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REVIEW OF THE ENDEMIC HAWAIIAN GENUS *SIGMATINEURUM* PARENT (DIPTERA: DOLICHOPODIDAE)

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REVIEW OF THE ENDEMIC HAWAIIAN GENUS *SIGMATINEURUM* PARENT (DIPTERA: DOLICHOPODIDAE)[1]

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ABSTRACT. The endemic Hawaiian dolichopodid genus *Sigmatineurum* Parent is reviewed and a key to species provided. *Sigmatineurum* was previously known only from the single species, *chalybeum*, recorded from Molokai. Four new species, *Sigmatineurum iao* from West Maui, *S. mnemogagne* from East Maui, *S. napali* from Kauai, and *S. omega* from the Wailuku River on Hawaii, are described and illustrated. *Sigmatineurum chalybeum* is redescribed, illustrated, and a lectotype chosen from the four known syntypes. Adults of *Sigmatineurum* appear to be restricted to particular riparian microhabitats consisting of moist vertical bedrock exposures adjacent to small splashing waterfalls in areas of mesic forest.

INTRODUCTION

Sigmatineurum was described by Parent (1938) as a new genus of Hydrophorinae based on an unspecified number of males and females of the single species *chalybeum* from Moaula Stream on Molokai. Later, Hardy & Kohn (1964) extended the distribution of the genus to include Maui, based on 2 specimens (misidentified as *chalybeum*) collected in Iao Valley, in western Maui.

An additional reference to the occurrence of *chalybeum* in the lowermost portion of Puaaluu Stream in the lower Kipahulu Valley of Maui (Hardy, 1979) is believed by us to be a misidentification (probably for a *Chrysosoma* species). Records from this Kipahulu survey were based solely on observations and voucher specimens were apparently not collected (Kinzie & Ford, 1979). A search for these voucher specimens was made by Dr. D.E. Hardy, University of Hawaii, Manoa and NLE, but none were found. The site (30 m from the ocean and heavily choked with *Pandanus*), recorded behavior of the fly, and low elevation of the site (10–12 m), are more typical of *Chrysosoma* than *Sigmatineurum*, species of which are normally found at elevations above 600 m (ca. 2,000 ft) in more pristine ecosystems.

Recent collecting in the Hono O Na Pali Natural Area Reserve on Kauai, and Hanawi Stream, Maui by one of us (DAP) resulted in collections containing 2 new species of *Sigmatineurum*. This prompted examination of the dolichopodids in the collections at the University of Hawaii, Manoa, the Hawaii State Department of Agriculture, Honolulu, and the Bishop Museum, for additional specimens of *Sigmatineurum*.

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1. Contribution No. 93-010 to the Hawaiian Biological Survey

Results of the examination of this material showed that the number of species in *Sigmatineurum* and distributional range of the genus was more extensive than previously known. The characters exhibited by the 5 species now treated in *Sigmatineurum* help further understand the generic limits. The distribution of the genus is extended to now include all the major Hawaiian islands except Oahu and Lanai.

The senior author reviews the systematic history and presents morphological information on the genus, describes and illustrates all known species, and provides a key to the species in the genus. Discussion of habitat preference is given at the end of the paper by the junior author.

MATERIALS AND METHODS

Specimens were examined in or borrowed from the following museum collections: Bishop Museum, Honolulu, Hawaii (BPBM), The Natural History Museum, London (BMNH), Hawaii State Department of Agriculture, Honolulu (HDOA), Museum National d'Histoire Naturelle, Paris (MNHN), and the University of Hawaii at Manoa, Honolulu (UHM). The collections at the National Museum of Natural History, Washington, D.C., and the Canadian National Collection of Insects, Ottawa, and the personal collections of Dan Bickel, Australian Museum, Sydney, and Richard Hurley, Humboldt State University, Arcata, California, were also checked, but no further specimens of *Sigmatineurum* were located.

Terminology and abbreviations for morphological structures follow Bickel (1991) and McAlpine (1981).

Specimens used for scanning electron microscopy were critical point dried from alcohol-preserved material, sputter coated with gold-palladium, and photographed on a Hitachi S-800 scanning electron microscope. Label data for specimens examined are given verbatim. Inferred data or data taken from other sources are placed in square brackets.

Abbreviations used:

I, II, III	= fore, mid, and hind leg
C	= coxa
CuAx ratio	= ratio of length of m-cu to portion of CuA_1 distal to m-cu
F	= femur
T	= tibia
MSSC	= male secondary sexual characters
ac	= acrostichal setae
dc	= dorsocentral setae
hm	= postpronotal setae
np	= notopleural setae
pa	= post alar setae
ph	= posthumeral setae
sc	= scutellar setae
t	= tarsus
t1–5	= tarsomeres 1 to 5

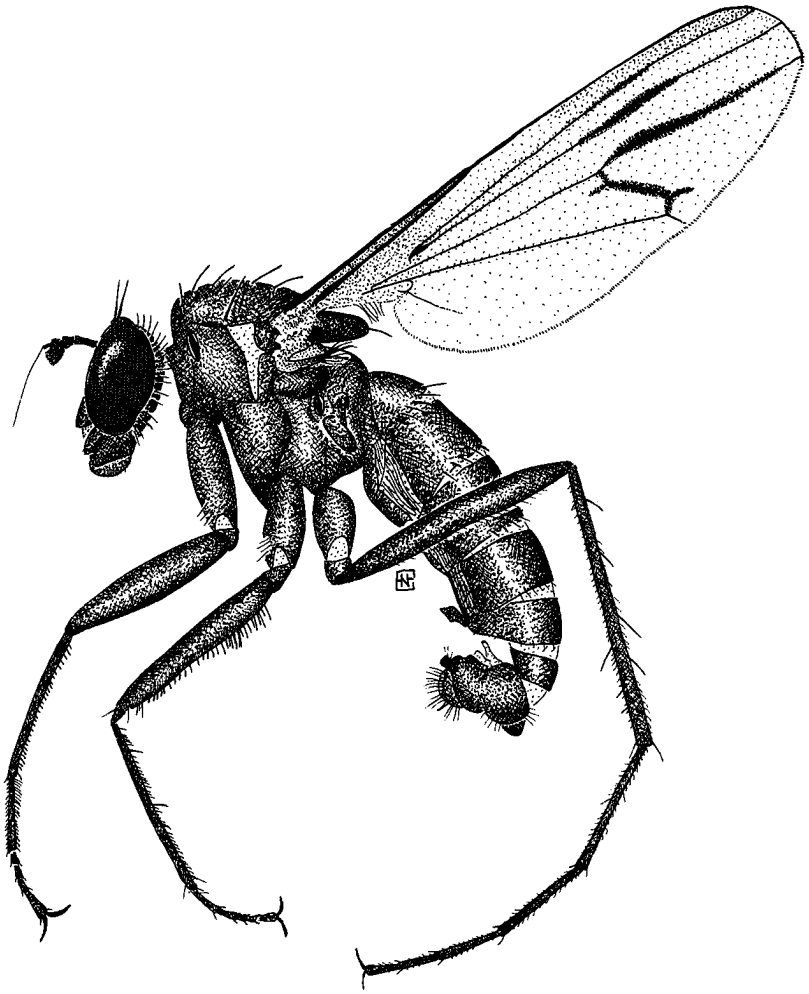


Fig. 1. *Sigmatineurum napali*, n. sp., male habitus.

