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THE CAVERNICOLOUS FAUNA OF HAWAIIAN LAVA TUBES

10. Crickets (Orthoptera, Gryllidae)[1]

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Abstract: This paper is a report on the systematics of 2 genera of flightless crickets which in part inhabit lava tube caves in the Hawaiian Islands. *Thaumatogryllus,* with short, lobelike tegmina, includes a surface-living species on Kauai and *T. cavicola,* n. sp. on Hawaii. The genus has long been placed in the Eneopterinae, but has some characters suggesting relationship to the Oecanthinae. *Caconemobius,* which has been overlooked previously by most entomologists, has a previously described species on Molokai and *C. fori,* n. sp. on Hawaii (both surface-dwelling), and 2 cave-dwellers, *C. varius,* n. sp. (Hawaii) and *C. howarthi,* n. sp. (Maui). *Caconemobius* (Nemobiinae) is entirely wingless and appears related to certain flightless nemobiine genera inhabiting other Pacific islands. Both *Thaumatogryllus* and *Caconemobius* are restricted to the Hawaiian Islands.

Cave dwelling (presumably troglobitic) crickets discovered recently in the Hawaiian Islands and noted briefly by Howarth (1972) are of much scientific interest because they are part of a long-overlooked underground fauna. The 3 new species of cavernicolous crickets thus far discovered (Howarth 1973) belong to 2 genera, *Thaumatogryllus* Perkins and *Caconemobius* Kirby.

Previous to these discoveries, affinities of both genera were poorly understood. For both *Thaumatogryllus* and *Caconemobius,* we suggest relationships to existing genera or higher groups either on their own part or through possible ancestral forms now unknown.

Thaumatogryllus now consists of a surface dwelling species on Kauai Island and a cavernicole on Hawaii Island. For many years the genus has been regarded as an aberrant member of the Eneopterinae, but now it appears possibly to be related to the Oecanthinae. *Caconemobius* includes a surface dweller on Molokai, another one on Hawaii, and 2 cavernicoles, 1 each on Maui and Hawaii. *Caconemobius* is in the Nemobiinae and appears to be related to *Scottiola* Uvarov and other genera of unusual, flightless nemobiines which occur, sometimes at high altitudes, on widely separated islands in the Pacific area. None of the suspected relatives is known in the Hawaiian Islands.

Judging from the discussion of Zimmerman (1948a: 44 and following), the Hawaiian land fauna, including the 2 or more introductions of ancestral species of Gryllidae, may have occurred during the late Pliocene, Pleistocene, or post-Pleistocene. Zimmerman believed (1948a: 71; 1948b: 143) that *Thaumatogryllus* and its relatives evolved from a common ancestor. It now appears equally evident that *Caconemobius,* belonging to a quite different group, the Nemobiinae, originated from another ancestor.

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Holotypes, allotypes, and a portion of paratypes of the new species are in the Bishop Museum, Honolulu (BISHOP); paratypes are also at the U.S. National Museum of Natural History, Washington (USNM), and the Academy of Natural Sciences, Philadelphia (ANSP).

GENUS **Thaumatogryllus** Perkins

Thaumatogryllus Perkins, 1899, Fauna Hawaiiensis 2(1): 27, pl. 2, fig. 10, 10a-d.

Type-species, by monotypy, *T. variegatus* Perkins.

Generic redescription of Thaumatogryllus. Body superficially smooth, finely pubescent at 10× magnification, legs more densely covered with fine short setae, no coarse bristles; many long sensory setae on cerci, also specialized flattened sensory setae near base. Head extending forward; eyes well developed, size variable; ocelli not apparent. Pronotum longer than wide, lateral lobes shallow; ♂ metanotum with deep transverse glandular pit; tegmina abbreviated, reaching onto mesonotum (♀), over base of metanotum (♂), attingent or narrowly separated, without stridulatory veins, venation degenerate; wings absent or vestigial; legs slender, tarsomere II laterally compressed but fully exposed; tarsomere I of front tarsus as long as, or longer than, combined length of tarsomeres II and III; front tibia without tympanum; hind tibia with row of many short, toothlike spines along each dorsal margin, without spurs basad of apical calcars, dorsal calcar on each side about 2× or more than 2× length of ventral; claws weakly or plainly toothed. Abdomen smooth, shiny, with many short inconspicuous setae; cercus shorter than hind tarsus, segmentation not evident, a terminal spine usually directed slightly ventrad; ovipositor subcylindrical, gently arcuate, not strongly sickle-like, apex as in FIG. 16, 17. ♂ genitalia elaborate (FIG. 31, 34).

The name *Thaumatogryllus,* combining a Greek word with a Latin, means "wonderful cricket."

HISTORY OF WORK ON *Thaumatogryllus.* Perkins (1899) described *Thaumatogryllus* and the single species *T. variegatus,* and he illustrated the terminal armature of the hind tibia and the tegmina of both sexes. He pointed out that *Thaumatogryllus* and related Hawaiian genera are entirely nocturnal and arboreal from his observations, and that they are concealed by day in dead leaves attached to trees, in hollow stems, beneath bark, and in similar places of concealment. Kirby (1906: 110) and Chopard (1968: 425) listed the species. Hebard (1922: 370) recorded a female and gave some descriptive information, but he was concerned chiefly with characters by which the genus differs from *Leptogryllus* Perkins. Zimmerman (1948b: 152-53) presented a photograph of *T. variegatus* and called attention to the laterally compressed 2nd tarsal segment of *Thaumatogryllus,* a character which conflicts with current descriptions and keys of the Eneopterinae.

RELATIONSHIPS OF *Thaumatogryllus.* There seems to be no doubt that *Thaumatogryllus* belongs to the same generic group as *Prognathogryllus* Brunner and *Leptogryllus;* all 3 are restricted to the Hawaiian Islands. Chopard (1968), in the most recent treatment, recognized the tribe Prognathogryllini, subfamily Eneopterinae. Except for some differences through the years in rank and spelling of the group name, that is an opinion beginning with Perkins (1899) who regarded the 3 genera as a distinct group. In the absence of a more comprehensive study of generic relationships, we provisionally accept Chopard's subfamily

placement. However, several characters suggest that in the evolutionary history of this genus there may have been some relationship to present Oecanthinae or their ancestors; these characters are listed below for the consideration of future students.

1. *Head* elongate, more or less porrect, not typically hypognathous.
2. *Pronotum* elongate, with shallow lateral lobes and posteroventral margin sometimes gracefully emarginate.
3. *Front femur.* In *Prognathogryllus* and *Neoxabea* Kirby (Oecanthinae), but not *Thaumatogryllus, Leptogryllus,* or *Oecanthus* Serville, base of front femur square, and attachment to trochanter confined to ventral 1/2, so that the basal end of dorsal margin is conspicuous and free (FIG. 25, *dm*).
4. *Tarsal claws.* Claws of *T. variegatus* and at least some species of *Prognathogryllus* have single extra tooth beside main one, those of *T. cavicola* sometimes have weak extra tooth. Those of *Neoxabea* strongly bifid, weakly so in *Oecanthus.* Claws bifid or with internal tooth in some species of *Xabea* Walker (Oecanthinae).
5. *Metanotum.* Glandular specialization usual in males of both Prognathogryllini and Oecanthinae.
6. *Cerci.* In both Prognathogryllini and Oecanthinae a tendency toward a short, thickened cercus; more elongate in *Oecanthus* than in *Neoxabea* and *Xabea* and often specialized in the 2 latter genera.
7. *Hind tibia.* Closely set denticulations or serrations along dorsal margins in Prognathogryllini, but no spines or large moveable spurs occur on margins. Margins variable in Oecanthinae, but an approach to the prognathogrylline condition sometimes suggested. In *Neoxabea* apical calcars are reduced to 2 on each side, as in Prognathogryllini. Chopard (1969: 266) stated that hind tibia of *Xabea* is serrulated but we have been unable to confirm it and in some species it seems untrue.
8. *Shape of 2nd tarsomere. Thaumatogryllus* distinctive by the laterally compressed 2nd tarsomere (Zimmerman 1948b: 153). This could be indication of relationship to Oecanthinae which, unlike Eneopterinae, possess such tarsal structure.
9. *Ovipositor.* Although upcurved in *Thaumatogryllus* and apex specialized differently from that of typical Oecanthinae, which in most species have short, blunt apical teeth, there is some resemblance in general structure and occurrence of lengthwise channeling near apex of both groups. Chopard (1920: 251) emphasized the distinctive ovipositor of Oecanthinae, and it is interesting that later Chopard (1951: 521-22) reported that the ovipositor valves of *Xabea podoscirtoides* Chop. are different "from other Oecanthidae and are quite similar to those of the Podoscirtidae." The latter group usually has not been accorded family rank, and in his catalogue Chopard (1968) regarded it as a tribe of Eneopterinae and placed it adjacent to the Prognathogryllini in linear arrangement, followed by the Oecanthidae, to which he gave full family rank.

