Flightless Dolichopodidae (Diptera) in Hawaii[1]

D. ELMO HARDY AND M.D. DELFINADO
UNIVERSITY OF HAWAII
HONOLULU, HAWAII

Wing reduction and flightlessness is rare in Dolichopodidae. Only eight known species have reduced wings and except for one from the alpine tundra in Nepal (Takagi, 1972) all are from oceanic and subantarctic islands (Table I); five of these are from the Hawaiian islands. The first recorded species was collected by Perkins in 1900 in the Koolau Mountains, Oahu and described as a new genus and species *(Emperoptera mirabilis)* by Grimshaw (1902:81). The latter species is apparently extinct (Zimmerman, 1948:153); Hardy and Kohn, 1964:119) and would support the concept of Takagi (1972:99): "Where predaceous ants (ap-

TABLE I. Oceanic Islands and Alpine Tundra Dolichopodidae with reduced wings.

Species	*Locality*	*Habitat*	*Wings*
Campsicnemus bryophilus (Adachi), 1954	Molokai 3700-4200 ft.	on forest floor under dense vegetation	Stenopterous
C. aeptus Hardy & Kohn, 1964	Maui, West (Puu Kukui) 4000-4500 ft.	on forest floor under dense vegetation	Stenopterous
C. haleakalaae (Zimmerman), 1938	Maui, East (Haleakala) 6000-6500 ft.	"	"
C. mirabilis (Grimshaw), 1902	Oahu (Koolau Mts.) 2000-3000 ft.	"	"
C. hawaiiensis n. sp.	Hawaii 5100 ft.	reared from leaf litter	"
Schoenophilus pedestris Lamb, 1909	Macquarie Island	under stones, moss leaf mould, low plants, flower head, etc.	"
S. pedestris campbellensis Harrison, 1964	Campbell Island	"	"
Acropsilus borboroides Oldroyd, 1956	Campbell Island	"	Apterous
Hydrophorus celestialis Takagi, 1972	Nepal 4200-4400 ft.	alpine tundra, on snow above timber zone	Stenopterous

[1]Published with the approval of the Director of the Hawaii Agricultural Experiment Station as Journal Series No. 1585.

terous!) are ubiquitous, habitats for various flightless insects would largely be occupied by them. If this is true, the relatively abundant occurrence of free-living wing-reduced insects in high altitude, high latitude and oceanic island faunas is due at least partly to the lack of predaceous ants." Zimmerman *(loc. cit.)* in discussing the biotic pressure brought on by introduced predators says that: "It appears that this remarkable fly is now extinct—at least in the type location—because it was unable to withstand the new pressure created by the invasion of its environment by immigrant predaceous ants." *Pheidole* ants have invaded the entire Koolau mountain range and it is doubtful that a flightless species would be able to survive.

Concerning flightlessness, Mani (1962:95) believes there seems to be a relation between wing reduction and flightlessness and the prevailing climatic conditions of the habitat, i.e. the interaction of abiotic factors. This supports Huxley (1942:243) on flightlessness of insects of oceanic islands as "an example of ecological differentiation after divergence was made possible in the first instance by isolation, but the type of differentiation is here more directly in relation to the physical than to the biological environment, winglessness in insects constituting an adaptation to prevent being blown out to sea." Similarly, Perkins (1913:50) suggests that wing reduction in Hawaiian insects is a result of their adaptation to living on the forest floor. He says: "Nearly all the flightless endemic insects are inhabitants of the forest . . . There is no ground for supposing that in these islands, as has been suggested for flightless insects inhabiting other Oceanic islands, the wings have been lost or degenerated through the agency of natural selection, as being a source of danger if used on small land areas, where flying insects are supposed to be liable to destruction from being blown out to sea. All the cases of flightlessness in Hawaiian insects are . . . to be explained simply by 'disuse'." Hackman (1964:87-88) however, points out that in dealing with flightless Diptera on oceanic islands the wind theory can hardly have validity since the adults live predominantly in rather concealed terricolous habitats: among litter, under stones, in low dense vegetation on the ground, in cavities in the soil and in narrow galleries of social insects. And according to him *(loc. cit.)*: "It seems very likely that the loss of wings is connected with these habits of life. A good running ability is there[fore] more important than flight in escaping from enemies." In this respect Takagi (1972) stated that "the shift of habit to terricoly, whether phenotypic or genetic, is a common prerequisite to wing reduction in free-living insects."