SYSTEMATICS

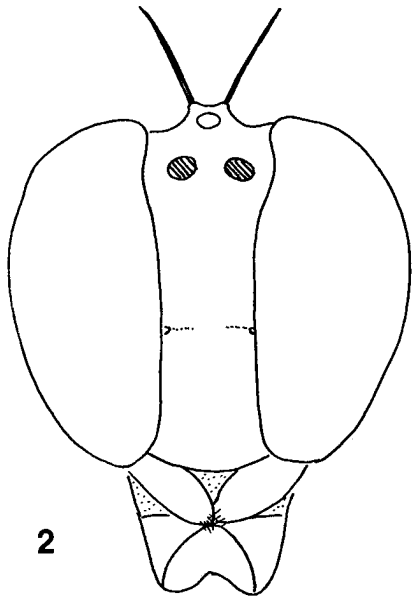
Genus *Sigmatineurum* Parent

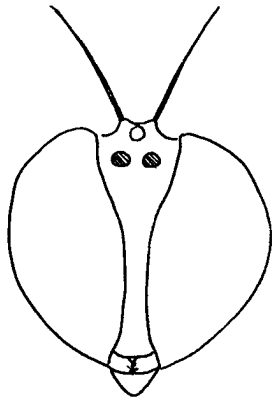
Sigmatineurum Parent, 1938: 215. Type species: *Sigmatineurum chalybeum* Parent, 1938, by original designation.

The genus was characterized by Parent (1938) and Hardy & Kohn (1964) using some or all of the following characters: S-shaped crossvein m-cu, thickening of veins R_{2+3}, R_{4+5}, and M_1 in males, and the lack of a bristle on the hind coxa. The new species added in this study do not possess all of these distinguishing characters. A revised diagnosis based on the 5 currently known species of *Sigmatineurum* is given below.

A comparatively large Hawaiian dolichopodid (4.0–5.8 mm) immediately distinguishable from other Hawaiian dolichopodids by the presence of a variously shaped process on the posterior margin of sternite 4 in males, the shape of the antennal flagellomere with a bare arista, and the striking S-shaped crossvein m-cu in most species.

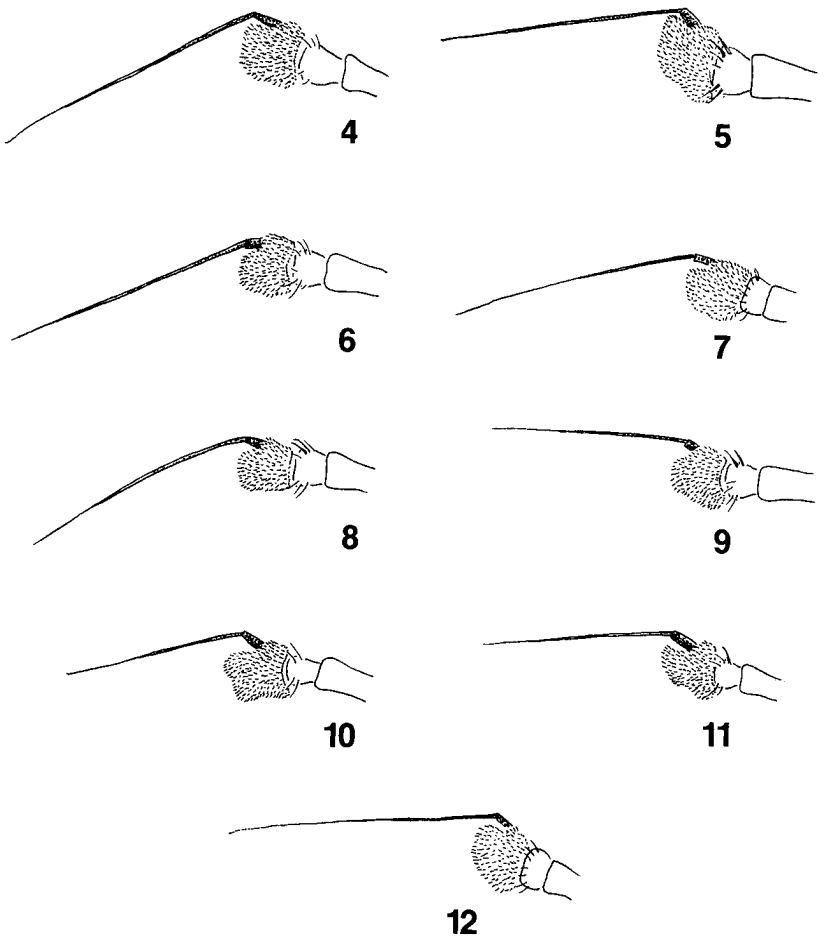
Some species do not have an S-shaped crossvein m-cu (e.g., *mnemogagne*, n. sp.) and look rather similar to *Eurynogaster*. In addition to its normally larger size compared to most other Hawaiian dolichopodids, *Sigmatineurum* is separated from typical *Eurynogaster* species (besides *Paraliancalus*, the only other Hawaiian genus it might be confused with) by the wide face (wider than the antennal sockets), the inner eye margins somewhat parallel from the level of the antennae to the oral margin (see Figs. 2–3) (in typical *Eurynogaster*, the face is considerably narrowed below the antennae with the inner





Figs. 2–3. Diagrammatic depiction of Dolichopodidae heads, antennae not shown for clarity. **2**, *Sigmatineurum mnemogagne*, n. sp., male. **3**, *Eurynogaster clavaticauda* Van Duzee, male.

eye margins converging above the oral margin), the large oral opening with large prementum, the prementum usually extending below the level of the eyes (in *Eurynogaster* the prementum and oral opening are much smaller and the prementum usually ends above the level of the eyes), the bare antennal arista (arista with micropubescence in *Eurynogaster*), the basitarsus longer than the second tarsal segment, and the presence of the posterior process on sternite 4 in males (absent in most species of *Eurynogaster*). The genus is separated from *Paraliancalus* Parent, which is the only other Hawaiian dolichopodid subequal to *Sigmatineurum* in size, by the lack of a strong bristle on the lateral portion of the hind coxa (some species of *Sigmatineurum* possess a few small hairs on the hind coxa) and the presence of the process on sternite 4 in males (absent in *Paraliancalus*).



Figs. 4–12. *Sigmatineurum* antennae. **4**, *S. chalybeum* Parent, male. **5**, *S. chalybeum*, female. **6**, *S. iao*, n. sp., male. **7**, *S. iao*, n. sp., female. **8**, *S. mnemogagne*, n. sp., male. **9**, *S. mnemogagne*, n. sp., female. **10**, *S. napali*, n. sp., male. **11**, *S. napali*, n. sp., female. **12**, *S. omega*, n. sp., male

Sigmatineurum also bears a superficial resemblance to the Holarctic and Oriental *Diostracus* Loew, which is found in the same splash-zone habitats in rushing steams. *Sigmatineurum* can be separated from *Diostracus* by the relatively smaller and dark-colored palpi (much larger and silvery pruinose in *Diostracus*), the foliate to triangular posterior process of the fourth sternite (shaped differently in those species of *Diostracus* in which it is present), the thickening of veins R_{2+3}, R_{4+5} and M_1 in most males (not thickened in most species of *Diostracus*), and the ovate to ellipsoid cerci of the male genitalia (usually much longer and thinner in *Diostracus*).