KEY TO THE SPECIES OF *Thaumatogryllus* (ADULTS)

1. Length of hind femur at least 10 mm; eye large in proportion to head length (FIG. 15); subapical sclerite of ♂ genitalia (FIG. 31, *sas*) with basal and apical lobes (*bl, al*) moderately separated; surface-living species with dark brown coloration. (Kauai) . . . . . **variegatus**

   Length of hind femur scarcely more than 8 mm; eye small in proportion to head length (FIG. 4); subapical sclerite of ♂ genitalia (FIG. 34, *sas*) with basal and apical lobes widely separated; cave-living species with pale, though somewhat spotted, coloration. (Hawaii) . . . . . **cavicola,** n. sp.

RECOGNITION OF ADULTS. Adults of *Thaumatogryllus* can be distinguished from large nymphs as follows: (1) tegmina of adults are sclerotized and papery thin, attingent or nearly so (may become more separated in adults dried from alcohol), in male, specialized metanotal pit is well developed under tegmina; in nymphs, tegmina are widely separated, fleshy lobes; (2) ovipositor of female is long, well sclerotized and upturned, specialized at

apex; in nymph it is short, fleshy, straight, unspecialized; (3) male genitalia of adult are visible, at least when probed, as sclerotized structures; in nymphs they are visible as paired scarcely sclerotized lobes.

Thaumatogryllus variegatus Perkins FIG. 1, 9, 15, 17, 22, 30, 31, 32

Thaumatogryllus variegatus Perkins, 1899, Fauna Hawaiiensis 2(1): 27, pl. 1, fig. 16; pl. 2, fig. 10, 10a-d.

Diagnosis (supplementing characters in key). Adults about 15 mm long (excluding appendages); maxillary palpus stouter than in *T. cavicola,* somewhat shorter than front femur (length ratio ca 4:5); lengths of palpal segments 10:12:36:29:50 in ♂ examined; ♂ metanotum with wide transverse pit bisected by narrow median carina, at each lateral end a hooklike sclerotized structure (FIG. 9); posterior cleft along median line of ventral plate of genitalia (FIG. 31, *pcv*) narrowly rounded and unevenly sclerotized. ♀ cerci not reaching to middle of ovipositor (FIG. 17); tegmina of ♀ with posterior margins oblique (FIG. 1).

TYPE DATA. Holotype (British Museum) from Hawaiian Islands, mountains of Kauai, 4000 ft (1200 m).

Perkins stated "Some individuals are considerably darker than others and there is some variation in size." Measurements given by him (without stating the number of specimens examined) are essentially like the following (in mm) from the 2 specimens we have examined; the female is the one reported by Hebard (1922). Body length, ♂ 15.5, ♀ 15.0; length pronotum, ♂ 4.0, ♀ 4.3; width pronotum, ♂ 3.7, ♀ 3.8; exposed length tegmen, ♂ 1.8, ♀ 1.2; width tegmen, ♂ 2.4, ♀ 2.8; length hind femur, ♂ 10.4, ♀ 10.8; length basal hind tarsomere, ♂ 2.9; ♀ 3.1; ovipositor, 8.5.

MATERIAL EXAMINED: HAWAIIAN IS: Kauai I: 1 ♂, Waimea, 4000 ft (1200 m), IV.1895, R. C. L. Perkins (BISHOP); 1 ♀, 1912, W. M. Gifford (ANSP).

This species has been taken only on the island of Kauai.

Thaumatogryllus cavicola Gurney & Rentz, new species FIG. 2-5, 16, 20, 21, 23, 24, 33, 34

Diagnosis. Adults 11-15 mm long; maxillary palpus slender, about as long as front femur, ratio of palpal segment lengths (in holotype) as 8: 9: 32: 24: 42. Metanotum of ♂ (FIG. 5) with narrow transverse pit bordered by pale membrane anteriorly and posteriorly, a specialized sclerotized area at each lateral end; posterior cleft along median line of ventral plate of genitalia (FIG. 34, *pcv*) broadly and evenly rounded. Cerci of ♀ reaching about to middle of ovipositor (FIG. 16); tegmina of ♀ with posterior margins broadly rounded (FIG. 3).

Holotype ♂. *Head* decidedly elongate dorsoventrally, weakly prognathous; eye cordate, situated dorsally on head, near dorsolateral margins of antennal sockets; length of eye subequal to 1st antennal segment, facets about 150; surface of eye only moderately bulging, protruding little above integument; vertex very broad, feebly convex; fastigium very broadly produced between antennal bases, without sulcus. 1st antennal segment 2× width of 2nd (shown in oblique view, FIG. 4), length ratios of 1st 3 segments as 15:8:9; total length of antenna about 2× length of body. *Pronotum* without traces of lateral sulci or carinae, surface smooth, with very sparse, delicate pilosity, lateral lobes with shallow sinus in anterior 1/2 of ventral margin. Tegmina protruding from beneath pronotum nearly their entire length (FIG. 2); tegmen quadrate, narrowed near base, of greatest width in median portion, apex broadly obtuse; tegmina narrowly separated; surface of tegmen smooth, not reticulate. *Abdomen* with dorsal surface finely setaceous; supra-anal plate 1-1/2× as long as basal width, apex truncate, periphery with many elongate hairs; subgenital plate broad basad, apex acutely pointed. Concealed genitalia as in FIG. 33, 34. Cerci

elongate, straight, gradually enlarged basad, tapering to blunt apex, with elongate spine at tip, directed ventrad. *Legs.* Front coxae with an acute ventral tooth on outer margin of anterior surface, middle coxa without tooth, with a somewhat protruding ventral margin. Front and middle femora of uniform width throughout, surface thinly hirsute; middle femur subequal in length to front femur; hind femur elongate, with submedial longitudinal sulcus running entire length of outer face, genicular lobe unarmed. Front tibia smooth, hirsute, with a single apical spine on posterior margin of ventral surface; middle tibia hirsute, with single short, apical spine on anterior margin of ventral surface on 1 side, pair of apical spines on other side. Hind tibia unarmed on ventral surface except at apex; dorsal surface with 16 short, stout, evenly spaced spines on inner margin, outer margin with 17 such spines; apex armed dorsally with 2 elongate spurs, the longer of which is nearly 1/2 the length of adjacent metatarsus, outer spine somewhat shorter than inner; ventral surface armed with pair of spurs much shorter than dorsal pair, the inner of which is slightly shorter than the outer, 1/5 to 1/6 length of adjacent metatarsus. All tarsi 3-segmented, uniformly densely hirsute, without distinct pattern of setation; tarsomere I of all legs very elongate, of front and middle legs 1/2 the length of tibia; tarsomere II very short, produced ventrally, apex acute; distal tarsomere elongate, 1/2 length of metatarsus, claws mainly simple, well developed, some with trace of inner tooth.

Allotype ♀. Similar to ♂ except for size (see TABLE 1), tegmina shorter, more quadrate, apices truncate; subgenital plate small, apex blunt, unspecialized, scarcely emarginate at apex. Ovipositor about 2× length of cercus, 3/4 length of hind femur, strongly curved, apex with several stout distinctive teeth. Ovipositor pale brown, apex and teeth dark reddish brown.

Coloration. Color reduced, overall pallid straw brown with following exceptions: surface of pronotum with brown streaking; surface of abdomen with 6 brown spots evenly arranged transversely in median portion of each segment; front, middle and hind femora with very faint subapical annulus, hind femur with brownish herringbone pattern dorsad of longitudinal sulcus. Head darker brown on vertex, especially in region of eyes.

We have examined 3 nymphs, the sex not readily apparent by inspection, preserved in alcohol and varying from 3 to 5 mm in body length. Dry specimens include 3 ♀♀ nymphs 7.5-10.5 mm long and 12 ♂♂ nymphs 7.5-14.0 mm long. Fleshy ovipositor valves and blunt lobes, quite evident but simple precursors of male genitalia, plainly indicate the sexes of the latter specimens. Black eye pigment occurs in all nymphs and brownish body markings usually are noticeable. Even the smallest nymphs of *Thaumatogryllus* are separated from *Caconemobius* by a lack of characteristic setae on the vertex and a lack of long slender spurs on the dorsal margins of the hind tibia. Nymphs of *Thaumatogryllus* have long antennae, which in tiny nymphs are 3× body length, in larger nymphs proportionally less, and in adults 2× body length.

TABLE 1. Measurements of *Thaumatogryllus cavicola,* in mm*.

	♂♂ (6)	♀♀ (5)
Body length	13.0 (12.0-15.0) 13.2	11.5 (11.0-15.0) 12.8
Length of pronotum	3.0 (3.0-3.4) 3.1	3.1 (3.0-3.4) 3.2
Width of pronotum	2.3 (2.3-3.1) 2.5	2.8 (2.6-2.8) 2.7
Length of hind femur	8.3 (7.9-8.5) 8.1	8.4 (8.0-8.5) 8.2
Width of hind femur	1.8 (1.7-2.0) 1.8	1.9 (1.7-2.1) 1.8
Length of tegmen	1.3 (1.3-1.7) 1.5	1.2 (1.1-1.3) 1.2
Width of tegmen	1.5 (1.5-1.9) 1.8	1.5 (1.4-1.7) 1.6
Length of ovipositor		5.2 (5.2-6.0) 5.4

*The 1st measurement in each column is for holotype ♂ or allotype ♀, followed in parentheses by extremes of measured series, then average.