The genus *Emperoptera* Grimshaw was synonymized with *Campsicnemus* Haliday (Hardy and Kohn, 1964:17) because of the close resemblance (other than flight characters) and obvious relationship to normal, fully winged species. It is apparent that wing reduction has occurred in at least two distinct evolutionary lines of *Campsicnemus*. One is char-

acterized by having the middle basitarsus of male short, not over one-third to one-fourth as long as second tarsomere and with a prominent spur developed at apex (Fig. 4) and the middle tibia strongly swollen and flattened laterally. This group is represented by *aeptus* Hardy and Kohn, *bryophilus* (Adachi) and *hawaiiensis* n.sp. The other is characterized by having the middle basitarsus slender, equal or longer than second tarsomere, with no spur at apex and middle tibia slender, with four or more bristles along dorsal surface. This is represented by *haleakalaae* (Zimmerman) and *mirabilis* (Grimshaw). It is not completely improbable that Adachi (1954:293) could be correct in her assumption that the stenopterous species in Hawaii could "have arisen from four different ancestral stocks in the genus *Campsicnemus.*" More detailed studies are needed to gain a more complete knowledge of the relationships. Two species, *mirabilis* on Oahu and *hawaiiensis* on Hawaii, completely unrelated, have the halteres rudimentary, represented by small stubby appendages (Fig. 1) and the wings reduced to thin strips along costal margin with only one faint longitudinal vein represented (Fig. 1). These two species obviously represent cases of convergent evolution in two phyletic lines of *Campsicnemus* and could have evolved separately from fully winged species. The other three species from Maui and Molokai have the halteres normal and the anterior half of the wing developed, with the radial veins and vein M_{1+2} present (Hardy and Kohn, 1964:40, Fig. 2c and 53, Fig. 5a). The latter species are active jumpers, found hopping about on the ground litter like fleas.

We appreciate the help we have received from Mr. Douglas Fujii as an assistant in the field and laboratory and Miss Camille Wong for doing the illustrations.

KEY TO KNOWN SPECIES OF CAMPSICNEMUS WITH REDUCED WINGS

1. Middle basitarsus short, one-third to one-fourth as long as second tarsomere and with a prominent spur at apex (Fig. 4); middle tibia swollen, flattened laterally (Fig. 4) 2

   Middle basitarsus slender, equal or longer than second tarsomere and with no apical spur; middle tibia slender, with four or more bristles arranged along dorsal surface 4

2. Anterior half of wing present and radial and first medial veins present (Hardy and Kohn, 1964: 53 Fig. 5a); halters well developed; spur on middle basitarsus blunt at apex; and middle tibia with a dense clump of peg-like anterodorsal bristles at about apical fourth of segment or a row of close set anterodorsal bristles in the same position. (Hardy and Kohn, 1964: 40, Fig. 2e and 53, Fig. 5b) 3

   Only costal margin of wing represented and with a prominent bristle at apex (Fig. 1); halteres reduced to short, stubby knobs (Fig. 1); tibial spur of basitarsus sharp pointed and middle tibia lacking the dense set of preapical dorsal bristles and with numerous

short, erect, blunt setae over anterior surface (Fig. 4). Hawaii .... *hawaiiensis* n.sp.

3. Spur on middle basitarsus strongly curved at right angle at about middle, enlarged and rounded at apex and with basal half of spur pilose (refer Hardy and Kohn, 1964: 40, Fig. 2e); preapical dorsal bristles of middle tibia not short and peg-like, arranged in a row near apical third ..... *aeptus* Hardy & Kohn

   Spur on middle basitarsus curved near base, otherwise straight, rather slender, parallel-sided and bare, not enlarged at apex; middle tibia with a dense clump of short peg-like anterodorsal bristles at apical third (*loc. cit.* p. 53; Fig. 5b).... Molokai ..... *bryophilus* (Adachi)