Males of *Eurynogaster binodata* Parent also possess a foliate posterior process on the fourth abdominal sternite (which typifies species of *Sigmatineurum*) and occurs in much the same habitats as *Sigmatineurum*. *Eurynogaster*, as is currently composed, is a very heterogeneous collection of species, which can be divided into many separate lineages, some of which may warrant generic status. Thus, we feel it is premature at this time to transfer *binodata* from *Eurynogaster* to *Sigmatineurum* without examining all the species of *Eurynogaster* and *Sigmatineurum* and determining the generic limits of each genus. This will be conducted in a forthcoming study.

We provisionally retain *Sigmatineurum* in the Hydrophorinae, based on the wide facial area, large palpi, and its having strong postvertical setae. However, phylogenetic analysis of Hawaiian and other genera of Dolichopodidae will be necessary before final subfamilial placement of this or any other endemic Hawaiian dolichopodid genus can be safely made. A cursory examination during this study of French Polynesian and Hawaiian dolichopodid genera showed that many of the characters previously used to separate subfamilies do not maintain their integrity when longer series of species and specimens of various genera are critically examined. One character in particular that will have to be examined in more detail is the prescutellar depression, which currently characterizes Hawaiian species of the sympycnine genera *Campsicnemus* Haliday and *Eurynogaster* Van Duzee (species of *Campsicnemus* from other regions do not possess this depression). *Sigmatineurum chalybeum* and *S. mnemogagne*, n. sp., also possess a prescutellar depression. It is most likely that this depression in *Sigmatineurum* is merely an artifact of air drying (specimens collected into alcohol do not have the depression, but specimens that are pinned after air drying usually show this depression); however, their wide facial area and strong postvertical bristles preclude species of *Sigmatineurum* (at this time) from being members of the Sympycninae.

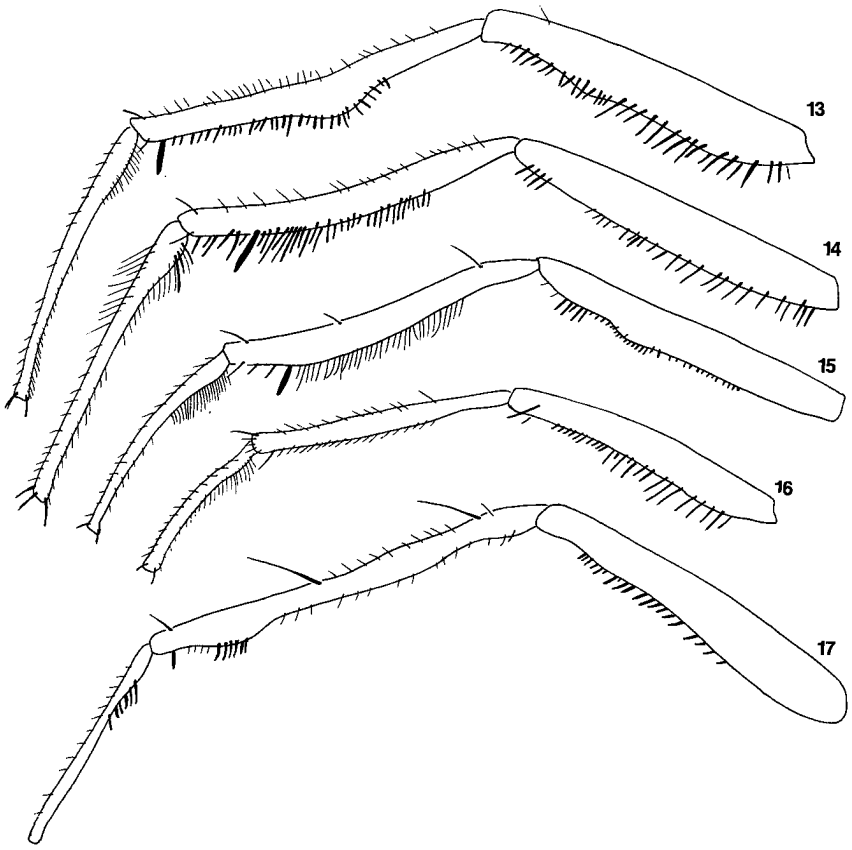
Zimmerman (1948) stated that *Sigmatineurum* is of Pacific origin. However, as no phylogenetic analysis has yet been conducted on this or related hydrophorine genera, we feel it is premature to make such assumptions here. *Sigmatineurum* is endemic to the Hawaiian Islands where it is known from Molokai, West Maui, and newly recorded from Kauai, Hawaii Island, and East Maui.

Sigmatineurum chalybeum Parent Figs. 4, 5, 13, 23, 27, 31

Sigmatineurum chalybeum Parent, 1938:216. Williams, 1939: 304, 305; Hardy, 1952: 455; Hardy & Kohn, 1964: 251–53; Bickel & Dyte, 1989: 406; Nishida, 1992: 98.

This species is characterized by the strong S-shaped crossvein m-cu lacking stump veins in males (less sinuous in females), the lack of pronounced infuscation on the wing veins, and the distinctive MSSC on the FII, TII, and IIt1 (Fig. 13). A redescription of *chalybeum* based on the 3 known specimens (all syntypes) is given below.

Male. Length: 5.0–5.3 mm; wing: 5.0 mm. *Head.* Front, face, clypeus, and vertex with blue-green reflections; clypeus gray-brown pruinose, with darker anterior tentorial pits; face almost parallel-sided along its entire length, slightly constricted near middle; palp and proboscis brown; antennal flagellomere as in Fig. 4; arista length subequal to head height.



Figs. 13–17. *Sigmatineurum* male FII, TII, IIt1. **13**, *S. chalybeum* Parent. **14**, *S. iao*, n. sp. **15**, *S. mnemogagne*, n. sp. **16**, *S. napali*, n. sp. **17**, *S. omega*, n. sp.

Thorax. Dorsum subshining green through gray-brown pruinosity; prescutellar area (clearly depressed in 2 of the 3 specimens) and scutellum shining emerald green; notopleural area and anepisternum brassy golden green; remainder of pleura covered with gray-brown pruinosity; thoracic setae black; 4–6 *dc*; 2 *np*; 1 *ph*; 1 + 2 *pa*; 2 *sc*; *ac* absent.

Legs. Brown with blue-green reflections on coxae, femora, and tibiae. FI with long black setae on apical half (MSSC); TI and It1 with long black setae along ventral margin, longest basally (MSSC); It2–5 unmodified. FII (Fig. 13) with strong black bristles along ventral margin (MSSC), thinning on apical one-fifth; TII distorted with distinct bulge near middle (MSSC), bearing stiff black bristles along ventral margin, longest and thickest at bulge (MSSC), strong spur at apex (MSSC); IIt1–5 without strong hairs. Leg III unmodified, without MSSC.