TYPE DATA. Holotype ♂ (BISHOP 10,517), HAWAIIAN IS: Hawaii I: Hawaii Volcanoes National Park: Bird Park Cave #1 (19° 27′ N: 155° 18′W) (100 m from entrance), 1250 m, pitfall trap, 20-23.VII.1971, F. G. Howarth; allotype ♀ (BISHOP), Bird Park Cave #3, dark zone, 23.VII.1971, Howarth & Gagné; 29 paratypes (6 ♂♂, 5 ♀♀, 18 nymphs): 1 ♂, 2 large nymphs, same data as holotype; 1 ♀, 1 large nymph, same locality, 3.VII.1971, Howarth; 1 large nymph, same locality but final room, 20.VII.1971, Howarth; 1 ♀, 2 large nymphs, same locality, dark zone, 23.VII.1971, Howarth & Gagné; 1 small nymph, Thurston Lava Tube, dark zone, 23.VII.1971, Howarth & Gagné; Kealakekua, Kealakekua Ranch: 1 ♂, Upper Papaloa Cave, 1600 m, 10.XII.1972, collected when recently dead, may have been carried accidentally from Shelter Cave, Howarth & Gagné; 1 ♀, 1 egg shell, Stonewall Cave, 1225 m, twilight zone, 11.XII.1972, Howarth; 2 nymphs, Pond Cave, 870 m, dark zone on roots, 10.XII.1972, Howarth, Gagné, J. Jacobi; 2 ♂♂, 1 ♀, 8 nymphs, 1 egg shell, Shelter Cave, 1310 m, 10.XII.1972, Howarth, Gagné, Jacobi; 2 ♂♂, 1 ♀, Upper Shelter Cave Annex, 1310 m, deep twilight, 11.XII.1972, Jacobi & Howarth (BISHOP, USNM, ANSP).

This species is known from caves at about 1200 m elevation in Hawaiian Volcanoes National Park and caves ranging from 870 to 1600 m at the Kealakekua Ranch above Captain Cook, on the west side of the Mauna Loa massif. The latter caves are some 60 air kilometers from the nearest cricket-inhabited caves in the Park. More recently Howarth (in litt.) reports this species in intervening high altitude caves on Mauna Loa.

Within the Park caves, *T. cavicola* has been noted by Howarth (in litt.) as common only on ash fill at the end of small lava tubes. Penetrating tree roots occur on which crickets probably feed, though feeding has not been observed. At the Ranch, *T. cavicola* is common in several shallow caves underlying pasture land. Until recently, rich native rain forest occurred there, but introduced grass has now replaced most of the trees and *T. cavicola* has been observed feeding on the grass roots penetrating the ceilings on or near which most crickets were collected. Several nymphs were seen on the tree roots in Pond Cave. All collections were from wet areas, usually with grass roots, though several nymphs were on dangling roots of trees.

Two empty egg shells, probably of *T. cavicola,* were collected at Kealakekua Ranch; they were found on successive days in different caves. As described by Francis Howarth (in litt.), "They were picked up in cracks on the floor, but may have fallen from the ceiling." The eggs measure 4 × 1 mm in size, are cylindrical, slightly curved, exhibit an inconspicuous pattern on the chorion, and no distinct spicules at the end. An oblique terminal hole was created at hatching, but no definite operculum is evident. Color is whitish, with a slight cream tinge.

The eggs appear orthopteroid, but seem large for the female body size. Presumably, such eggs could be produced and laid, but if so, only 1 or 2 at a time. For comparison, Zimmerman (1948b: 145) stated that Swezey found eggs of *Prognathogryllus* in the midribs of leaves, that measured 6 × 1 mm. *Prognathogryllus* adults are considerably larger than *T. cavicola,* but the ovipositors of some species are not much larger in diameter than those of *T. cavicola.* Vandel (1965: 356-63) emphasized that certain cave animals frequently deposit

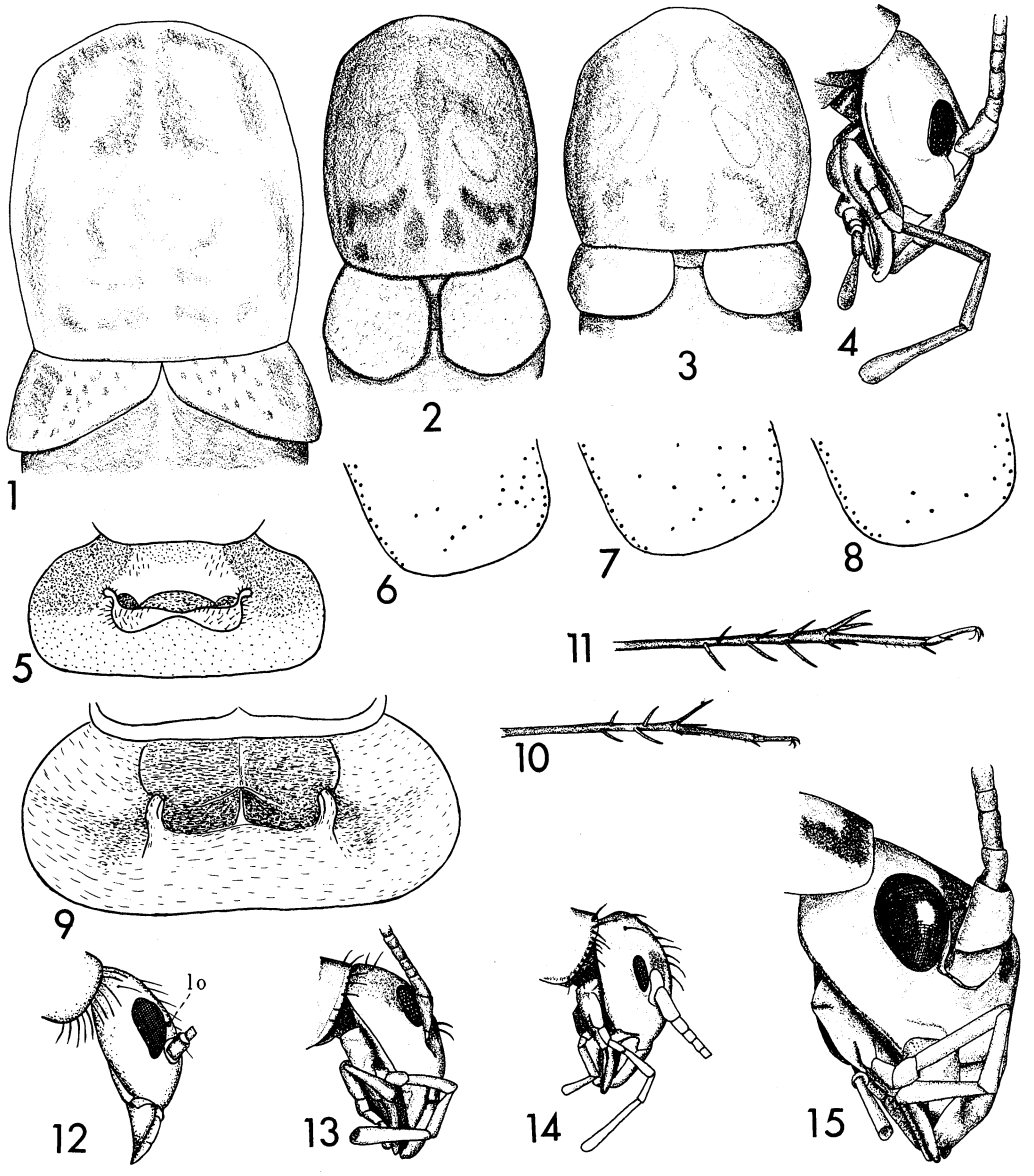


FIG. 1-15. 1, 9, 15, *Thaumatogryllus variegatus* Perkins: (1) pronotum and tegmina, ♀; (9) metanotum, ♂; (15) lateral view of head, ♀. 2-5, *T. cavicola,* n. sp.: (2) pronotum and tegmina, ♂ from Bird Park Cave #1; (3) same view, allotype ♀; (4) lateral view of head, holotype ♂; (5) metanotum, ♂ from Bird Park Cave #1. 6, 11, 13, *Caconemobius varius,* n. sp.: (6) ventral part of left lateral lobe of pronotum showing locations of setal pits, ♂ from Kaumana Cave; (11) left hind tibia and tarsus, ♀ from Kaumana Cave; (13) lateral view of head, ♂ from Bird Park Cave #3. 7, 10, 14, *C. howarthi,* n. sp.: (7) lateral lobe of pronotum, ♀ from Offal Cave; (10) left hind tibia and tarsus, ♀ from Offal Cave; (14) lateral view of head, ♂ from Offal Cave. 8, 12, *C. fori,* n. sp.: (8) lateral lobe of pronotum, ♂ paratype; (12) lateral view of head, ♂. *lo*=lateral ocellus.

only a few eggs. Some insects are included in this category, but he gave no data on eggs of cavernicolous Gryllidae.

GENUS **Caconemobius** Kirby

Caconemobius Kirby, 1906, Syn. Cat. Orthoptera **2:** 13.