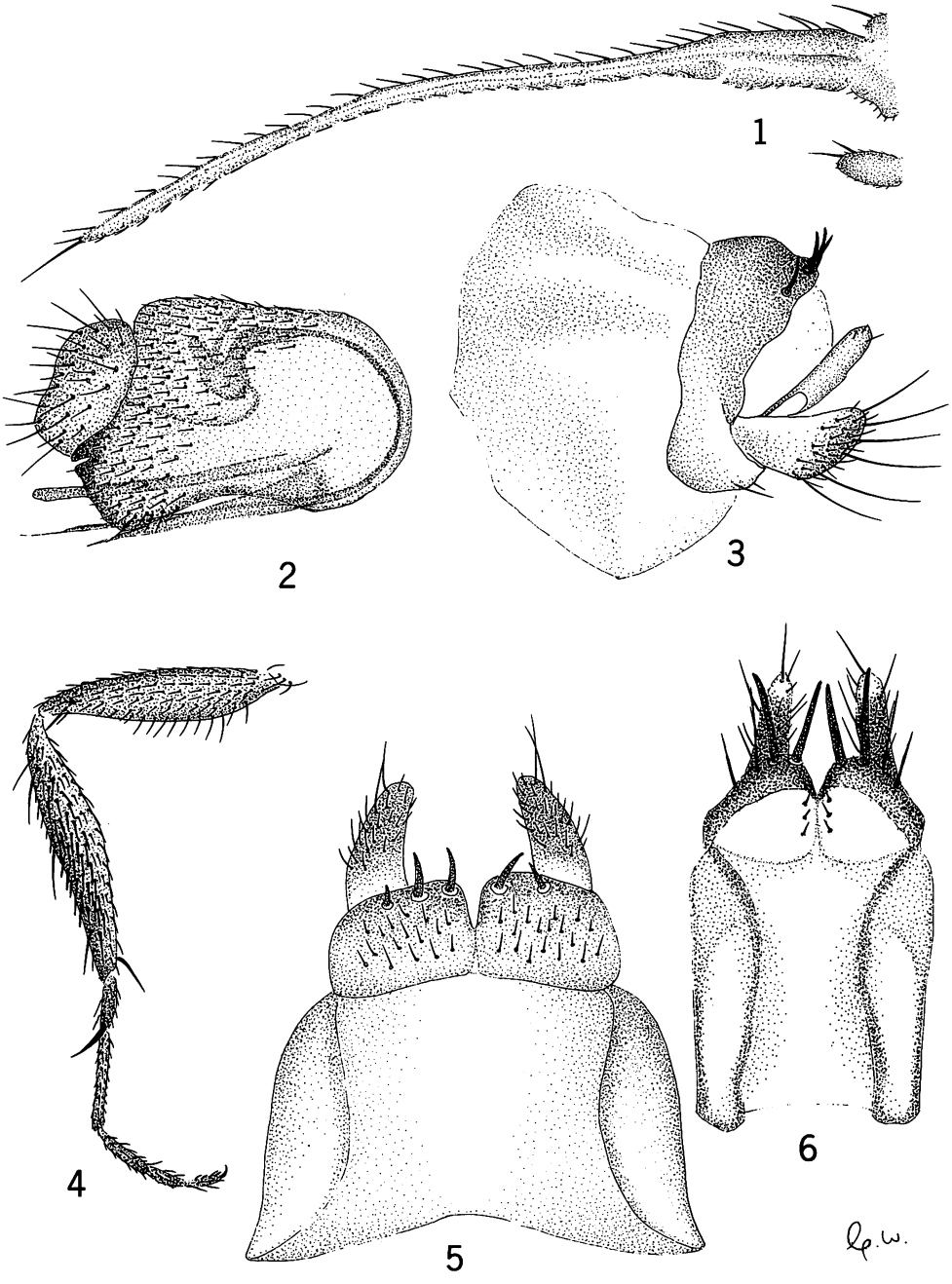
4. Wings reduced to just the costal margin and with an apical bristle, very similar to *hawaiiensis* n.sp. (Fig. 1); halteres rudimentary, represented by small knobs; middle tibia with four dorsal bristles; mesonotum polished black....Koolau Mts., Oahu .... *mirabilis* (Grimshaw)

   Wings represented by approximately the anterior half with the radial and the first medial veins developed and lacking an apical bristle; halteres well developed; middle tibia with seven long posterodorsal bristles; mesonotum subopaque bronze-brown....East Maui ..... *haleakalaae* (Zimmerman)

Campsicnemus hawaiiensis n.sp. (Figs. 1-5).

Because of the development of the legs, with the middle basitarsus short and with a prominent apical spur and the middle tibia swollen, flattened laterally, this species fits in the grouping of species with *aeptus* Hardy and Kohn and *bryophilus* (Adachi). It differs strikingly from these species by the great reduction of the wings and halteres and obviously the total loss of flight ability; also the characteristics of the legs are distinctly different. The middle femora lack ventral bristles and the middle tibiae lack preapical anterodorsal bristles; also the spur of middle basitarsus is attenuated to a sharp point at apex and only two pairs of dorsocentral bristles are present. Because of the development of the secondary sexual characters of the legs and the absence of acrostichal setae it would appear to be more closely related to *nigroanalis* Parent (fully winged) from Oahu, than to any of the stenopterous species.

