rests head upwards and high on its legs on a dripping-wet bank. The male may sometimes be seen courting the female—placing himself a half inch or so behind her and fluttering his wings at short intervals. A few females were observed laying eggs on fine plant growth on

a vertical bank sheeted over with water (Text fig. 4). The eggs were glued singly or a few side by side for their length; in one case on a tiny bit of moss just above the water line (fig. 23,A and B) and in another, among submerged green algae. They are slender, amber yellow and about 0.65–0.70 mm. long. Captive females likewise firmly glued their eggs on suitable materials. One individual may lay over 100 eggs, as determined by dissection. As far as could be determined, the incubation period appeared to be in the neighborhood of a week or a little more. The hatching *Eurynogaster* larva escapes from the egg shell by cutting a slit that extends from the apex of the narrower end to a little past the middle length where it is rather suddenly curved. The larva is then about twice the length of the egg and shows a well-silvered tracheal system in its semi-transparent body. Posteriorly, the four lobes that are provided with tufts of long bristles may be brought together for closure (fig. 28). Note that the spiracles are placed very close to the apex of each dorsal lobe (fig. 31). Lateroventrad on each side of the anal convexity is a hook-tipped pseudopod-like process, while slightly anterior to these in the mid-ventral region is a transverse row of hooks (fig. 29). This armament which disappears with moulting, may perhaps serve at times to anchor the larva against the current. A considerable number of *Eurynogaster* larvae were secured. Based on size—up to 13.5 mm. or more—and on further development, a good proportion of these were *E. minor*. On a steep, nearly bare wet rock bank alongside the spring a very slender and active *Eurynogaster* larva was found. Accumulations of fine brownish materials, mostly diatoms, or other fine plant life, on steep watered banks sometimes yielded *Eurynogaster* larvae, but these were more commonly obtained from the compact, flattened mop-like masses of fine roots of such plants as *Touchardia,* firmly pressed against the rocky substratum, and over or alongside which a sheet of water flowed, or that were merely water-soaked. Such well-shaded root-masses contained mud and silt, and when dissected out in a dish of water often proved rich in various water-loving larvae and pupae. Occasionally a less slender dolichopodid larva with shorter posterior lobes was found in the catch. Present also were early stages of *Scatella* flies (Ephydridae), those of *Lispocephala* (Anthomyiidae), as well as of *Tanytarsus* and *Spaniotoma?* (Chironomidae), these last two probably serving in large measure as food for the *Eurynogaster* and the other carnivorous fly larvae.

EURYNOGASTER MINOR AND HYDROPHORUS WILLIAMSI

Explanation of Plate 17

23. Male, from the side, Koolau Mts., Oahu. Inset at A, egg, greatly enlarged; at B. subaquatic moss, showing on one of the lower scales two eggs, the slender upper one is that of *E. minor,* the lower stouter one is probably that of an ephydrid fly; at C, aedeagus, from side, Mt. Kaala, Oahu; at D, wing of Hydrophorus williamsi, male; Molokai.


A
B
e
23
C
D

The larva of *E. minor* is whitish or pale yellowish, more slender than usual among the dolichopodid larvae with which I am familiar, and almost smooth, a slight fine roughness appearing in profile on some of the segments. Ventro-laterally on each thoracic segment is a tuft of four bristles (fig. 24,A). These are present in all the larval instars. Though hardly able to swim, it is very active, bending almost in a circle. They will devour one another in captivity. Well-grown specimens were placed in separate salve boxes or vials supplied with a bit of towel paper, fine rootlets and diatomaceous material, all well saturated with water. They were fed larvae of mosquitoes and of smaller midges. Such, more or less, is their natural food, as shown by an examination of gut contents of the specimens, the alimentary canal of one larva containing numerous portions of tracheal tubes and the head capsule and body portion of what seemed to be a *Spaniotoma.* Another *Eurynogaster* larva had swallowed a diatom and a quantity of hair-like material or bristles. Indifferent success attended my efforts at rearing these larvae. Several of the far-advanced individuals formed firm short-oval cocoons, gluing fine debris, etc., together. The interior was smoothly coated with a shining material. Such cocoons were much shorter than the contained larva which rested loop-like within. Soon the larva undergoes its final moult to become a pupa (figs. 25–27). It now measures about 4.3 mm. in length, or 6.5 mm. including the slender breathing tubes that protrude some distance out of the cocoon. The pupa is largely of a pale amber color, the breathing tubes brown except apically where they are blackish, and the dorsal spines on the abdomen, brown. No pupae hatched.

This fly occurs also in other parts of the Waianae Range and in the Koolau mountains.

Eurynogaster viridifacies, rather small and brilliantly metallic, is at least in the male sex, a restless species. It has the habit of making short hovering flights in its up-grade exploration of dripping wet banks and, upon locating a female, of finally alighting near her.