Type-species, by monotypy, *Paranemobius schauinslandi* Alfken.

Generic redescription of Caconemobius. Body surface well clothed with fine setae; strong setae on vertex, a few on occiput, anterior and posterior margins of pronotum, also sparsely on pronotal disk, numerous medium-sized ones on posterior margins of terga 1-6; terga 7-9 with about 4, 2, and 2, respectively, large conspicuous setae near midline of posterior margin. Tegmina and wings lacking. Eyes well formed, rather small; ocelli very small or absent. Maxillary palpi (FIG. 13, 14) elongate. Legs moderately elongate; front legs lacking tympanum. Front tibia with 1 or more black setae on each ventral margin, with 2 apical spurs; tarsomere I (metatarsus) with 6 or more robust setae on inner and outer ventral margins, apex with 4 or more such setae; tarsomere II 1/4 or less length of tarsomere I, ventrally with numerous stout setae; apical tarsomere about 3× as long as 2nd, covered with fine setae and a few longer ventral ones, sometimes moderately stout; each tarsal claw with ventrobasal sensory seta. Middle tibia unspined dorsally, ventrally usually with 1-3 conspicuous black setae, apex with pair of equal ventral calcars. Hind tibia unarmed on ventral surface, dorsal surface with 2 or 3 elongate moveable spurs on inner margin and 1-3 somewhat longer spurs on outer margin; moveable spurs with short, rather appressed setae, a few short but erect fine setae, no decidedly long ones as in *Allonemobius* Hebard and relatives, some spurs with 1 or more dark heavier spinelike setae near apex; apex of hind tibia bears 3 short external and 2 longer internal calcars; latter calcars include a dorsal one about 2/3 length of tarsomere I and ventral one about 1/3 length of tarsomere I, other 2 much shorter; internal calcars with decided fringe of obliquely extending strong setae near base; hind tarsomere I armed ventrally on each margin with several stout setae, apex with 2 calcars, the inner surpassing tarsomere II, outer shorter, both calcars with sclerotized terminal spine and 1 or more ventral spinelike setae. Front femur subequal to middle femur; hind femur nearly 2× as long as middle femur; all femora unarmed except for occasional black setae on finely setose surface, black setae of hind femur only on dorsal surface. Front coxa expanded, but not spined, ventroexternal angle deeply excised, surface bearing black setae. Cerci slender, about 1/3 body length or more, with numerous short setae appressed to surface; each cercus with some very long, delicate sensory setae; inner surface near base with dense flattened sensory hairs similar to those described by Gnatzy & Schmidt (1971). ♂ genitalia with symmetrical, paired, well-sclerotized structures (FIG. 39, 43, 47). Ovipositor elongate, apical section scarcely enlarged, not noticeably serrate, ventral valve shorter than dorsal valve; apices widely separated.

PIGMENTED SPOTS ON ABDOMEN. Adult males of *Caconemobius* frequently show 2 small accumulations of black pigment under the cuticle of tergum 2, as shown in *C. fori* (FIG. 36); the pigment usually occurs in the posterior 1/2 of the tergum, but sometimes is in the intersegmental area when the segments are positioned so as to expose the membrane (FIG. 37). Rather similar black areas also occur in *C. howarthi* and *C. varius,* but insufficient comparisons have been made to determine whether there may be specific differences in the marks. The pigment is most evident in fresh specimens preserved in alcohol, but some degreased pinned specimens display traces of the marks. Within the male subgenital plate, visible through the cuticle in ventral view, but not part of the main genital complex, there often is a pair of large, obliquely positioned accumulations of pigment (FIG.41). These marks occur in *C. howarthi* and *C. varius,* but have not been seen clearly in *C. fori.* The pigment in both positions is easily disturbed by probing alcoholic specimens with a needle. No such black marks occur on females. The function, if any, of these pigment accumulations is

unknown, but those on tergum 2 may be sex attractants similar to certain glandular areas present in several cricket genera.

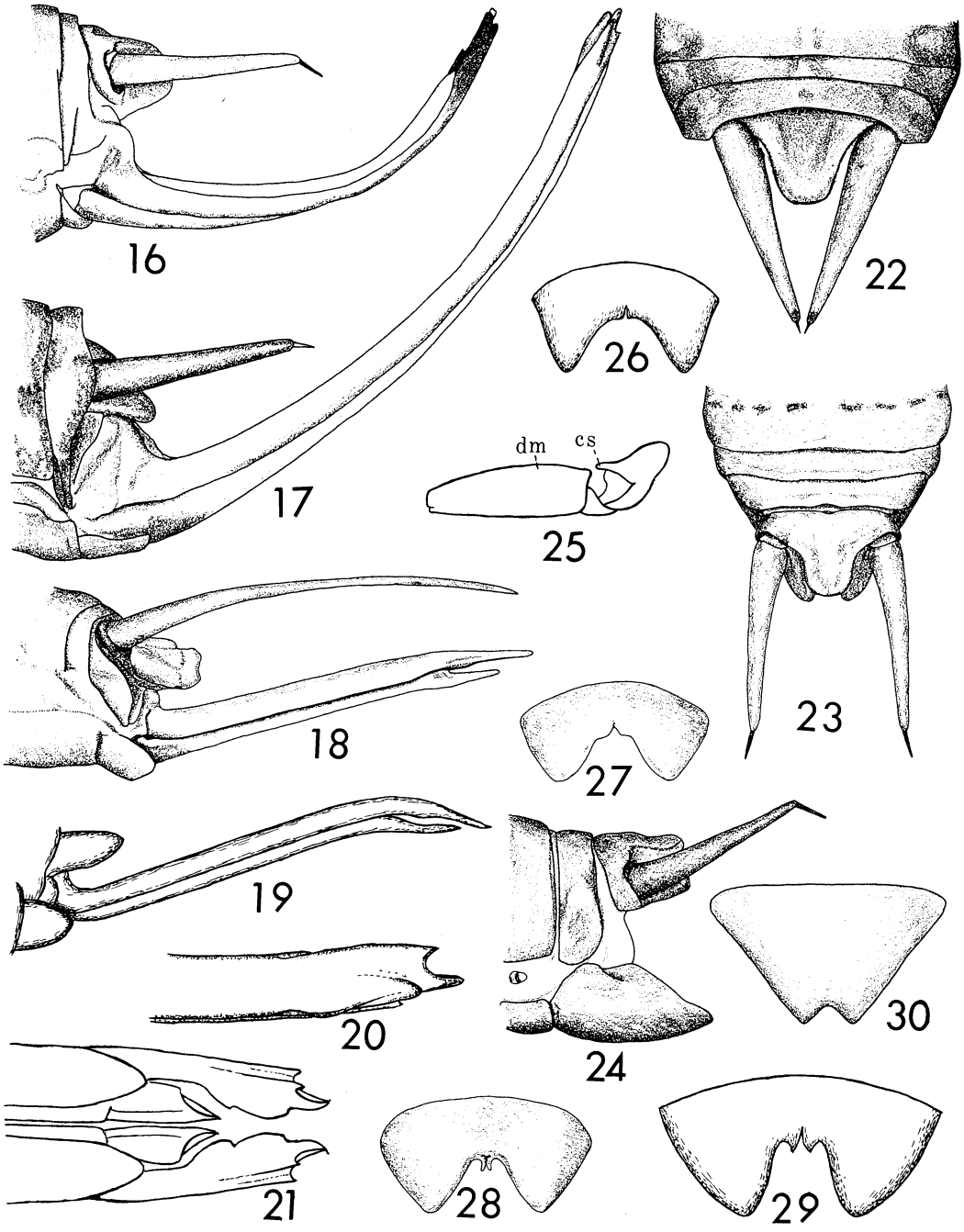
The name *Caconemobius* literally means a bad or poor "Nemobius," derived from the Greek *kakos* and the name of the typical nemobiine genus, which itself is from the Greek *nemos* (forest) and *bios* (life), i.e., "one living in woodland."

HISTORY OF WORK ON *Caconemobius*. This generic name was proposed as a replacement for *Paranemobius* Alfken, 1901, preoccupied by *Paranemobius* Saussure, 1877 for a different cricket genus occurring in India and Ceylon, as noted by Gurney (1972). Only Chopard (1967: 192) used the name *Caconemobius* again prior to 1972. Discovery of the 2 cave species here described led to the clarification of the genus' true nature, and late in our study (1974) a new surface-dwelling species was collected on the island of Hawaii; a nymph had been taken in 1973, but its generic identity was unrecognized at that time.

RELATIONSHIPS OF *Caconemobius*. We have considered various genera to which *Caconemobius* or earlier relatives may be closely related. The only nemobiine cricket listed in compilations of cave-inhabiting insects is *Speonemobius decoloratus* Chopard (Vandel 1965: 181; Leroy 1967: 665). Although originally described as from a cave entrance in India, Chopard (1969: 170) has since expressed doubt that *S. decoloratus* is a true cave species. The large eyes and moderately large tegmina suggest to us the correctness of Chopard's opinion.