I—9.6; 9.6; 4.8/ 0.8/ 0.8/ 1.0/ 1.6

II—12.1; 13.4; 8.6/ 8.0/ 4.4/ 3.6/ 2.0

III—14.0; 20.0; 10.6/ 6.0/ 4.0/ 3.0/ 2.6

Wing (Fig. 23). Subhyaline, tinted pale brown in field, tinted brown along most veins and basal-

ly, darkest tinting in cell r; m-cu strongly S-shaped; R_{2+3} thickened slightly just before middle (MSSC); R_{4+5} thickened less so at same level (MSSC); CuA_1 not quite reaching wing margin; CuAx ratio: 5.6; halter dark brown.

Abdomen. Brown with magenta and blue-green reflections; strong black hairs posterolaterally on tergite I, thinner hairs posterolaterally on tergite V; sternite 4 process (Figs. 31b, c) small, foliate, with truncate apex, thin in lateral view. Hypopygium (Fig. 31a) brown, not dissected.

Female. Length: 5.0 mm; wing: 5.0 mm. Similar to male except lacking MSSC; otherwise as follows: vertex bright green; antennal flagellomere as in Fig. 5; dorsum of thorax with magenta reflections; m-cu less S-shaped (Fig. 27); CuAx ratio: 3.2.

Types. This species was originally described from an unspecified number of specimens from Moaula (as "Moalua") Stream on east Molokai. From Parent's original description, it is apparent that he had at least 1 male and 1 female. Hardy & Kohn (1964) mention only a single male specimen in the Parent Collection in MNHN; however, they illustrate a male specimen from the BMNH. A third syntypic specimen (female) was found in the BMNH collection. The MNHN Parent syntype male was also examined (which, besides being headless, is in good condition). A fourth syntypic specimen (female) was located in the HDOA collection. It is in excellent condition. The BMNH male was collected at 2,100 ft, otherwise the other 3 syntypes fit the locality and elevational data published by Parent (i.e., 2,000 ft), except that Parent misread the collecting date (published as 24 November 1933; actually 29 November 1933). The best preserved of these 4 syntypes, the male in BMNH is here designated **lectotype**. The female paralectotype in BMNH (which carries a red-ringed circular "type" label) has been transferred to the BPBM on exchange. The lectotype male carries the following labels: "Moalua [sic] Str. / Molokai 2100 ft [ca. 650 m] / wet rock etc. [with "wet" struck out]/ Nov. 29. 1933 / F.X.W[illiams]", "Pres. by / Imp. Inst. Ent. / B.M.1936–522.", "Sigmatineurum/ chalybeum n. sp./ Type/ O. Parent", "LECTOTYPE / Sigmatineurum / chalybeum / Parent / det. N.L. Evenhuis".

The lectotype male is slightly damaged and double-mounted onto an acetate stage with a thick minuten. The left wing and right hind leg are glued to the stage; the left femur is torn in half, but is still intact. There is slight vertigris on the pin above the thorax.

The species is known only from the original collections by Williams. Recent collecting forays to the general area on Molokai have proven unsuccessful in collecting further material.

Habits. None specifically known for *chalybeum.* See under Habitat Preference of *Sigmatineurum* below for more details.

Sigmatineurum iao Evenhuis**, new species** Figs. 6, 7, 14, 24

Sigmatineurum chalybeum: Hardy & Kohn, 1964: 252, figs. 70a and 70b only (misidentification).

Distinguished from its congeners by the exaggerated S-shaped m-cu crossvein (Fig. 24) and the different MSSC on the mid leg.

Male. Length: 3.0 mm [the abdomen is broken off beyond tergite I and missing]; wing: 5.0 mm. *Head.* As in *chalybeum* except as follows: clypeus slightly smaller; antennal flagellomere as in Fig. 6; arista length about four-fifths head height.

Thorax. As in *chalybeum* except as follows: notopleural area and scutellum with blue-green reflections; 4 *dc*, 2 *sc* plus 2 pairs of supernumerary hairs lateral to *sc*.

Legs. Brown with blue-green reflections on coxae femora, less so on tibiae. FI unmodified; TI with alternating long and short hairs (1 long, 4 short) along ventral margin (MSSC); It1 with paired ventrolateral rows of very long, thin hairs (MSSC). FII (Fig. 14) without distinct bulge near middle,

with strong, stiff black bristles along ventral margin (MSSC), bristles ending subapically; TII slightly distorted, slight swelling at basal one-third with patch of setae (MSSC), larger patch of longer setae on ventral margin at apical two-thirds (MSSC), strong spur subapically (MSSC); IIt1 with dense setae along ventral margin, longest and densest basally, patch of long fine hairs dorsolaterally (MSSC); IIt2–5 unmodified. Leg III unmodified (IIIt3–5 lost).

I—10.8; 9.6; 7.0/ 1.4/ 1.0/ 1.0/ 1.6

II—10.4; 12.6; 9.4/ 6.0/ 3.6/ 2.0/ 2.0

III—15.0; 17.2 [remainder of leg broken off and missing].

Wing (Fig. 24). Subhyaline, tinted pale brown throughout, darkest tinting basally, in middle of cell r, and along basal three-fourths of vein CuA_1; m-cu strongly S-shaped, with spur veins; veins R_{2+3}, R_{4+5}, and M_1 thickened at level just beyond m-cu (MSSC); CuA_1 not quite reaching wing margin; CuAx ratio: 6.4; halter brown.

Abdomen. Tergite I brown with bright emerald green reflections, long dark setae posterolaterally [remainder of abdomen broken off and missing].

Female. Length: 5.1 mm; wing: 5.1 mm. Similar to male except lacking MSSC; otherwise as follows: front dull brown, vertex bright green; antennal flagellomere as in Fig. 7; dorsum of thorax brown, prescutellar area and scutellum with coppery and magenta reflections; m-cu less S-shaped; CuAx ratio: 3.0; abdominal tergites II and IV–V with dark emerald green reflections dorsally, tergite III with predominatly magenta reflections dorsally.

Types. Holotype male (BPBM 15,217) from: [HAWAIIAN ISLANDS: Maui I (W):] Iao Valley, [2,000 ft.], 1.iii.1915, J.F. Illingworth. *Paratype female*. Same data as holotype except: 19.xii.1931, F.X. Williams, on sheltered side of wet rock in rapids (HDOA).

The holotype is damaged, but enough salient characters and MSSC remain to easily distinguish it from the congeners. It is double mounted with a minuten pin to a clear yellow acetate stage. The left TIII and right FIII and TIII are glued to a corner of the acetate stage. The abdomen is broken off beyond segment I and is missing. The paratype female only lacks the left wing and the left hind leg beyond the coxa, otherwise it is in excellent condition.

Remarks. The illustrations in Hardy & Kohn (1964; figs. 70a, b) of wing and antenna of *chalybeum* are actually of the *S. iao* male collected by Illingworth.

Etymology. This species is named for the type locality on west Maui.