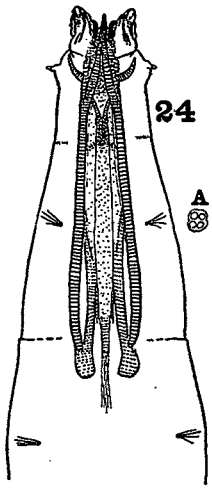
A shining green species, slightly larger than *E. minor* is *E. bino-*

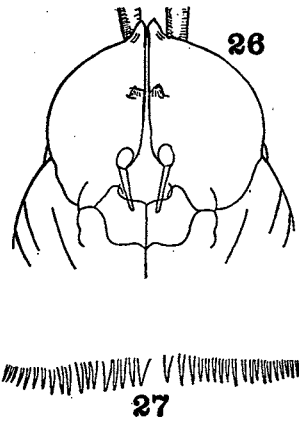
EURYNOGASTER MINOR

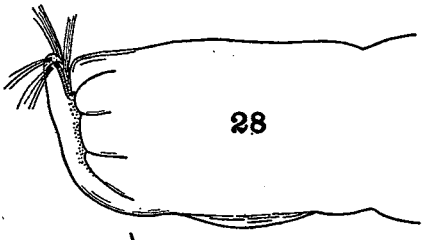
Explanation of Plate 18

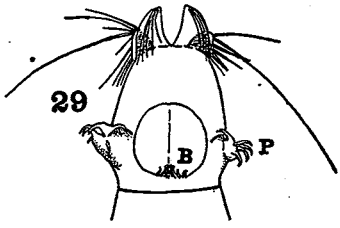
24. Large larva, head end, from beneath to show two of the three hair tufts. At A, more enlarged is the base of one of these hair tufts.
25. Pupa. Length exclusive of respiratory processes, 4.3 mm.
26. Pupa, front view of head.
27. Pupa, row of dorsal spinules on 5th abdominal segment.
28. Larva, caudal end, side view to show terminal cup closed.
29. Larva, first stage, caudal end, from beneath to show latero-ventral proleg P, and mid-ventral spine band B.
30. Male, fore tarsus, dorsal view.
31. Large larva caudal end from above. At T, is one of the spiracles.
32. Male, antenna.

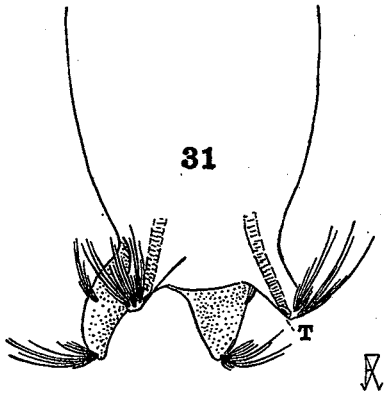
Proc. Haw. Ent. Soc., Vol. X, No. 2 Plate XVIII

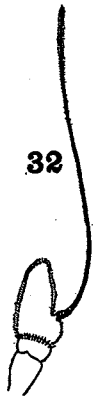












data Parent, thus far found only on the wet boulders of Kaluanui stream, Koolau Mts. (figs. 34–39). This region, one of the wettest on Oahu, lies at an elevation of about 2000 ft. Here and there among the fern, succulent plants and low, generally moss-grown and often none-too-healthy trees and shrubs is the sturdy fan palm *Pritchardia rockiana* Beccari, while the attractive white or pink-tinged, though nearly scentless flowers of *Phyllostegia,* a plant of the mint family help brighten the rather monotonous landscape. The perennial stream, in part bordered by the large native shrub-like *Hibiscus arnottianus* Gray, gives rise in a narrow cleft far below, to the famed Sacred Falls. *E. binodata,* a particularly wary species occupies much the same station as the native anthomyiid fly, *Lispocephala fusca* Malloch that occurs more rarely along this stream. Typically, it rests head upwards on the steep and even overhanging wetted and shaded face of a boulder and at a height there of a few inches above noisy or at least, rushing waters. It is usually difficult to catch, and so for its capture I often used a small jar rather than a large vial—as with many other dolichopodids—to place over it (Text fig. 5). Usually a single individual would be found here and there along the stream. Sometimes two were perched on the same boulder face, and if one of these were a male a courting scene might be witnessed. A male about two inches abreast of his prospective mate, gradually approached her in sidling advances of a few millimeters; then making a little curved flight alighted directly behind her. In this case the female soon took wing, but the male when situated just behind the female may rapidly move his wings—as we have recounted for *Eurynogaster minor.* It is on such wet boulders that these flies secure their prey. One was seen grasping a small nematocerous fly larva that suggested that of the green *Tanytarsus* midge. While no oviposition was ob-