It seems more likely that the complex including *Scottiola, Tahitina* Hebard, and *Apteronemobius* Chopard, all noncavernicolous genera without tegmina present on Pacific islands, is related to *Caconemobius*. The description of *Tahitina* (Hebard 1933) suggests that the reduced eyes, type of ovipositor apex, and long maxillary palpi of that genus are somewhat like those of *Caconemobius*. However, F. G. Howarth has examined the unique female type of *T. mumfordi* Hebard from Tahiti and has reported basic differences from *Caconemobius* in proportions of palpal segments, distribution of body bristles, apex of ovipositor, number of apical calcars of hind tibia, and robustness of spurs along dorsal margins of hind tibia. *Apteronemobius* includes a single Samoan species which, from the description, agrees well with *Caconemobius* in basic anatomy, though each dorsal margin of hind tibia has 2 instead of a variable number of spurs. *Scottiola* now comprises 10 species variously distributed on Madagascar, the Seychelles and Chagos Island (Indian Ocean), India, Ceylon, Malaysia, Borneo, and Samoa. The front tibia usually lacks a tympanum, but in some species a small one occurs; likewise, 6 hind tibial calcars sometimes occur though 5 is usual. We have examined only a pair of nymphs of *S. hirsuta* Chopard from Madagascar, and the genital structures are unknown. The chief differences between *Scottiola* and *Caconemobius* appear to be longer legs, longer palpi, smaller eyes, and somewhat larger body size in *Caconemobius* (females seldom as short as 6 mm in *Caconemobius* vs rarely as long as 6 mm in *Scottiola*).

In sum, a *Scottiola*-like ancestor seems the best suggestion of a source for the Hawaiian genus. The complex of flightless Pacific nemobiines also includes *Cophonemobius* of Samoa,


16
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←

FIG. 16-29. 16, 20, 21, 23, 24, *Thaumatogryllus cavicola,* n. sp.: (16) lateral view, end of abdomen, allotype ♀; (20) left lateral view of ovipositor, apical portion, ♀ from Bird Park Cave #1; (21) same specimen, dorsal view; (23) end of abdomen, ovipositor omitted, dorsal view, ♀ from Bird Park Cave #3; (24) end of abdomen, ♂ holotype, lateral view. 17, 22, 30, *T. variegatus* Perkins: (17) lateral view, end of abdomen; (22) end of abdomen, ovipositor omitted, ♀; (30) ventroposterior view of subgenital plate, ♀ (posterior margin is truncate in direct ventral view). 25, *Prognathogryllus oahuensis* Perkins, lateroposterior view of left front coxa, trochanter, and femur, ♂ from Waianae Mts, Oahu. 26, 27, *Caconemobius howarthi,* n. sp.: (26) ventral view of subgenital plate, allotype ♀; (27) same, ♀ from Offal Cave. 18, 28, *C. varius,* n. sp.: (18) lateral view, end of abdomen, ♀ from Kaumana Cave; (28) ventral view of subgenital plate, ♀ from Kaumana Cave. 19, 29, *C. fori,* n. sp.: (19) end of abdomen, lateral view, allotype ♀; (29) ventral view of subgenital plate, allotype ♀. *cs*=coxal spine, *dm*=dorsal margin of front femur.

which has short tegmina. The moderate number of flightless Nemobiinae occurring on numerous Old World islands is enough to give credence to the idea that a relative found its way to Hawaii.

Although Miss Diane Johnstone has sent us some results of her study of nemobiine male genitalia, we have failed to correlate the structures of *Caconemobius* males with those of *Allonemobius* and closely related genera; therefore, we are unable to suggest any significant relationship evidenced by genitalic homologies. Accordingly, we have used general or arbitrarily chosen terms for genital parts illustrated.

KEY TO SPECIES OF *Caconemobius* (ADULTS)

1. Well-pigmented, surface-living (epigeic) species; medium to large size, hind tibia at least 6.5 mm long 2
   Pale, cave-dwelling (presumably troglobitic) species; small size, hind tibia less than 6.5 mm long 3
2. Large, hind tibia of ♀ 9 mm long (TABLE 2) (Island of Molokai) . . . . . **schauinslandi**
   Medium sized, hind tibia of ♀ 7.5 mm or less (TABLE 2) (Island of Hawaii) . . . . . **fori,** n. sp.
3. Each dorsal margin of hind tibia with 2 moveable spurs (FIG. 10); posterior margin of ♀ subgenital plate with median emargination, but without teeth (FIG. 26, 27); terminal processes of ♂ epiphallus broad at apex (FIG. 43, *tp*) (Island of Maui) . . . . . **howarthi,** n. sp.
   Outer dorsal margin of hind tibia with 3 moveable spurs, number on inner margin varying from 1 to 3 (FIG. 11 of left leg); posterior margin of ♀ subgenital plate with median area bearing 2 small teeth (FIG. 28); terminal processes of epiphallus acute at apex (FIG. 39, *tp*) (Island of Hawaii) . . . . . **varius,** n. sp.

COMMENTS ON DARK PRONOTAL SETAE. The ventral portion of the lateral lobes of the pronotum of each species of *Caconemobius* has a more or less constant arrangement and number of small dark setae in addition to those near the median longitudinal sulcus, not shown in FIG. 6-8, and those along the anterior and posterior margins. In the case of *C. fori* there clearly is a smaller number of disk setae on the lateral lobe, but some variation occurs, especially in *C. varius* and *C. howarthi,* and we are unable to distinguish the latter 2 species on this basis.

Caconemobius schauinslandi (Alfken)

Paranemobius schauinslandi Alfken, 1901, Abh. Naturw. Ver. Bremen **17:** 145.
Caconemobius schauinslandi: Kirby, 1906, Syn. Cat. Orthoptera **2:** 13.

TABLE 2. Measurements of 3 species of *Caconemobius*, in mm.*

	howarthi (5 ♂♂, 7 ♀♀)	*varius* (11 ♂♂, 11 ♀♀)	*fori* (5 ♂♂, 6 ♀♀)
Length of body ♂	6.7(5.7-6.8, av. 6.3)	8.2(6.6-8.2, av. 7.1)	9.5(8.6-9.5, av. 9.0)
♀	6.9(6.0-8.0, av. 6.9)	8.5(6.2-9.1, av. 7.7)	9.0(8.4-10.0, av. 9.3)
Length of pronotum ♂	1.4(1.1-1.4, av. 1.3)	1.5(1.4-1.6, av. 1.5)	2.0(2.0-2.1, av. 2.0)
♀	1.5(1.4-1.7, av. 1.6)	1.5(1.4-1.7, av. 1.5)	2.1(2.1-2.2, av. 2.2)
Width of pronotum ♂	1.7(1.6-1.9, av. 1.7)	2.1(1.7-2.1, av. 1.9)	2.5(2.5-2.7, av. 2.6)
♀	1.7(1.7-2.1, av. 1.9)	2.1(1.8-2.3, av. 2.1)	2.9(2.7-2.9, av. 2.8)
Length of hind femur ♂	4.8(4.4-5.1, av. 4.7)	6.1(5.2-6.3, av. 5.6)	7.3(7.2-8.0, av. 7.4)
♀	5.2(5.1-5.5, av. 5.3)	6.1(5.2-6.7, av. 6.0)	7.5(7.5-8.1, av. 7.8)
Width of hind femur ♂	1.3(1.0-1.4, av. 1.2)	1.5(1.2-1.6, av. 1.4)	2.2(2.0-2.2, av. 2.1)
♀	1.5(1.3-1.5, av. 1.4)	1.6(1.2-1.7, av. 1.5)	2.2(2.1-2.3, av. 2.2)
Length of ovipositor ♀	3.7(3.5-4.0, av. 3.7)	4.6(3.0-4.8, av. 4.2)	5.0(5.0-6.0, av. 5.6)

*Measurements before parentheses are for holotype ♂ or allotype ♀, followed in parentheses by size range and average as shown by all measured specimens.

Alfken based this species on a single female specimen from the island of Molokai. Later (Alfken 1904: 567, pl. 32, fig. 1-4), he added that his type was collected at Kalae, Molokai, and gave illustrations which clearly show that this is the genus which we have been studying. Several characters of generic rank stated in the description, i.e., lack of tympanum, lack of tegmina and wings, the nature of the ovipositor, fine hairs on spines of hind tarsus, and nature of compound eyes, also agree. The original reference to calcars, "End of hind tibia has 3 thorns, 1 outer and 2 inner" (translation), probably is inaccurate because the genus as we know it has 3 outer and 2 inner hind tibial calcars. His drawing of the hind leg lacks several details at the end of the tibia. There is no indication that *C. schauinslandi* is a cave species. Hind tibial length (9 mm) is the only measurement given.

The type of *C. schauinslandi* probably was originally deposited at the Übersee-Museum in Bremen, Alfken's home institution, but Dr Herbert Hohmann has written (in litt., 11.X.1973) that it is no longer there. Dr Kurt K. Günther of the Museum für Naturkunde, Berlin (the museum to which some Alfken material was sent), states (in litt., 29.X.1973) that the type is not there and has not been traced.

Perkins (1910: 688) listed *P. schauinslandi* as a household species, but in a footnote on the same page stated that the identification was incorrect, as the species he had did not agree with Alfken's figures. Hebard (1922: 352) and Zimmerman (1948b: 134) stated that the species which Perkins found was the mogoplistine *Cycloptiloides americanus* (Sauss.).