Habits. Unknown except for the label data provided for the paratype female.

Sigmatineurum mnemogagne Evenhuis, **new species** Figs. 2, 8, 9, 15, 19–22, 25, 28, 32

Separated from congeners by the slight bend in the m-cu crossvein (more S-shaped in other species in the genus), by the different MSSC on the mid leg, and by the shape of the process on sternite 4.

Male. Length: 4.6–4.8 mm; wing: 4.4–4.5 mm. *Head* (Fig. 2). Front, face, and vertex dark brown with dark blue-green reflections, clypeus slightly gray-brown pruinose, with darker anterior tentorial pits and light blue-green reflections; inner eye margins parallel-sided from level of antenna to level of upper margin of clypeus; palp and proboscis brown; antennal flagellomere as in Fig. 8; arista length slightly less than head height.

Thorax. Dorsum and scutellum brown with brownish gray pruinosity, some blue-green reflections; notopleural area shining blue-green; anepisternum with greenish reflections, coppery reflections at notopleural suture; katepisternum with greenish and magenta reflections; remainder of pleura covered with grayish pruinosity; thoracic setae black to dark chocolate brown; 4 *dc*; 2 *np*; 1 *ph*; 1 *pa*; 2 *sc*; *ac* absent.

Legs. Brown, blue-green reflections on coxae, femora, and tibiae. FI predominantly bare, a few hairs ventrally at apex; remainder of leg I unmodified. FII (Fig. 15) with strong stubby black bristles along ventral margin (MSSC) (Figs. 19–20), bristles absent at base, thinning out apically; TII slight-

Figs. 19–22. Scanning electron micrographs of *Sigmatineurum mnemogagne*, n. sp. **19**, Ventral surface of FII showing subapical patch of strong bristles. **20**, Magnified view of subapical patch of strong bristles on FII. **21**, Magnified view of strong subapical spur on TII (spur indicated by pointer). **22**, Detail of male hypopygium, sinistral view.

ly distorted with ventral hairs (MSSC), strong subbasal setae (Fig. 21) on dorsal surface (MSSC), strong spur subapically on ventral surface (MSSC); IIt1 bowed (MSSC), with small dense patch of hairs basally (MSSC); IIt2–5 unmodified. Leg III unmodified.

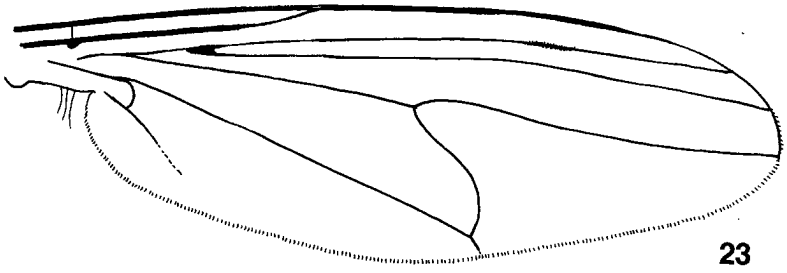
I—11.0; 10.2; 5.4/ 1.0/ 1.0/ 1.0/ 1.8

II—14.0; 12.4; 8.0/ 6.0/ 4.4/ 2.6/ 2.4

III—16.2; 17.6; 8.6/ 6.0/ 4.0/ 2.4/ 2.6

Wing (Fig. 25). Subhyaline throughout, brown color densest basally at apex of cell r; m-cu bent slightly at middle, not S-shaped, with or without small spur vein at bend; slight thickening of veins R_{2+3}, R_{4+5}, and M_1 at level just beyond m-cu, with brown tinting surrounding thickening, thickest on M_1 (MSSC); CuA_1 reaching or almost reaching wing margin; CuAx 5.0; halter dark brown, knob white ventrally in some specimens.

Abdomen. Dark brown with magenta and green reflections dorsally, reflections brassy green lat-



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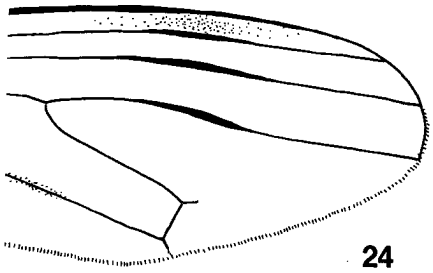

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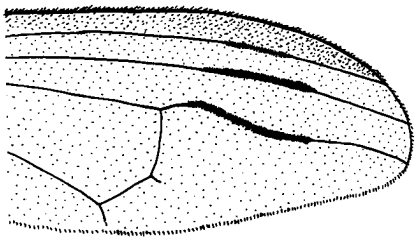

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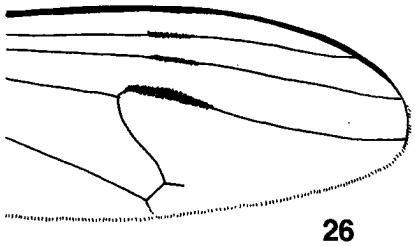

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Figs. 23–26. *Sigmatineurum* male wings. **23**, *S. chalybeum* Parent, infuscation omitted. **24**, *S. iao*, n. sp. **25**, *S. mnemogagne*, n. sp. **26**, *S. omega*, n. sp., infuscation omitted.

erally; black hairs posterolaterally on tergite I, thinner denser patch of hairs at posterolateral angle of tergite V; sternite 4 process (Figs. 32b, c) rather large, foliate, thin in lateral view. Hypopygium (Fig. 32a) dark brown.

Female. Length: 5.0–5.8 mm; wing: 4.8–5.6 mm. Similar to male except lacking MSSC; otherwise as follows: antennal flagellomere as in Fig. 9; anepisternum, katepisternum, and notopleural area shining green; wing as in Fig. 28; halter knob white ventrally.

Types. Holotype male (BPBM 15,218), 6 male and 3 female paratypes from: HAWAIIAN ISLANDS: Maui I: tributary to Middle Hanawi Stream, Station 3, Hanawi Natural Area Reserve, 2900 ft [885 m], along stream, 12.xi.1992, D.A. Polhemus. *Other paratypes*: HAWAIIAN ISLANDS: Maui I: 1 female, Hahalawe Gulch, 365–410 m, sweeping over rocks in waterfall spray zone, 5.v.1984, G.M. Nishida (BPBM); 1 female, Haleakala, Paliku, 6800 ft. [1980 m], sweeping, 24.vi.1975, R. Burkhardt (BPBM). Holotype and 8 paratypes in BPBM. Paratype male and female in BMNH and one paratype male in MNHN.

Variation. There appear to be 2 color forms among the 5 female specimens collected: 4 have the wing distinctly smoky brown in color; 1 has the wing almost hyaline; otherwise the 5 are indistinguishable from each other.

Etymology. This species is named in memory of Wayne Gagné, whose knowledge of and efforts to conserve native Hawaiian ecosystems were unsurpassed. The name derives from the Greek *mnemo* = memory + Gagné.

Habits. Most of the types were collected along Hanawi Stream while sweeping the rock margins in the splash zone a few inches above the water. Detailed description of the site and insects collected there are provided by Englund & Polhemus (1993). One other paratype female was collected in a similar situation along the Hahalawe Stream.