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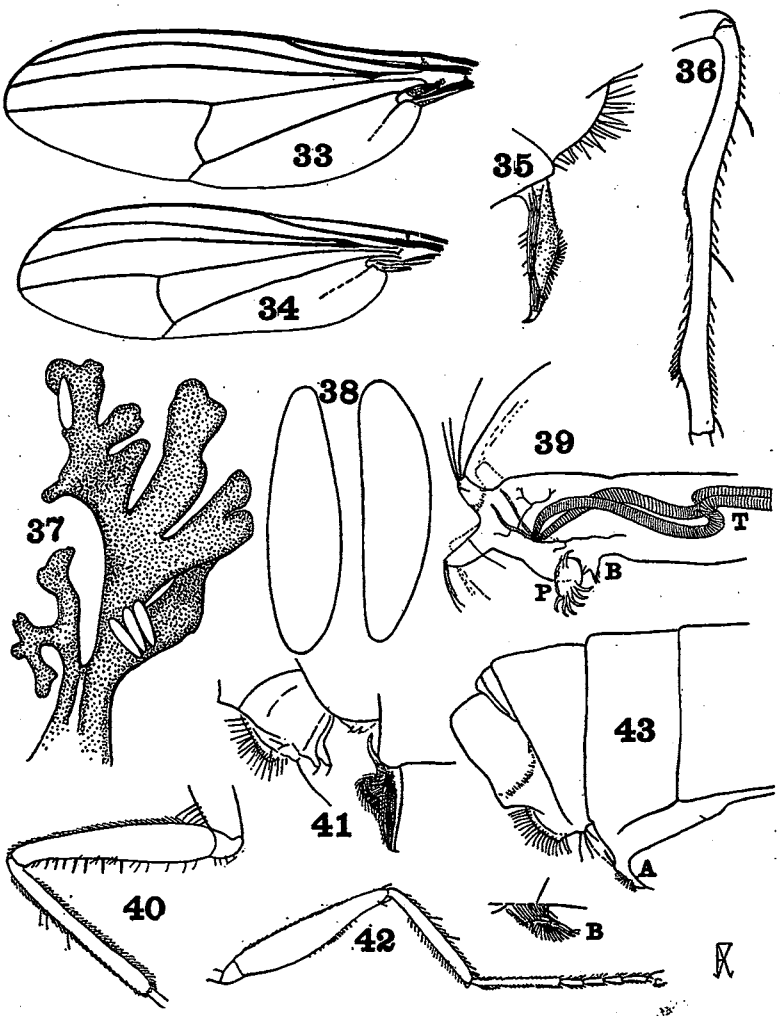
SIGMATINEURUM AND EURYNOGASTER

Explanation of Plate 19

33. *Sigmatineurum chalybeum,* wing; female. East Molokai.
34. *Eurynogaster binodata,* wing; male. Koolau Mts. Oahu.
35. " " male aedeagus. Side view.
36. " " " middle tibia.
37. " " Four eggs on a liverwort plant (Hepaticae) on wet rock in Kaluanui stream, Oahu.
38. *Eurynogaster binodata.* Eggs, more enlarged. Length 0.75 mm.
39. " " larva, first stage; caudal extremity in side view, to show hair fans, longitudinal tracheae (T), latero-ventral proleg (P) and mid-ventral spine band (B).
40. *Eurynogaster nigrohalterata,* male, fore femur and tarsus, from side. Mt. Kaala, Oahu.
41. *Eurynogaster nigrohalterata,* male, aedeagus, side view.
42. *Eurynogaster obscurifacies,* male, fore leg, from side, Mt. Kaala, Oahu.
43. *Eurynogaster viridifacies,* male, portion of abdomen from side to show aedeagus at A, Mt. Kaala, Oahu. At B, *Eurynogaster luteihalterata,* aedeagus, from side, Palikea, Oahu.


33
34
35
36
37
38
39
T
P
B
41
43
A
40
42
B

TEXT FIG. 5. Catching *Eurynogaster binodata* along the Kaluanui Stream, Oahu, at about 2000 ft. elevation. Photo by Dr. Manson Valentine. April 1938.

served, eggs were found glued to small liverwort plants, probably of the genus *Marchantia* growing flatly on a wet boulder (figs. 37 and 38). They resembled those of *E. minor* and were about 0.75 mm. long. Likewise, the first stage larvae were very similar to the latter sp. (fig. 39). No further data were secured on this insect.

Along streams of the Islands of Molokai and Maui we find *Sigmatineurum chalybeum* Parent (1938) occupying situations similar to those of *E. binodata. Sigmatineurum* Parent, an endemic genus and so named because of the S-shaped posterior cross-vein (fig. 33). It is quite as large as *E. binodata* and appears to be rare.

Finally, there is *Paraliancalus metallicus* (Grims.), largest of our Dolichopodidae and also addicted to cascades, dripping banks, and boulders, along the mountain streams on the Islands of Molokai, Maui and Hawaii.