MATERIAL EXAMINED. None.

Caconemobius fori Gurney & Rentz, new species FIG. 8, 12, 19, 36, 37, 46-48

Diagnosis. Compound eye large, longer than 1/2 distance from base of antenna to occiput (FIG. 12), about 30 facets in maximum width; ocelli present, with distinct lenses; head with vertex and occiput dark brown in contrast with pale lower face; average length of hind femur, ♂ 7.42 mm, ♀ 7.83; ♂ genitalia: exposed terminal processes of epiphallus while *in situ* slender (FIG. 48, *tp*); main elongate clasper with apical fork arms of similar length (FIG. 47,

fa); broad posterior emargination of ♀ subgenital plate bearing 2 small median teeth (FIG. 29); apical part of dorsal valve of ovipositor distinctly downcurved (FIG. 19).

Holotype ♂. *Head* dorsoventrally elongate; eye large for genus, pointed at ventral extremity, distinctly protruding; vertex broad, width at median ocellus equal to basal width of 1st antennal segment; ratio of segment lengths of maxillary palpus as 7:9:26:23:34. *Pronotum* with distinct impressed median longitudinal sulcus, a short partial transverse sulcus each side of median line at base of anterior 3rd, strong setae numerous along anterior and posterior margins, sparse on disk. *Abdomen* with dorsal surface setose with fine appressed hairs; the posterior margins of terga 1-7 with numerous moderately long bristles, not conspicuous due to blending brown color; terga 8-9 with pair of large conspicuous blackish bristles near median line; supra-anal plate more broadly rounded than

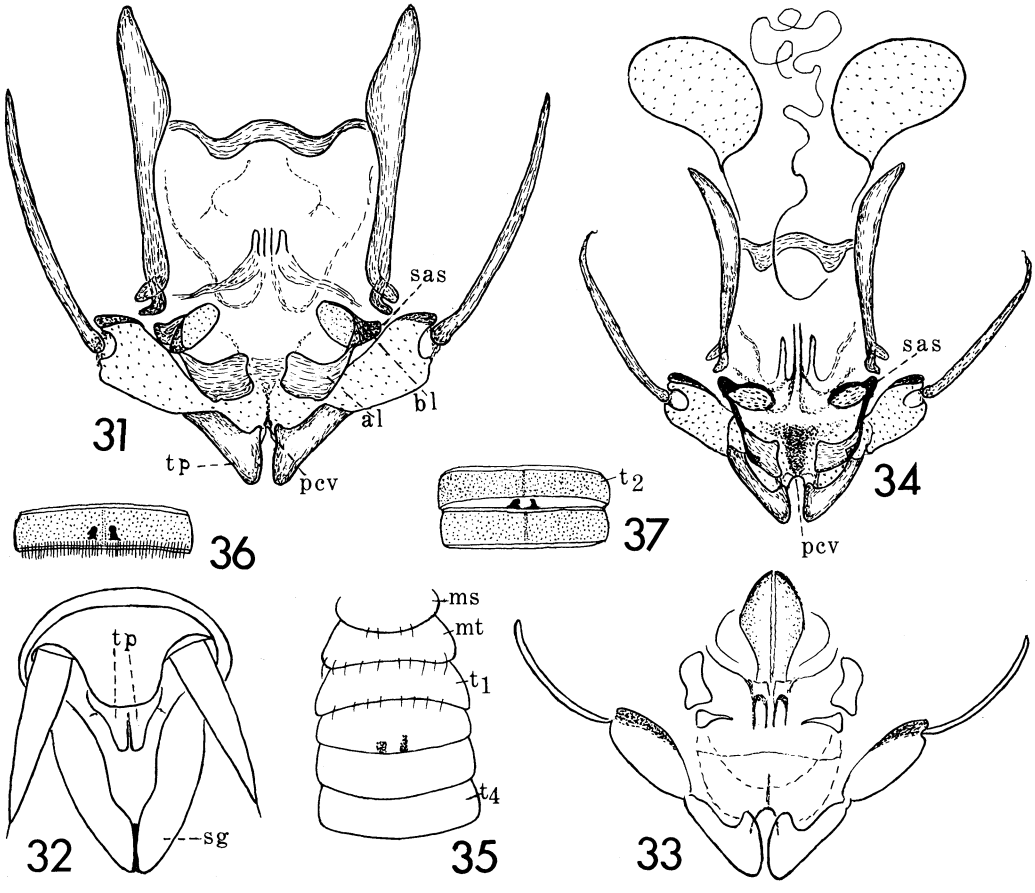

FIG. 31-37. 31, 32, *Thaumatogryllus variegatus* Perkins: (31) ventroposterior view of ♂ genitalia, KOH preparation; (32) dorsal view of end of ♂ abdomen. 33, 34, *T. cavicola,* n. sp.: (33) dorsal view of ♂ genital complex before KOH treatment, from Upper Papaloa Cave; (34) ventroposterior view of ♂ genitalia, KOH preparation from holotype. 35, *Caconemobius varius,* n. sp., dorsal view of part of body in alcohol, showing location of black pigmentation on tergum 2, ♂ from Kealakekua Ranch, Hawaii. 36, 37, *C. fori,* n. sp.: (36) dorsal view of tergum 2, ♂ paratype in alcohol, showing pigment spots; (37) dorsal view of terga 2 and 3, ♂ paratype in alcohol, showing pigment spots in intersegmental area (posterior marginal setae omitted). *al*=apical lobe of subapical sclerite; *bl*=basal lobe of same; *ms*=mesonotum; *mt*=metanotum; *pcv*=posterior cleft of ventral plate; *sas*=subapical sclerite of genitalia; *sg*=subgenital plate; t_1, t_2, t_4=terga 1-4; *tp*=terminal process of epiphallus.

in *C. varius;* subgenital plate simple, rounded a little less broadly than supra-anal plate; concealed genitalia with details as in FIG. 47; cerci tapering, about 1/2 length of body. *Legs.* Front tibia with pair of ventral apical spurs, the inner at least 1/4 longer than outer; tarsomere I with 10-12 stout dark setae on each ventral margin.

Allotype ♀. General structure as in ♂. Subgenital plate as in FIG. 29; ovipositor (FIG. 19) with considerable curvature in apical 1/3, dorsal valve conspicuously downcurved near apex. *Color* brown-ochre; legs, cerci, and ventral parts pale. Compound eyes blackish (pale gray when degreased and pinned).

The 49 nymphs examined vary from 4 to 10 mm in length. General body color is brown, nearly as dark as adults, and eyes are black. Antennae of the smallest nymphs are 4 × body length.

TYPE DATA. Holotype ♂ (BISHOP 10,518), HAWAIIAN IS: Hawaii I: Hawaiian Volcanoes National Park, Ainahou Ranch, Mauna Ulu, 1969 lava flow, cheese trap 100 m from vegetation, ca 975 m altitude, 17.II.1974, F. G. Howarth & F. D. Stone; allotype ♀ (BISHOP), same locality as holotype, 15.II.1974, Howarth & Stone; 61 paratypes (6 ♂♂, 6 ♀♀, 49 nymphs): 4 ♂♂, 1 ♀, 3 ♂ nymphs, 3 ♀ nymphs, same data as holotype; 2 ♂♂, 1 ♀, same locality as holotype, 13.II.1974, Howarth; 7 ♂ nymphs, 9 ♀ nymphs, same data as preceding, Howarth & Stone; 4 ♀♀, 9 ♂ nymphs, 15 ♀ nymphs, same locality, 15.II.1974, Howarth & Stone; 1 large ♀ nymph, nr Summit Mauna Ulu Vent, about 1 km from nearest vegetation, 1050 m, 8.II.1973, alive on bare lava, Howarth; 1 very small nymph, 1 nearly mature ♂, Mauna Ulu, November 1973 lava flow, cheese trap 100 m from vegetation, 1000 m, 13-15.II.1974, Howarth & Stone (BISHOP, USNM, ANSP).

The name *fori* is the genitive form of a Latin word meaning "of the forum" or "of an open place," with reference to the species' occurrence in the outdoors rather than in a cave.

BIONOMICS. Biological information about *C. fori* is limited to inferences drawn from Howarth's finding 1 nymph in March 1973 on bare lava and his trapping numerous specimens there in February 1974. Howarth wrote (in litt.): "Fifteen cheesebait traps were set out; 10 on the 1969 lava flow at Ainahou Ranch, Hawaii Volcanoes National Park, at 975 m elevation, 1 in a kipuka of that flow 100 m from vegetation. The traps were checked 3 times during the week and numbers noted. Most immature crickets were released. Traps on the 1969 flow had as many as 36 individuals per trap period. None were captured near the edge, in the kipuka, or in vegetation near the flows. All specimens are from traps set a distance from the edge, including on the 1973 flow. It appears this species is a scavenger on lava flows." (A kipuka is defined as an area of older land, ranging in size from a few square feet to several square miles, which is surrounded by later lava flows.)