Sigmatineurum napali Evenhuis, **new species** Figs. 1, 10, 11, 16, 29, 33

Easily separated from the congeners by the distinctive wing venation and infuscation pattern, lack of MSSC on the mid leg, and by the shape and thickness of the process on sternite 4 in the male.

Male (Fig. 1). Length: 4.0 mm; wing: 4.0 mm. *Head*. Front, face, and vertex black with blue-green reflections; clypeus gray-brown pruinose with darker brown anterior tentorial pits; face almost parallel-sided from level of antennae to upper margin of clypeus; palp and proboscis brown; antennal flagellomere as in Fig. 10; arista length about five-sixths head height.

Thorax. Dorsum brown, brown pruinose with some greenish reflections; scutellum shining green; anepisternum shining blue-green; katepisternum with blue green reflections through covering of gray pruinosity; rest of pleura gray pruinose; notopleural area shining blue-green; thoracic setae black; 4 *dc*; 2 *np*; 1 *ph*; 1 + 1 *pa*; 2 *sc*; *ac* absent.

Legs. Coxae gray pruinose, with blue-green to green reflections, rest of legs brown, femora and tibiae with blue-green reflections. CI with short strong black hairs apically (MSSC); rest of leg I unmodified. FII (Fig. 16) swollen slightly at basal third, with strong, stubby bristles along ventral margin (MSSC), becoming shorter and thinner on apical two-fifths, without apical or subapical spur; rest of leg II unmodified. Leg III unmodified.

I—8.6; 7.6; 3.2/ 0.6/ 0.6/ 0.6/ 1.4

II—10.6; 8.8; 5.4/ 4.0/ 2.0/0.7/0.8

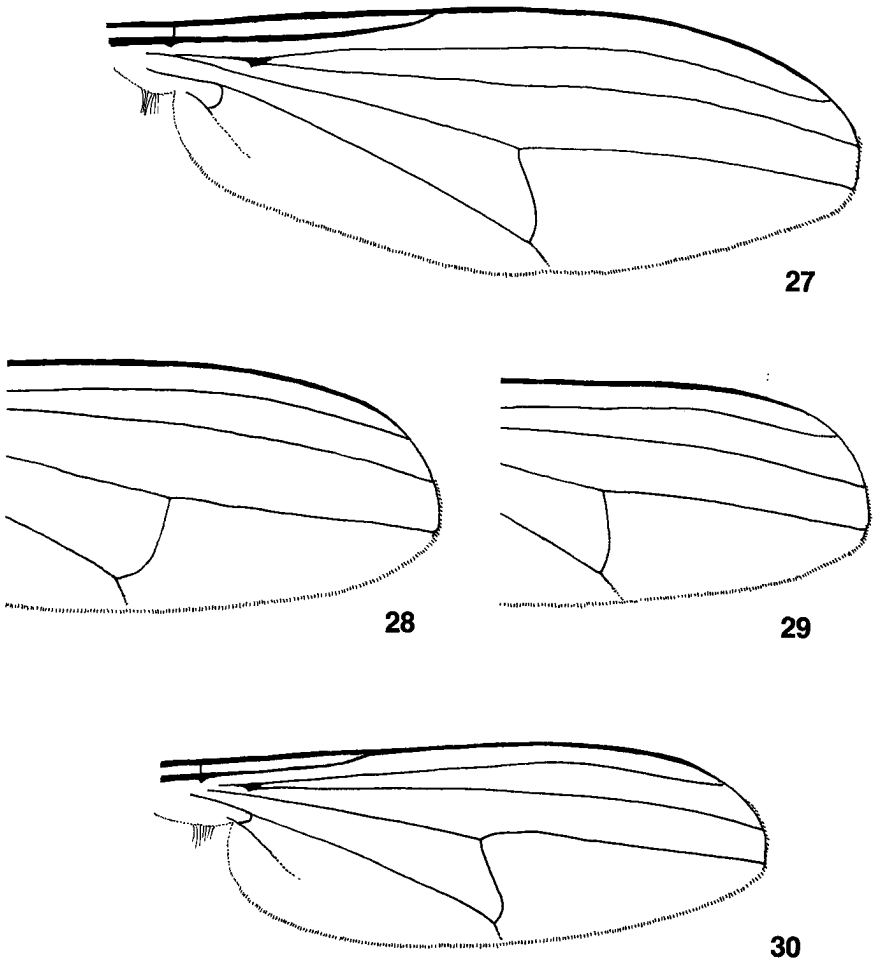
III—12.6; 14.4; 6.6/ 4.8/ 3.4/ 2.0/ 2.0

Wing (Fig. 1). Subhyaline throughout, tinted with brown color basally, along most veins, and apically in cell r; thick dark tinting along m-cu including spur veins and along proximal half of M_1 (MSSC); m-cu strongly S-shaped, with spur veins; R_{2+3}, R_{4+5}, and M_1 thickened at level just beyond m-cu (MSSC); CuA_1 barely reaching wing margin; CuAx ratio: 4.5; halter brown, knob with blue-green reflections.

Abdomen. Brown with green reflections dorsally, brassy green reflections laterally; strong black hairs posterolaterally on tergites I and II, thinner black hairs posterolaterally on tergite III; sternite 4 process (Figs. 33b, c) small, foliate, thick, triangular in lateral view. Hypopygium (Fig. 33a) brown, with blue-green reflections.

Female. Length: 3.9–4.6 mm; wing: 4.0–4.5 mm. Similar to male except lacking MSSC; otherwise as follows: antennal flagellomere as in Fig. 11; notopleural area, anepisternum, and katepisternum with brassy green highlights; m-cu much less S-shaped (Fig. 29); CuAx ratio: 3.0; abdominal tergites with more brassy green and magenta reflections.

Types. Holotype male (BPBM 15,216) and 4 paratype females from: HAWAIIAN



Figs. 27–30. *Sigmatineurum* female wings. **27**, *S. chalybeum* Parent. **28**, *S. mnemogagne*, n. sp. **29**, *S. napali*, n. sp. **30**, *S. omega*, n. sp.

ISLANDS: Kauai I: Upper Hanakoa Stream, Hono O Na Pali Natural Area Reserve, 3800 ft [1160 m], margins of waterfall, 28.iv.1992, D.A. Polhemus. *Other paratype*: HAWAIIAN ISLANDS: Kauai I: 1 male, Hanakapai Val., below falls, 600 ft, 10.viii.1971, D.E. Hardy. Holotype and 2 paratypes in BPBM. Paratype male in UHM; one paratype female each in BMNH and MNHN.

The holotype is in excellent condition except the apical tarsal segments of the mid-leg have been broken off and are missing.

Etymology. This species is named for the Na Pali Coast of northern Kauai, where Hanakoa Stream and Hanakapai Valley are located.

Habits. The types were collected at the head of a waterfall while sweeping the rock margins in the splash zone of the stream a few inches above the water.

A subsequent trip to the type locality in October 1992 by DAP to assess the effects of Hurricane Iniki (which passed directly over the island of Kauai in September 1992) failed to recover additional specimens. The type locality was inaccessible due to fallen trees and foliage along the stream so it is not known if the population of this species survived the effects of the storm.