For the descriptive literature referring to *Eurynogaster viridifacies,* and *minor* (=*Paraliancalus minor*), *Paraliancalus metallicus* (Grims.) (=*Liancalus metallicus*) and *Sigmatineurum chalybeum,* see Parent, Abbé O., "Konowia," XVI, Heft 3, 4, pp. 209–219, 1937; and for the remaining water-loving *Eurynogaster,* and further discussion, refer to the same author in Proc. Haw'n Entom. Soc., X, No. 2, pp. 240–248, 1939. I am greatly indebted to Abbé Parent for his excellent treatise of many of our Hawaiian Dolichopodidae, a work that has taken much time and study in a very busy life.

Hydrophorus pacificus Van Duzee (Plate 20)

Van Duzee, M. C., Proc. Haw'n Entom. Soc., VIII, pp. 347–348, Pl. 24, Figs. 78 and 79, 1933.

A study of the insect fauna of our maritime marshes will soon bring to light this rather large, interesting, pale-colored dolichopodid fly (fig. 44). Long-legged and rangy, about 4.5 millimeters in length of body, in color a combination chiefly of light gray, metallic greenish, a tinge of purplish and stripes of that color on the back of the thorax, *Hydrophorus* is often seen bestraddling the waters of muddy shallows or exploring the oozy ground of their vicinity. Pairs of these insects, the male atop the female, will be noticed wandering about or, if disturbed, flying off a short distance. Quite at home on small unruffled sheets of water, the fly may walk or run over the surface, much as it would ashore, or this procedure will be aided by a momentary use of the wings; it is also capable of skating quite swiftly, and here, resting rather low on the water, its forefeet bent forward to the water, the hind ones trailing, *Hydrophorus* propels itself entirely by strong simultaneous strokes of its far-spreading middle legs. This last method, though effective, appears rather stiff and mechanical. And finally, it may proceed in skimming flight against a breeze.

It seems that this inhabitant of the sun-beaten lowlands requires occasional refreshment, for it will often stoop or teeter so as to bring the mouth down to moisture, while food may be wetted in the same manner. No doubt the fly eats many kinds of small organisms floating on the water, and it is very fond of "bloodworms" (the larva of the mosquito-like midge, *Chironomus hawaiiensis* Grims.). Observations made on *Hydrophorus* on May 3, 1931, in an abandoned rice field at Honouliuli, near Ewa, Oahu, are as follows: "In a locality where the mud was barely covered by water, and with here and there scant low herbs, this pale restless fly was not uncommon. A bright reddish object that the female of a pair was holding with her mouth was certainly a bloodworm *Chironomus hawaiiensis* Grims. The bloodworms, and the flies into which they develop, were abundant in and about these shallows. A wandering *Hydrophorus* fly seized with her tongue-like organ, or labella, a bloodworm that, despite its comparatively large size and vigorous struggles, was hoisted clear out of water and soon quieted. A little later, a second *Hydrophorus* stooped down and grasped a bloodworm, extricating it from the mud with a final heave. In one of these cases, the fly laid hold of the victim with a foreleg—in the laboratory both forelegs were frequently employed to hold small wounded flies placed in its prison. The grip that *Hydrophorus* secures on its prey with the forelegs is not very firm, the femora and tibiae being used while the tips of its legs protrude beyond the burden. The stout forelegs of both the male and female *Hydrophorus* are armed with strong spines, particularly at the apex of the tibiae beneath (fig. 44,A).

These flies live well in captivity, provided they have a good mucky environment with plenty of food. They will soon grow plump on a bloodworm diet, and tender wounded little flies are also acceptable. A captive female was observed eating a dead male of its own species and when disturbed flew off with it. Her labella was closely applied to the side of the thorax of her prey, of which she was evidently sucking the juices. This large morsel was held with the labella and fore tibiae.