Caconemobius varius Gurney & Rentz, new species FIG. 6, 11, 13, 18, 28, 35, 38-41

Diagnosis. Eye of medium size, about 1/2 as long as distance from base of antenna to occiput, about 9 to 11 facets in maximum width (FIG. 13); ocelli variable, with lenses present or absent; head with vertex and occiput distinctly brown in contrast with pale lower face; usually larger than *C. howarthi,* average length of hind femur, ♂ 5.6, ♀ 6.0; ♂ genitalia: exposed terminal processes of epiphallus while *in situ* not evenly rounded (FIG. 40, *tp*); main elongate clasper with apical fork arms of similar length (FIG. 39, *fa*); posterior margin of female subgenital plate broadly emarginate, bearing 2 tiny median teeth (FIG. 28); apical part of dorsal valve of ovipositor straight or weakly downcurved (FIG. 18).

Holotype ♂. *Head* nearly oval in outline; eye triangulate, scarcely protruding, facets pronounced; vertex elongate, raised, median impression ovate, poorly indicated. 1st antennal segment much broader than 2nd, as 13:5. Ratio of segment lengths of maxillary palpus as 7:7:23:18:32. *Pronotum* with distinct but shallow median and transverse sulci; anterior and posterior margins and humeral angles densely clothed with long black hairs; surface smooth except for numerous tiny setae. *Abdomen.* Dorsal surface highly setose, median carina indicated solely by color; posterior margin of each segment with 15-18 long black hairs; supra-anal plate smooth, unspecialized; subgenital plate large, longer than broad, apex blunt; concealed genitalia with terminal processes broadly triangulate; genitalia as in FIG. 39; cerci elongate, about 1/2 the length of body. *Legs.* Front tibia armed with a pair of apical spurs of equal length on ventral surface; tarsomere I armed with at least 6 elongate setae on inner and outer margins, apex with 4 or more such setae; tarsomere II only 1/4 as long as I, the apex ventrally with 4 elongate black setae; tarsomere III ca 3 × as long as II, unarmed except for slender setae on ventral surface; tarsal claw armed with ventroproximal sensory seta. Middle tibia unspined dorsally, ventral surface armed on outer margin with 1-2 stout, black setae, apex with pair of ventral calcars; hind tibia unarmed ventrally, dorsal surface with 2 elongate, moveable spurs on inner margin and 3 more elongate, more widely spaced spurs on outer margin, apex with pair of internal calcars, the more dorsal of which is 1/4 longer than the other and fully 2/3 as long as tarsomere I, outer margin with 3 calcars, the median much the longest, but scarcely 1/2 as long as longer inner calcar, ventral a little longer than dorsal; tarsomere I armed ventrally on inner and outer margins with 6-8 stout black hairs, apex with 2 calcars, the inner somewhat surpassing tarsomere II, outer slightly shorter than tarsomere II; tarsomere II nearly 1/2 length of tarsomere III. Front femur subequal to middle femur; hind femur nearly 2 × as long as middle femur; all femora unarmed except for occasional black hairs on finely setose dorsal surface. Front coxa expanded, but not spined, ventroexternal angle deeply incised.

Allotype ♀. Differs from holotype in following: size somewhat larger; subgenital plate deeply incised, with paired digitiform processes mesad (FIG. 28); supra-anal plate about as wide at base as long, evenly rounded at apex, unspecialized; cerci attaining apex of ovipositor. Ovipositor slender (FIG. 18); ventral margin of dorsal valve minutely serrate.

Color. Body pallid straw brown except for following: head and proximal antennal segments darker brown in region of vertex and eyes; eyes gray; pronotum somewhat darker brown in posterior 1/2; hind femur with dark brown area on inner pagina near apex. Entire body densely clothed with short light brown setae except where noted in description.

Nymphs (25) range in body length from 2.6-5.7 mm. In the smallest specimens, only vestiges of spurs along the dorsal margins of hind tibia occur. Even those small specimens have dark gray eye pigment, and the vertex and occipital part of the head are clearly darker than the ventral part of the face.

TYPE DATA: Holotype ♂ (BISHOP 10,519), HAWAIIAN IS: Hawaii I: Kaumana Cave, dark zone, ca 290 m, 2.X.1971, F. G. Howarth; allotype ♀ (BISHOP), same data as holotype; 46 paratypes (11 ♂♂, 7 ♀♀, 24 nymphs): 1 ♀, 1 nymph, same data as holotype; 2 ♂♂, 3 ♀♀, 3 nymphs, same locality except 330 m in cave, 21.VII.1971, Howarth; 1 ♂, 1 nymph, same data, 26.IV.1972, Howarth & D. R. Davis; 1 ♂, Mountain View, Kazumura Cave, dark zone, 200 m in cave, 22.VII.1971, Howarth; 2 ♀♀, 1 nymph, same except 230 m in cave; 2 nymphs, same except 60 m in cave, 25.VII.1971; 10 nymphs, same data except dark zone, Howarth & Gagné; 1 ♀, same data except 13.VII.1972, Howarth; 1 ♂, 1 nymph, same data except 15.VII.1972, Howarth; 2 ♂♂, 1 nymph, same data except 13-15.VII.1972, Howarth & Jacobi; 1 nymph, same data except 27.IV.1972, Howarth & D. R. Davis; 2 ♂♂, 1 nymph, Hawaii Volcanoes Nat'l. Park, Bird Park Cave #1, dark zone, general collecting, 23.VII.1971, Howarth & Gagné; 1 ♂, Hawaii Volcanoes Nat'l. Park, Bird Park Cave #3, twilight zone, 23.VII.1971, Howarth; 1 ♂, Kealakekua, Kealakekua Ranch, Pond Cave,

dark zone, final room, 870 m, 10.XII.1972, Howarth, Gagné, Jacobi; 2 nymphs, same locality, on roots (BISHOP, USNM, ANSP).

The specific name *varius* is a Latin word for "different," chosen with reference to variation in number of hind tibial spurs on the inner dorsal margin.

BIONOMICS. *Caconemobius varius* occurs in caves from 300-1200 m on Mauna Loa and Kilauea. It appears to be commonest in low, wet caves. Captive specimens observed by Howarth fed readily on cheese, bread and refined brewer's yeast. They seemed to be omnivorous or perhaps scavengers. *C. varius* came to cheese bait in the caves. It lives only in caves with a true dark zone, and only 1 capture was made in the twilight zone, in a small passage off the main passage in the entrance room of a cave. Howarth visited caves both by day and at night and no evidence of migration was seen; these observations are preliminary. Experiments involving light reactions indicate that the eyes appear to be sensitive to light and dark, but not to movement and images. In light normal for reading, undisturbed crickets were observed feeding, and when a hand passed over the vial but did not make a shadow, the cricket continued feeding; if the hand was moved so as to form a shadow over the cricket, it stopped feeding instantly.

VARIATION. The variation in *C. varius* is interesting and merits further study. Eight adult specimens, from Kaumana Cave, Kazumura Cave, and Bird Park Cave No. 1, have small, poorly developed ocelli, without a definite lens present on the median ocellus. Each of the specimens has only 1 spur along the inner dorsal margin of the hind tibia. Fifteen other specimens, from Kaumana and Kazumura Caves and Bird Park Cave No. 3, have larger, better-developed ocelli with a distinct lens on the median ocellus, and these specimens have either 2 or 3 inner dorsal hind tibial spurs, except rarely when 1 leg has only 1 inner dorsal spur. We have not found genital differences between specimens of the above segregations.

Caconemobius howarthi Gurney & Rentz, new species FIG. 7, 10, 14, 26, 27, 42-45

Diagnosis. Eye with pigmented portion (FIG. 14) narrower than in *C. varius,* 6-8 facets in maximum width; ocelli indicated, but poorly developed, lenses not evident; head with vertex and occiput not conspicuously darker than lower face; average length of hind femur, ♂ 4.7 mm, ♀ 5.3; ♂ genitalia: exposed terminal processes of epiphallus while *in situ* evenly rounded (FIG. 48, *tp*); main elongate phallus with 1 arm of apical fork much longer than other (FIG. 43, *fa*); posterior margin of ♀ subgenital plate (FIG. 26, 27) emarginate, without median teeth; apical part of dorsal valve of ovipositor straight or weakly decurved.