Remarks. Two additional females from Kalalau [Valley], Kauai, 18.vi.1922, E.H. Bryan, Jr. (BPBM) appear close to *napali*, but have a slighly different wing venation and are in a damaged and very greasy condition making determination difficult. They may be members of *Sigmatineurum*, but without males, specific or generic determination is impossible.

Sigmatineurum omega Evenhuis, **new species** Figs. 12, 17, 26, 30, 34

Males can be separated from congeners by the swollen areas subapically and subbasally on the mid tibia and by the setation on the mid femur.

Male. Length: 5.2–5.3 mm; wing: 5.1–5.2 mm. *Head*. Front and vertex dark brown, face shining dark brown with some purple reflections, clypeus brown pruinose, with darker anterior tentorial pits; inner eye margins almost parallel-sided from level of antenna to level of upper margin of clypeus; palp and proboscis brown; antennal flagellomere as in Fig. 12; arista length slightly less than head height.

Thorax. Dorsum and scutellum brown with brownish gray pruinosity, with dark green reflections, paler blue-green reflections on some parts of scutellum; notopleural area and anepisternum with greenish reflections, brassy reflections at notopleural suture; katepisternum with greenish reflections above, magenta reflections below; remainder of pleura covered with grayish pruinosity; thoracic setae black ; 5 *dc*; 2 *np*; 1 *ph*; 1 *pa*; 1+1 *sc*; *ac* absent.

Legs. Brown, gray pruinose on coxae, blue-green reflections on femora and tibiae. FI with row of long hairs ventrally; remainder of leg I unmodified. FII (Fig. 17) with strong stubby black bristles along ventral margin (MSSC), bristles absent at extreme base and apex; TII swollen subbasally and subapically on ventral surface (MSSC), small patch of strong setae on subapical swelling on ventral surface (MSSC), strong spur subapically on ventral surface (MSSC); dense long hairs on apical 7/8 of dorsal surface (MSSC); IIt1 with patch of strong bristles subbasally on slight swelling of ventral surface (MSSC); IIt2–5 unmodified. Leg III unmodified.

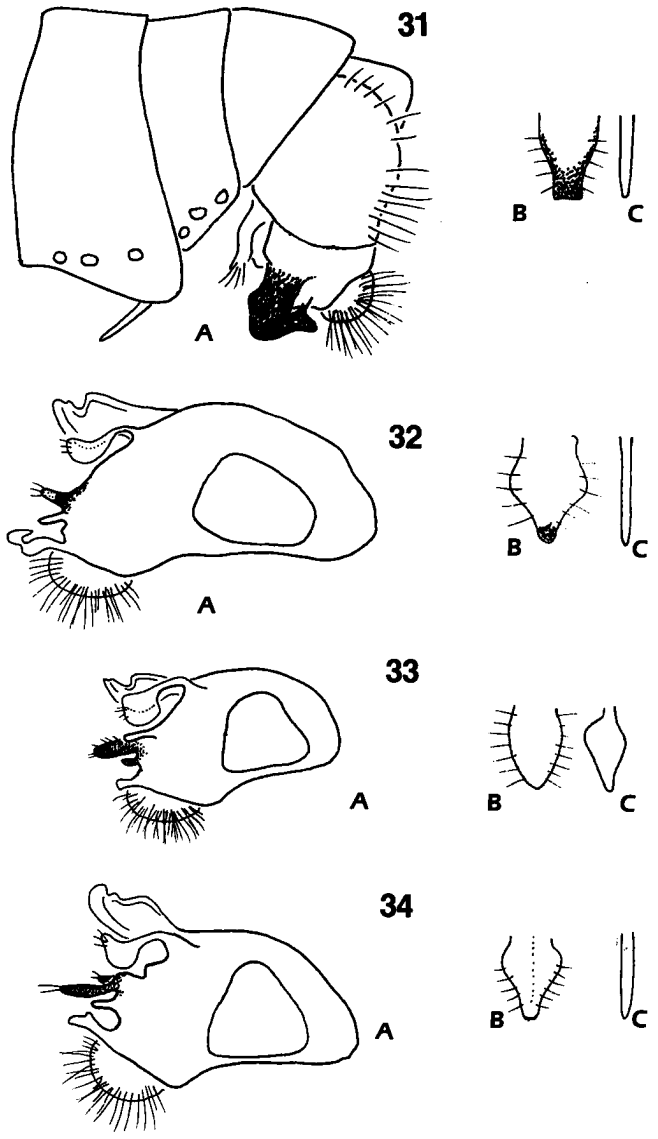
I—10.0; 10.0; 4.8/ 0.6/ 0.6/ 0.7/ 1.5

II—12.0; 13.4; 8.0/ 6.0/ 4.2/ 3.0/ 2.0

III—15.0; 22.2; 8.4/ 6.0/ 4.0/ 3.4/ 1.4

Wing (Fig. 26). Smoky brown throughout except in anal area, brown color densest basally at apex of cell r; m-cu strongly S-shaped, with small spur vein at bend; slight thickening of veins R_{2+3}, R_{4+5}, and M_1 at level just beyond m-cu, with brown tinting surrounding thickening, thickest on M_1 (MSSC); CuA_1 reaching wing margin; CuAx 5.5; halter dark brown.

Abdomen. Dark brown with dark green to brassy green reflections dorsally, reflections brassy



Figs. 31–34. *Sigmatineurum* male postabdomina, hypopygia, and sternite 4 processes. **31**, *S. chalybeum* Parent; **a**, postabdomen; **b**, sternite 4 process, ventral view; **c**, sternite 4 process, lateral view. **32**, *S. mnemogagne*, n. sp.; **a**, hypopygium, sinistral view; **b**, sternite 4 process, ventral view; **c**, sternite 4 process, lateral view. **33**, *S. napali*, n. sp.; **a**, hypopygium, sinistral view; **b**, sternite 4 process, ventral view; **c**, sternite 4 process, lateral view. **34**, *S. omega*, n. sp.; a, hypogyium, sinistral view; b, sternite 4 process, ventral view; c, sternite 4 process, lateral view.

green laterally; black hairs posterolaterally on tergite I, thinner denser patch of hairs at posterolateral angle of tergite 5; sternite 4 process (Figs. 34b, c) rather large, foliate, with medial ridge, thin in lateral view. Hypopygium (Fig. 34a) shining dark brown, with some blue-green reflections.

Female. Length: 5.0 mm; wing: 5.0–5.5 mm. Similar to male except lacking MSSC; otherwise as follows: anepisternum with brassy green reflections, katepisternum with pale blue-green refelctions above, brown below; wing as in Fig. 30, with or without small spur vein at bend of m-cu.

Types. Holotype male (BPBM 15,225),from HAWAIIAN ISLANDS: Hawaii I: Wailuku Riv, 1270 ft [390 m], 22.vi.1971, J.A. Tenorio. *Paratypes*: same data as holotype except: 1 male, 900 ft. [275 m]; 1 male, 1 female, 4220 ft [1290 m], 25.vi.1971; 1 female, "Boiling pots", Wailuku Riv, 850 ft. [260 m], 14.viii.1970, D.E. Hardy. Holotype and paratypes in BPBM.