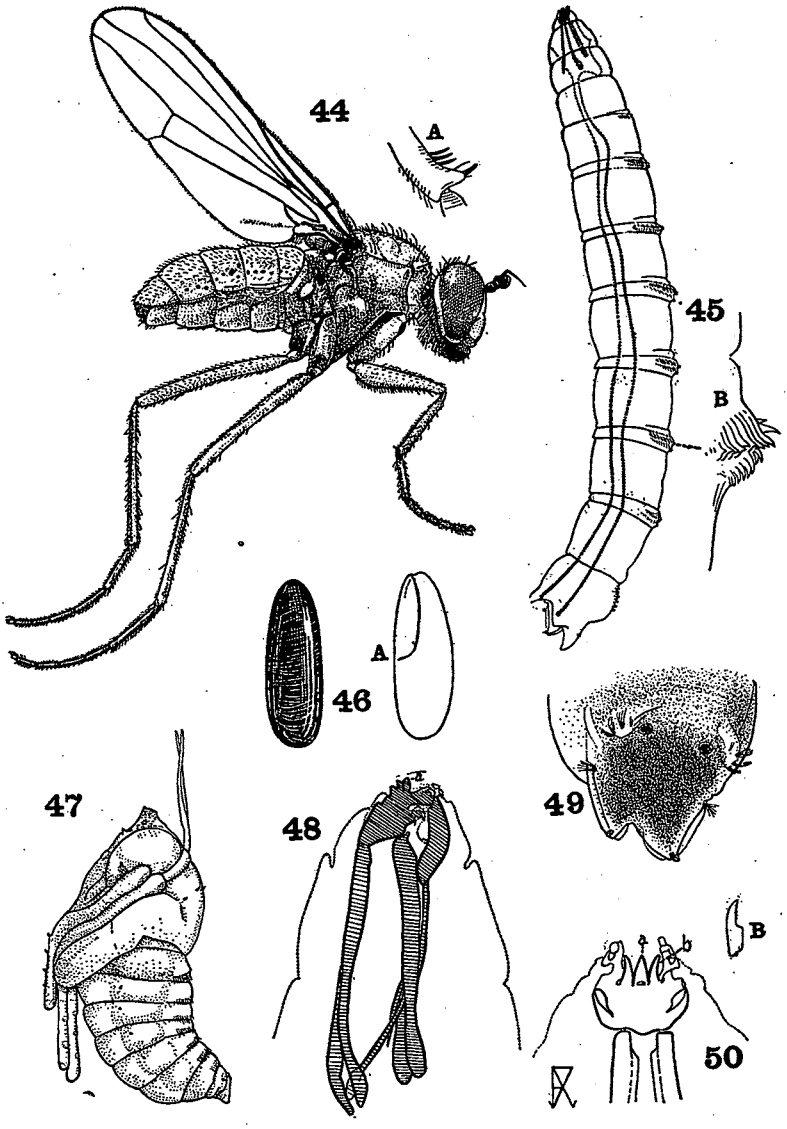
On December 6, 1931, twenty *Hydrophorus* flies, some in pairs, were caught in a low brackish coral-bed marsh frequented by cattle, near Waialua, Oahu. They were confined in a glass culture dish about 9 inches in diameter and 2 inches deep partly filled with very wet mud from the flies' environment, and to which filamentous green algae, and ooze containing a quantity of bloodworms, were added. The *Hydrophorus* quickly made themselves at home in this muslin-screened receptacle of ill-smelling watery material, for almost immediately several of them had yanked a bloodworm out of the mud and water and were holding clear these squirming morsels by means of their labella and tweezer-like, with the middle portion of their forelegs. Five days later these flies were liberated; all were then in good condition, two were in a pair, and a number of purplish-black or dark brown eggs had been fastened in the wet algae along and above the water margin and on the muddy scum. These rather tough eggs (fig. 46) are smoky brown in transmitted light and very polished. One measured was 0.67 millimeter long. In the laboratory they are often pierced and sucked by the flies, so that it is advisable to remove the latter as soon as enough eggs have been laid.

In a few days—between 3 and 4 in one lot of eggs under observation—the active, glassy white maggots hatch, rupturing the eggshell

HYDROPHORUS PACIFICUS

Explanation of Plate 20

44. Adult fly, female. Length 4.5 mm. Note the narrow spiracle at angle of prothorax. A, extremity of fore tibia of male, highly magnified.
45. Full-grown larva, from the side. Length about 8.5 mm. The two black lines represent the tracheal or breathing tubes; their numerous branches having been omitted. B, spines on underside of segment 9, in profile; highly magnified.
46. Egg, A, the same hatched, showing characteristic emergence slit. Length about 0.67 mm.
47. Pupa, side view. Length to extremity of horns, 5 mm.
48. Head skeleton of full-grown larva, side view, to show the saw-like median tooth a, in profile; highly magnified.
49. Terminal breathing cup of full-grown larva, obliquely from above. The two spiracles show eye-like near the inner base of the dorsal valves. Highly magnified.
50. Head skeleton of full-grown larva; anterior portion, from above, to show the median tooth a, of Fig. 48; and the two lateral teeth b. B, lateral tooth, more highly magnified.


44
A
45
B
46
A
47
48
49
50
B
b

in a line that, commencing at or near the more conical extremity, extends to near the middle length, where it curves to one side (fig. 46,A). Under the microscope, the tiny *Hydrophorus* larva shows the contrasting blackish internal head skeleton (cephalopharyngeal skeleton) resembling somewhat parallel rods more or less fastened together anteriorly and extending freely backwards as far as the second segment of the thorax. Fine spines on paired transverse ventral swellings assist in locomotion. The respiratory system is represented by a pair of silvery tracheae, or breathing tubes that extend the length of the body and give forth smaller branches; at the fore end they terminate in prothoracic spiracles while posteriorly they connect with much larger spiracles situated in a sort of cup at the rather bulbous and truncate end of the body.