Male. Tiny, predominantly brownish yellow species. *Head:* Higher than long with the eyes short pilose. Basal antennal segment yellow, third segment dark brown to black, triangular in shape and with prominent setae around margin. Arista pubescent. *Thorax:* Yellow to rufous, tinged with brown on mesonotum and scutellum. Halteres reduced to small rounded appendages, with three prominent subapical setae on posterior margin and densely covered with microscopic setae. Two pairs dorsocentral bristles on anterior half of mesonotum; two humerals; one notopleural; one supraalar and one postalar; also one pair



FIGS. 1-5, *C. hawaiiensis*, n.sp.—1. Wing and halter; 2. ♂ terminalia, lateral view; 3. ♀ terminalia, lateral view; 4. ♂ middle leg; 5. terminalia, dorsal view. FIG. 6, *C. bryophilus* (Adachi) ♀ terminalia, dorsal view.

of large scutellar bristle, almost equal in length to mesonotum. The postalar is weak compared to *bryophila,* scarcely over one-third the size of the supraalar. Mesonotum subshining, very faintly pollinose. *Legs:* Entirely yellow except for a tinge of brown on middle coxae. Middle femur lacking ventral bristles but with a row of fine posteroventral hairs along basal half. Middle tibia with anterior surface rather densely covered with short, thick, blunt setae (Fig. 4); also with one prebasal posterodorsal bristle; one median anterodorsal; one preapical dorsal; one preapical anterior and one preapical ventral bristle. Middle tibia flattened, as wide as femur. Mid basitarsus short, scarcely over one-third as long as second tarsomere and apical spur gently curved, equal in length to basitarsus and sharp-pointed at apex (Fig. 4). Hind tibia with opposing posterodorsal and anterodorsal bristles before base; one posterodorsal at basal third; one anterodorsal at middle and with opposing dorsal and anterodorsal preapical bristles. *Wing:* As in Fig. 1, with one longitudinal vein faintly developed, this is evidently the radius. Halteres as in Fig. 1. *Abdomen:* Mostly yellow, tinged with brown at apices of terga. Male genitalia as in Fig. 2. Aedeagus thin, needle-like.

Length: body, 1.4-1.5 mm.

Female. Fitting description of male except for secondary sexual characters. Female terminalia, as in Figs. 3 & 5, with four short spines at apical margin of ninth tergum. The terminalia is distinctly different from that of *bryophila* which has four strong spines and four bristles on hind margin of tergum (Fig. 6).

Holotype male; allotype female, 18 paratypes, 5 males and 13 females taken at 5100 feet elevation on the Saddle Road, Hawaii, 19°40′32″ N latitude and 155°20′30″ E longitude collected in two adjoining Kipukas (islands of vegetation in lava fields) (about one-fourth mile apart) tentatively labeled Kipukas 9 and 14. The specimens were reared from leaf litter predominantly consisting of leaves from *Metrosideros, Cheirodendron, Ilex,* and tree ferns. 25-27 February 1972 (M.D. Delfinado). The average temperature in the litter is approximately 50°F. and the humidity almost a constant 100%. Also 1 female, 2 males same locality as type on forest floor, running and hopping amongst the litter. 18 February 1973 (D. Fujii).

Holotype, allotype and some paratypes in the B.P. Bishop Museum. Other paratypes in the collections of the U.S. National Museum and the University of Hawaii.

BIBLIOGRAPHY

Adachi, M.S. 1954. Preliminary studies in Hawaiian Dolichopodidae (Diptera), Part II. The genus Campsicnemus Grimshaw. Proc. Hawaiian Entomol. Soc. **15:** 293-296.

Grimshaw, P.H. 1902. Diptera. In: Fauna Hawaiiensis, David Sharp, Ed. **3:** 79-86. Cambridge Univ. Press.

Hackman, W. 1964. On reduction and loss of wings in Diptera. Not. Entomol. **44:** 73-93.

Hardy, D.E. and M. Adachi Kohn. 1964. Insects of Hawaii vol. **II,** Diptera: Brachycera, Family Dolichopodidae pp. 13-256.

Huxley, J. 1942. Evolution. The modern synthesis. Harper & Brothers Publ. N.Y. & London. 645 pp.

Kohn, M.A. 1962. Insects of Macquarie Island. Diptera: Dolichopodidae: Pac. Ins. **4:** 959-962.

Lamb, C.G. 1909. The Diptera of the Subantarctic Islands of New Zealand. Art. VII, Vol. **1:** 124-145.

Mani, M.S. 1962. Introduction to high altitude entomology. Insect life above the timberline in the northwest Himalaya. London. 302 pp.

Oldroyd, H. 1955. A wingless Dolichopodid (Diptera) from Campbell Island. Rec. of Dominion Mus. **2:** 243-246.

Perkins, R.C.L. 1913. Introduction to Fauna Hawaiiensis, David Sharp, Ed. **1:** xv-ccxxviii, pls. 1-16. Cambridge Univ. Press.

Takagi, S. 1972. A micropterous dolichopodid fly from Nepal Himalaya (Diptera). Kontyu **40:** 90-99.

Zimmerman, E.C. 1938. Emperoptera from Maui (Diptera, Dolichopodidae). Proc. Hawaiian Entomol. Soc. **10:** 145-148.

_____. 1948. Insects of Hawaii vol. **I.** Introduction. Univ. Haw. Press, Honolulu, 206 pp.