Etymology. The name derives from the Greek, *omega* = last; referring to the fact that this was the last undescribed species of *Sigmatineurum* found in this study.

Habits. Not recorded. A collecting expedition to the Wailuku river by the senior author was conducted in April 1993, but no specimens of *omega* were found at Rainbow Falls, the Boiling Pots locality, or along the river at approximately the 3,500 ft elevation.

KEY TO SPECIES OF *SIGMATINEURUM* BASED UPON MALES

1. Crossvein m-cu with slight bend near middle, but not distinctly S-shaped (Figs. 25); FII with only short weak bristles on basal 1/2; sternite 4 process apically pointed (Figs. 32b, c) . . . (East Maui) . . . . . ***mnemogagne*** Evenhuis, **n. sp.**
– Crossvein m-cu strongly S-shaped (Figs. 1, 23, 24, 26), with or without spur veins; FII with long strong bristles on basal 1/2 (except in *omega*); sternite 4 process variously shaped 2
2. Crossvein m-cu with spur veins (Figs. 24, 26); TII without distinct bulge at middle 3
– Crossvein m-cu without spur veins (Fig. 23); TII with prominent bulge near middle; sternite 4 process apically truncate (Figs. 33b, c) . . . (Molokai) . . . . . ***chalybeum*** Parent
3. TII with distinct bulge subapically; FII with ventral row of short bristles in middle, bare at base and apex (Fig. 17) . . . (Hawaii) . . . . . ***omega*** Evenhuis, **n. sp.**
– TII without distinct bulge subapically; FII with ventral bristles much longer (Figs. 14, 16) 4
4. Wing infumate basally, anteriorly, and along most veins; veins R_{4+5}, M_1 and crossvein m-cu thickened and darkly tinted; TII without MSSC (Fig. 16); sternite 4 process small, pointed, thick in cross section . . . (Kauai) . . . . . ***napali*** Evenhuis, **n. sp.**
– Wing weakly infuscate basally and anteriorly; crossvein m-cu without thickening and dark tinting; TII with strong bristles and preapical spur (Fig. 14) . . . (West Maui) . . . . . ***iao*** Evenhuis, **n. sp.**

HABITAT PREFERENCE OF *SIGMATINEURUM*

Adults of *Sigmatineurum* appear to be tightly restricted to particular riparian microhabi tats consisting of wet, shaded, vertical bedrock exposures next to small splashing waterfalls in areas of mesic forest. Both recent collections of this genus made by DAP have come from such situations along second order streams (Strahler, 1952) lying at or above 885 m elevation in two drainage systems, the Hanakoa Stream on Kauai and the Hanawi Stream on Maui. However, previous collections of *napali* and *omega* by others show that species of *Sigmatineurum* can occur at elevations as low as 600 feet.

Hanakoa Stream lies in northern Kauai, and occupies a steep-sided catchment approximately 5 km in length, draining from a source near Pihea peak northward to the Na Pali Coast. The Hanakoa headwaters occupy an elevated plateau in the Hono O Na Pali Natural Area Reserve, forming an intricately dissected network of heavily forested drainages. The gradient in this headwater area above the Na Pali cliffs is moderate, although punctuated with occasional waterfalls up to 15 m high. Upon reaching the Na Pali cliffs the stream plunges over a very high waterfall, then continues to its seaward terminus in a rocky bed with a moderate gradient.

Sigmatineurum napali were found in the Hanakoa headwaters at the first major waterfall on the main branch as one progresses downstream from Pihea peak. This fall formed a sloping cascade cradled in a U-shaped bedrock channel, and was shaded by native kanawao (*Broussasia arguta*) and ohia (*Metrosideros polymorpha*). Adults of *S. napali* occurred on sloping to vertical wet rock faces just above the water surface at the head of this fall, and were taken by sweeping a net swiftly back and forth just above these rock surfaces. The flies appeared tightly confined to this particular area; none were found on horizontal wet rock faces near the fall, and no other site similar to the fall was encountered along the kilometer of stream reach sampled. The forest surrounding the collecting site was relatively pristine, with little evidence of damage from humans or feral animals. Weather at the time of collections was cool, overcast and raining, with the air temperature recorded at 14 °C.

Collections of *Sigmatineurum mnemogagne* were made along Hanawi Stream, a swift, rocky perennial stream occupying a catchment approximately 11 km in length on the northern, or windward, slopes of Haleakala, East Maui. The stream begins as a set of streamlets lying in open montane grasslands at approximately 2300 m, and drops swiftly along a steep gradient down the forested slopes of Haleakala to its seaward terminus. The stream flows through a predominantly bedrock channel in the headwater and midreach sections, with the profile punctuated by numerous dry jump offs and small waterfalls, alternating with deep pools. In the upper two-thirds of the catchment Hanawi Stream and its tributaries also flow in and over old lava tube systems in many places so that much of the flow is subterranean, leaving long sections where the surface flow is naturally interrupted and intermittent. From the crossing of the Hana Road at 365 m to the seaward terminus, the subterranean flows resurface and the stream enters a deep, narrow gorge with steep walls, plunging over several high waterfalls before entering the sea just west of Nahiku.

Sigmatineurum was found along a tributary to the middle section of Hanawi Stream at an elevation of 885 m. The tributary sampled was a moderately sized second order stream flowing in a bedrock channel containing exposures of columnar basalt, with a profile consisting of small cascades and deep pools interspersed with cobble-bottomed runs. Vegetation along this reach consisted of large, scattered native koa (*Acacia koa*) and ohia (*Metrosideros polymorpha*) with a thick understory of uluhe ferns (*Dicranopteris linearis*), providing partial shade to the channel. As at Hanakoa Stream, there was little evi-

dence at this site of disturbance by either feral animals or humans. Weather at the time of the collections was fair, with sunny mornings and cloudy, dry afternoons.

Adults of *S. mnemogagne* occurred at Hanawi in conditions very similar to those in which they had been encountered on Kauai. The preferred habitat was vertical wet bedrock walls in the splash zone of small, sloping cascades, and the insects were captured in the same manner as before, by sweeping a net back and forth just above the rock surfaces. Small populations were found at four different small cascades along the section of stream sampled, but at most only 3 or 4 individuals were ever taken at a single spot. Only by working along the length of the stream and repeatedly sampling each potential habitat during the course of the day was it possible to obtain a series of 10 specimens.

Additional observations on behavior of *Sigmatineurum chalybeum* may be found in Williams (1939), who stated simply that its habits were similar to those of *Eurynogaster binodata* Parent, which he described as follows:

> "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. Usually a single individual would be found here and there along the stream."

The courting behavior of the male of *binodata* was also observed by Williams (1939) who describes it as follows: "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. [T]he male when situated just behind the female may rapidly move his wings."

It seems likely that *Sigmatineurum* is in fact more widespread and abundant than has been previously realized, but that its strict microhabitat preferences and occurrence in remote areas with difficult access have led to its being overlooked by most collectors.

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