There are at least three larval stages, the cylindrical larva attaining a final length of 8.5 or more millimeters (fig. 45). Several large larvae were secured in their natural habitat, others were reared in the laboratory. Dwelling in muck they keep their cup-like tail end (fig. 49) in contact with the air; they move backwards as readily as forwards and, when disturbed, retreat below, partly closing the cup by drawing its valves closer together and enclosing, with the help of the slightly incurved finger-like tips of these valves, a small bubble of air. At least when small, the larvae can suspend themselves by the tail end to the surface film of water. They did not appear capable of swimming. They are active and, like their parents, quite voracious. The sometimes red color of their alimentary tract showed that they ate the bloodworms in their dishes; they likewise fed upon the larvae of small moth-fly (Psychodidae) and probably also that of a tipulid fly, that occurred naturally in their environment. Cannibalism seems to exist here, and dead *Hydrophorus* larvae were found in the laboratory material. A part-grown individual successfully attacked the larva of a tipulid fly much bigger than itself; it clung to its squirming prey and made a large hole near the posterior end so that fluid issued from the wound. A mosquito wriggler placed in contact with a hydrophorid was also pierced and eaten of.

In the full-fed larva (fig. 45), the fore part of the head skeleton, as seen from above, (fig. 50) shows three strong teeth; a simple curved one, B, on each side and a stouter one, a, in the middle. A profile view of the head skeleton (fig. 48) shows that this unpaired median tooth, a, is really a three-toothed saw. These are evidently the cutting mouthparts. On each side of the ventral line of the fore part of segments 4 to 10 inclusive is a low transverse swelling or "pseudopod." These swellings have, as outgrowths, two series of fine, backward-pointing spines (fig. 45,B, 9th segment), the anterior series close-set in one transverse row, the second series, posterior to the first but adjoining it, consisting of somewhat curved spines arranged in oblique parallel rows. The spine development

is somewhat rudimentary on segment 4, while on the 11th or terminal segment there are two nearly ventral patches of spines and some spines about the rectal opening situated on the underside of this segment.

The *Hydrophorus* larva has a pair of small apparently functional spiracles on the prothorax, and another much larger caudal pair situated near the inner base of the dorsal wedge-shaped cup-valves, there being two larger ventral protuberances with a very small one between each and the dorsal valves. Fig. 49 shows the breathing cup obliquely from above; note the little whisker-like tufts of hair on the margin of the flanged lobes or valves. The interior of the breathing cup is kept dry.

Several larvae that appeared to be full fed were kept separately in a little mud in small tins. From these I secured three cocoons—oblong, mud-covered outside but glossed smooth inside, not overstrong, flexible and capable, even when broken up, of withstanding prolonged soaking without dissolution of the thin inner membrane-like sac. I kept them very moist and finally dissected out two of them thus exposing the horned mobile pupa (fig. 47) and the shrivelled larval exuvium. The pupa is about 5 mm. long to the tip of horns. It is in part a sort of pale brownish. On the face are a pair of rather short dark ridges and a large median one on the top of the head. The delicate horns are, of course, breathing tubes that connect with the large spiracle on each side of the thorax of the developing adult. A row of stiff hairs are present on the back of most of the abdominal segments. The pupa works itself, wholly or in part, out of the cocoon to disclose the adult fly. The pupal stage lasts but a few days.

My records of the life history of this fly are scant. *Hydrophorus* larvae were not isolated until near pupation and were placed in mud secured in the field that may have already contained larvae. Three records, however, give 29, 33, and 41 days as the intervals from the placing of adult flies in prepared jars, to the appearance of a new brood of adults.

Hydrophorus pacificus is also found in rain pools at quite a distance from the sea, but is more abundant in marshes near the coast and occurs even at salty puddles along beaches. Likewise, it may be seen in standing water in irrigation lines of lowland fields of sugar cane that are not far removed from seaside marshes—as at Kahuku, Oahu. In September 1935, it was observed in very large numbers at Kailua, Oahu where a remaining thread of water margined with slimy green algae ran through the low water-soaked ground.

It is an insect apparently peculiar to the Hawaiian Islands. Records show adults, presumably all of this species, seen or taken in the following localities: Waimea, Kauai, April 30, 1905 (Shore), F. W. Terry; Kekaha, Kauai, November 17, 1931 (trench water near

shore), F. X. Williams; Honolulu, O. H. Swezey; Honouliuli (mud flats), Ewa Plantation Company, January 26, 1931 (on water weeds at edge of reservoirs); Waialua (mud flats); Kailua, August 19, 1931 (shallow rain puddles in cane field road); Kahuku, summer 1933 (cane field); Pineapple Experiment Station, Honolulu (rain puddle), Oahu, F. X. Williams. It has also been observed abundantly, running over salty or brackish water at Mokapu Point, and elsewhere on Oahu, by Mr. E. H. Bryan, Jr. Another and far removed locality is Laysan Island, April 8 and 13, 1923 (D. T. Fullaway).