Holotype ♂. *Head* dorsoventrally elongate; eye linear, of equal width in median 2/3, hardly protruding, facets few in number; vertex broad, little raised, median ocellus poorly indicated. 1st antennal segment much wider than 2nd (as 12:4); ratio of segment lengths of maxillary palpus as 6:5:19:15:26. *Pronotum* with poorly developed median and transverse sulci; anterior and posterior margins thinly clothed with long black hairs. *Abdomen* with dorsal surface lightly setose, posterior margin of each segment bearing 6 or more long black hairs; supra-anal plate as broad as long; subgenital plate 1-1/2 × broader than long, apex rounded; genitalia with terminal processes evenly rounded (FIG. 44); details as in FIG. 43; cerci about 1/2 length of body. *Legs.* Front tibia with pair of apical, ventral spurs, the inner fully 1/4 × longer than outer; tarsomere I with 7 elongate dark brown hairs on inner and outer margins, apex with 3 such hairs; tarsomere II 1/5 length of I, with 6 elongate hairs on distal 1/2; tarsomere III 2-1/2 × length of II, unarmed except for 4 slender ventral hairs. Each tarsal claw with ventroproximal sensory

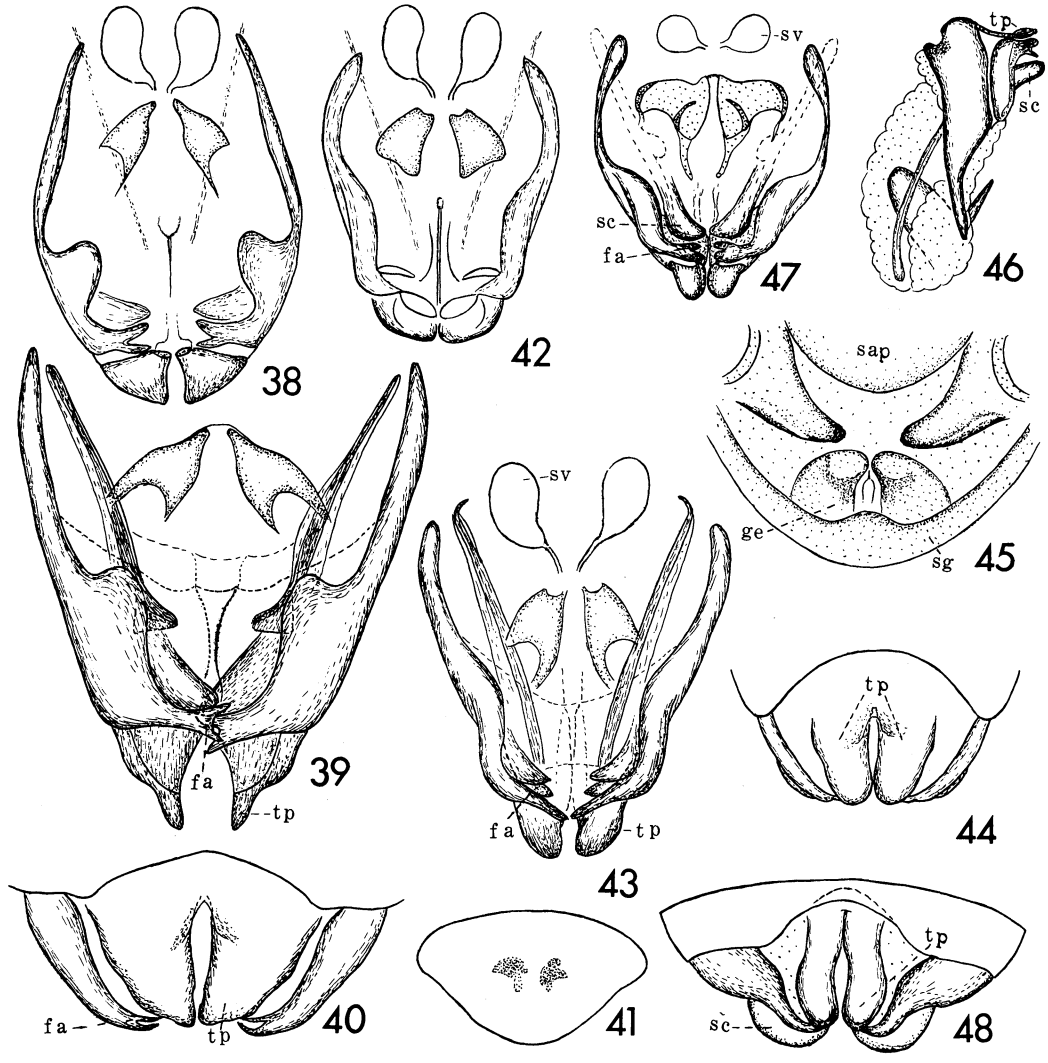

FIG. 38-48. 38, 39, 40, 41, *Caconemobius varius,* n. sp.: (38) ventroposterior view of genitalia, in alcohol before KOH treatment, ♂ from Bird Park Cave #3; (39) same, KOH preparation, vesicles omitted, ♂ from Kaumana Cave; (40) dorsal view of apex of abdomen before KOH treatment, ♂ from Bird Park Cave; (41) ventral view of subgenital plate, showing black pigment spots, ♂ from Kealakekua Ranch, Hawaii. 42-45, *C. howarthi,* n. sp.: (42) ventroposterior view of genitalia in alcohol before KOH treatment, ♂ from Offal Cave, Maui; (43) same, KOH preparation, ♂ from Offal Cave; (44) dorsal view of apex of abdomen in alcohol before KOH treatment, Offal Cave; (45) posterior view of developing genitalia and associated structures in alcohol, late nymphal ♂, Offal Cave. 46-48, *C. fori,* n. sp.: (46) lateral view of genitalia in alcohol, *in situ* in muscle, posterior surface at right, ♂ paratype; (47) ventroposterior view of genitalia, KOH preparation, holotype; (48) dorsal view of apex of abdomen before KOH treatment, ♂ paratype in alcohol. *fa*=forking arms of main clasper; *ge*=genitalia; *sap*=supra-anal plate; *sc*=secondary clasper; *sg*=subgenital plate; *sv*=seminal vesicle; *tp*=terminal process of epiphallus.

seta. Middle tibia unarmed dorsally, ventral surface armed with a single black hair distad of middle; apex with pair of equal-length ventral calcars. Hind tibia with pair of moveable spurs on each dorsal margin; 5 apical calcars (2 inner, 3 outer), middle 1 of outer trio about 1/3 length of tarsomere I, other 2 much shorter, dorsal 1 of inner pair fully 1/2 length of metatarsus, ventral 1 less than 1/2 that length. Tarsomere I of hind tibia with 5-6 short brown ventral hairs; apex with pair of calcars, inner 1 fully 2 × length of outer; tarsomere II 1/3 length of tarsomere III which is unarmed except for few thin brown hairs on lateral margins. Front femur almost as long as middle femur; hind femur much longer than middle femur (as 50:29). All femora unarmed except for scattered black dorsal hairs. Front coxa expanded, ventroexternal angle very deeply incised.

Allotype ♀. Differs from holotype as follows: size somewhat larger; subgenital plate as in FIG. 20, without digitiform median processes; supra-anal plate slightly longer than broad; cerci surpassing apex of ovipositor. Ovipositor short, stout, dorsal valve but little beyond ventral valve, ventral margin of dorsal valve weakly serrated, somewhat downcurved.

Color. Body pale straw, ventral parts lighter; head with no pronounced brown, ventral part only slightly paler than region of vertex; eyes pale gray; genicular crescents at apex of hind femur dark brown; apical part of ovipositor richly tinged with reddish brown.

Thirty nymphs, ranging up to 6.5 mm long, all show reddish brown eye pigment.

TYPE DATA: Holotype ♂ (BISHOP 10,520), HAWAIIAN IS: Maui I: Hana: Offal Cave, 90 m, 15.XII.1971, F. G. Howarth & W. C. Gagné; allotype ♀ (BISHOP), same data as holotype; paratypes, 41 (5 ♂♂, 6 ♀♀, 30 nymphs): 3 ♂♂, 14 nymphs, same data as holotype; 3 ♀♀, 1 nymph, same locality, 12.XII.1971, Howarth & Gagné; 2 ♂♂, 1 ♀, 4 nymphs, same data except 13.XII.1971; 2 ♀♀, 8 nymphs, same data except 20.VII.1972; 1 nymph, Holoinawawai Stream Cave, 290 m, 14.XII.1971, Howarth; 1 nymph, Waihoi Valley Trench Cave, 450 m, 7.VII.1972, Howarth, Gagné; 1 nymph, Lower Wananalua Cave, dark zone, 180 m, 20.VII.1972, Howarth. (BISHOP, USNM, ANSP).'

This species is named in honor of Francis G. Howarth in recognition of his notable accomplishments in developing knowledge of the Hawaiian lava tube fauna.

BIONOMICS. Observations on *C. howarthi* were made by F. G. Howarth in 2 caves near Hana at 90 and 290 m altitude, respectively, but the species was common only in Offal Cave, which had been used as an offal pit by the community and a local slaughterhouse. In addition to the crickets, Offal Cave harbors an exceptionally large population of other arthropods, mostly introduced troglophiles. The crickets have never been seen closer to the entrance than 100 m and have always been within the true dark zone.

Howarth kept 1 male alive in Honolulu for a month in December 1971, though it was not seen feeding. Cheese, raisins, honey, and freshly killed flies were offered, but none showed evidence of having been fed upon, and he concluded that the feeding habits of this species differ from those of *C. varius*.

C. howarthi is less sensitive to light than *C. varius*. A waving hand creating a shadow over a specimen elicited no response. When the vial containing it was moved, the cricket responded by waving its antennae. A spot beam from a 6-volt headlamp (approximating sunlight) held 1 foot (.305 m) from the cricket produced a response. In 5 repetitions of the shadow and light tests the cricket responded only to the bright light. It appears from these

experiments that *C. howarthi* is sensitive only to bright light. Judging by the eyes, smaller than in *C. varius,* and a paler dorsal head area, *C. howarthi* is more cave adapted than *C. varius.*

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