The larva, pupa and cocoon of the related *Hydrophorus agalma* Wheeler, are excellently figured and described by C. T. Greene, (Proc. Entom. Soc. Wash. 25, pp. 66–69, 1923, 1 plate). His material was secured from Lake Winnipeg, Canada. Here is repeated in part, Greene's quotation of Prof. O'Donoghue, who secured the specimens, as follows: "The specimens were taken in water only a few inches deep. . . . The bottom here is a mixture mainly composed of sand." The larva and pupa appear scarcely to differ from those of the Hawaiian species. "The long anterior spiracle of the pupa projects through the sand cocoon about the length of one joint." In one case the pupal spiracles of the Hawaiian *Hydrophorus* were partly extruded from the cocoon when the fly was nearly ready to issue but a poke made the pupa back entirely out of sight.

Hydrophorus williamsi Parent

Hydrophorus williamsi, Parent, O., Konowia, XVI, pp. 211–212, figs. 22 and 23, 1938.

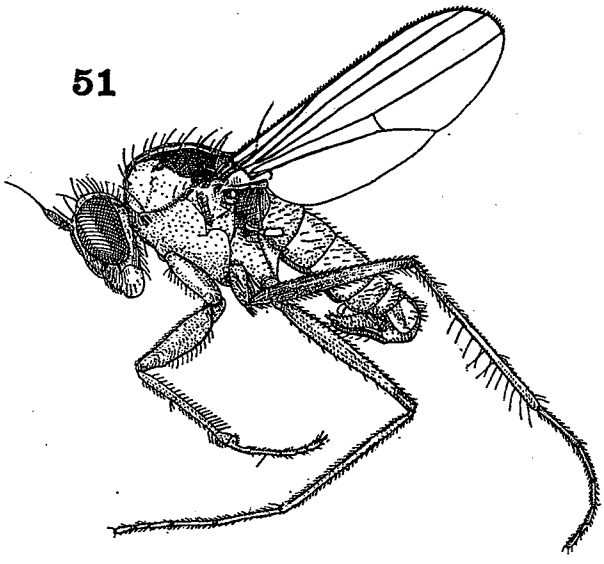
This species may be distinguished from *H. pacificus* chiefly by the infuscation along the wing veins (Pl. 17, fig. 23,D), by the weaker bristling of the fore femora and by its smaller size.

The type was described from specimens taken October 20, 1933, in a maritime marsh at Honuapu, Kau district, Hawaii. This area of apparently brackish water resting on a bed of black lava seemed not directly connected with the adjoining sea. It contained fish, crabs and shrimp-like crustaceans. Along its muddy bottom, the bug *Trichocorixa blackburni* (White), could be seen, at or near

CYMATOPUS ACROSTICALIS

Explanation of Plate 21

51. Adult, male. Length about 3.20 mm. East Molokai, seashore.
52. Larva.
53. Larva; portion of spinous area of third abdominal proleg.
54. Egg. Length 0.50 mm, diameter 0.25 mm.
55. Adult, male, to show modification of fore tibia and tarsus.
56. Larva; caudal extremity of body, posterior view, to show processes, hair fans and spiracles.
57. Pupa, from the side. Length of body about 3.30 mm.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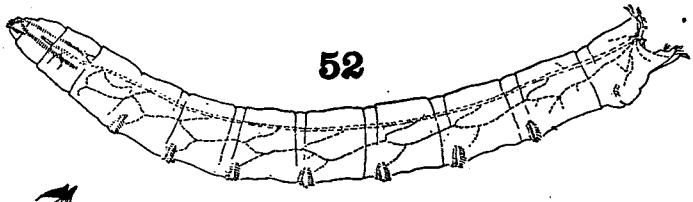
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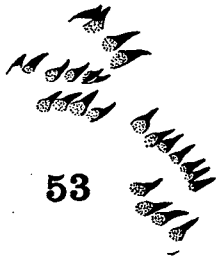
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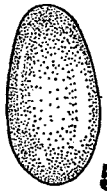
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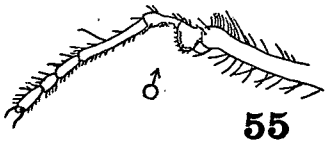
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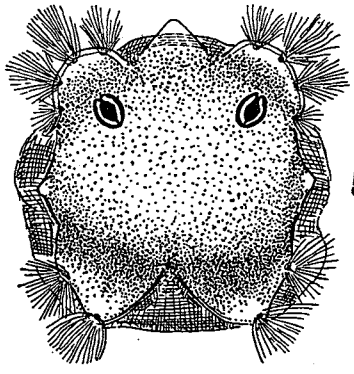
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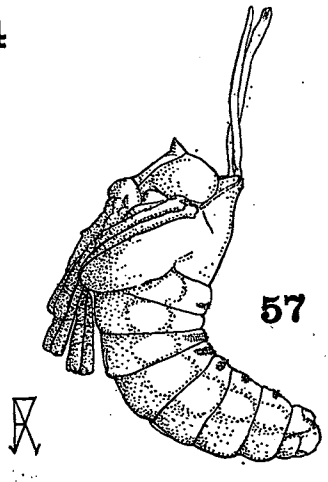
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the shore was the little *Microvelia vagans* (White) bug, and the flies, *Brachydeutera hebes* Cress., *Scatella sexnotata* Cress. (Ephydridae), the common dolichopodid *Syntormon distortitarsis* V.D. and one of the Psychodidae. It seems less of a water skater than its larger relative but addicted to more saline waters. Near Honolulu it may be common on tidal mud flats and at Mapulehu, Molokai was not uncommon at or near the edge of a mullet pond narrowly connected with the sea. Like *H. pacificus* it is often seen in pairs. It is quite voracious, attacking weaker flies when confined with it. Nothing is known of its early stages.

Cymatopus acrosticalis Parent. (Plate 21)

Parent, O., Konowia, XVI, pp. 69–71, Figs. 4 and 5, 1938 (male and female).

Hanauma Bay lies a few miles east of Honolulu and is formed by a tuff crater that is widely open to the sea. There is a rather extensive sandy beach at its head, but elsewhere the shore is rugged and rocky. A reef protects a considerable part of the shore from the full force of the waves. Because of its accessibility and the relative abundance of seashore insects, Hanauma Bay has contributed most of the data on these forms of life. While the sandy beach above the tidal mark is the chief habitat of the elusive little *Chersodromia hawaiiensis* Melander (Empididae) and of one or two other flies, the sea rocks just above and within the tidal zone furnish the more truly water-loving forms and the one that concerns us here.

Everywhere on rocks exposed by the tide and even on the coarse sand towards the sea we may observe *Cymatopus acrosticalis* (fig. 51, male), a chiefly grayish dolichopodid fly somewhat over 3 millimeters long. The place is alive with them. They move in rapid jerky progress, now flying over a short space, and now, when one disturbs another, jumping well up in air; or dozens upon dozens of them may wander briskly over the limp foliaceous green *Ulva* and other algae. They do not seem to prey upon the quiet though alert *Canace* flies but are intent upon picking up the slender orange-red larvae, and probably also the pupae of *Dasyhelea calvescens* Macfie (Ceratopogonidae) occurring near the upper tidal limits, or beyond.[1] Available well within the tidal zone are other midges—one or more species of *Clunio,* and *Telmatogeton pusillum* Edw.,—of the family Chironomidae. On one occasion *Cymatopus* was observed with a young larva of its own species in its mouth, while on another, with that of *Canace nudata* Cresson.

Cymatopus confined in a vial and fed with *Chironomus* larvae laid a few oval, fairly polished brownish eggs (fig. 54) that measured about 0.50×0.25 mm. Within a week or a little more, four glassy white larvae hatched, issuing from an oblique cut at the narrower end of the eggs. The bristles on the lobes at the tail end of

[1] Notes of May 19, 1936, 8: 30 A.M., at quite low tide.

the body are well developed, and efficient thorn-armed swellings or prolegs ventrad on the body are already present. Larvae were not reared to pupation but well-grown individuals were found in a very shallow detached splash pool lined with felt-like algal mud, in the upper tidal zone of rock with tiny pockets of mud and algae, and more rarely within the zone of green algae. The larvae (figs. 52, 53 and 56) are carnivorous like the adults and their often yellowish orange coloration suggests that their prey is commonly immature stages of *Dasyhelea calvescens*. Pupal shells exposed by low tide, or in splash pools and sometimes protruding from a cell or cocoon may be found. The pupa (fig. 57) is more or less glassy orange yellow, with the spines on the abdominal segments above reddish brown. There is a sharp cocoon breaker on the head while the respiratory processes are strap-like and rounded apically.

Cymatopus acrosticalis described from the Island of Molokai, also occcurs plentifully on the shores of Oahu and Maui. Further collecting will probably show that it occurs widely over the Archipelago. In 1923, it was collected on the Tanager Expedition, chiefly by E. H. Bryan, Jr., on Wake Atoll, more than 2000 miles west of Honolulu, and on Nihoa, Necker, French Frigate Shoals and Lisiansky, atolls and rocks extending WNW from the main Hawaiian group. (Insects of Hawaii, Johnston Island and Wake Island; Bryan, E. H., Jr., and Collaborators; B. P. Bishop Museum, Bull. 31, Tanager Expedition, Publ. No. 3, pp. 1–94, 1926.) Abbé O. Parent (1938) gives a key differentiating the eight species of the genus *Cymatopus* described from the Pacific littoral. He is of opinion (p. 71) that this genus occupies the same place in the Pacific that the genus *Aphrosylus* does on the Atlantic shores.

Dr. L. G. Saunders in his excellent account of "Some Marine Insects of the Pacific Coast of Canada" (Ann. Entom. Soc. America, XXI, pp. 521–545, 9 figs., 1928) describes and figures some of the early stages of *Aphrosylus*[2] *praedator* Wheeler (1897). This insect both in biology and in structure bears considerable resemblance to our *Cymatopus acrosticalis*.

[2] Referred to the subgenus *Paraphrosylus* by Dr. T. Becker (1921).