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Zoogeography, Ecology, and Systematics of the Genus *Rhagovelia* Mayr (Heteroptera: Veliidae) in Borneo, Celebes, and the Moluccas

John T. Polhemus
University of Colorado Museum, Englewood, Colorado

Dan A. Polhemus
U.S. National Museum of Natural History, Smithsonian Institution, Washington, D.C.

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John T. Polhemus
University of Colorado Museum
3115 South York St.
Englewood, Colorado 80110 USA

Dan A. Polhemus
Department of Entomology
U.S. National Museum of Natural History
Smithsonian Institution
Washington, D.C. 20560

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Abstract

The genus *Rhagovelia* is revised for the region comprising Borneo, Celebes, and the Moluccas. Redescriptions are given for species previously described from the area, and 26 new species are described. Figures of the dorsal habitus and key characters are provided for all species, accompanied by a key to species and distribution maps. Species occurring in the region are divided into eight monophyletic intrageneric species groups, some of which also contain members outside the region, based primarily on wing venation, thoracic morphology, and genitalia. A zoogeographic analysis is presented based on the distribution of these groups within the Malay Archipelago and surrounding regions. We conclude that the present *Rhagovelia* fauna of the Malay Archipelago is derived from species which originated in continental Southeast Asia, Australia, and New Caledonia. Distinct lineages have entered the region from each of these three source areas, penetrating the archipelago with differing degrees of success and contributing to the fauna of each individual island to varying extents. Species groups of

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Asian origin do not extend beyond Celebes and the Lesser Sunda islands, while species groups of Papuan origin are absent in the Lesser Sundas and do not extend west of Borneo. Endemic species groups have also arisen on New Guinea, the Philippines, the north Moluccas, and Borneo. A section on ecology and behavior is provided, dealing in particular with the altitudinal segregation of species on individual islands.

The following new *Rhagovelia* species are described: *bacanensis*, *borneensis*, *celebensis*, *christenseni*, *grayi*, *hamdjahi*, *incognita*, *lorelinduana*, *meikdelyi*, *melanopsis*, *minahasa*, *obi*, *pruinosa*, *ranau*, *sabela*, *samardaca*, *samarinda*, *sarawakensis*, *silau*, *simulata*, *sondaica*, *sulawesiana*, *tawau*, *tebakang*, *unica*, and *wallacei*. *Rhagovelia mindanaoensis* Hungerford and Matsuda 1961 is synonymized with *Rhagovelia orientalis* Lundblad 1937 (new synonymy).

Introduction

Small water striders of the genus *Rhagovelia* are nearly ubiquitous in upland tropical streams throughout the world, yet the last revisor of the group for the Old World was Lundblad (1936). Since then various workers have dealt with Asian and Indo-Pacific *Rhagovelia* species, i.e. Andersen (1965), Drake (1948), Hungerford and Matsuda (1961), Lundblad (1937), Polhemus (1979), Polhemus and Herring (1970a, 1970b) and Polhemus and Reisen (1976), but except for the Philippines (Hungerford and Matsuda 1961) none of these were revisionary works. Brown (1956), Hoberlandt (1941, 1951), Poisson (1942, 1948, 1949, 1951, 1952, 1955a, 1955b, 1958), and Sallier Dupin (1976, 1979) have dealt with the species from Africa, Madagascar and adjacent islands so that this fauna is better known, but there is still a need for a modern revision, since there are undescribed taxa in these regions, and no complete key to the species exists. When we began collecting *Rhagovelia* in the islands of the Malay Archipelago we soon realized that this part of the world contained an extremely diverse and almost entirely unreported fauna, whose analysis would offer valuable clues to the zoogeography of the region. This report is thus intended to fill a major gap in the systematics of the genus, and to offer hypotheses as to how the species attained their present distribution.

This is the first of a series of papers in which we intend to revise the genus *Rhagovelia* a region at a time for the Old World. We feel justified in this approach because, aside from some taxa present on mainland Asia and Africa, most species are endemic to particular islands or continental regions and often have extremely limited distributions. We have at hand extensive material, mainly from our expeditions supported by the National Geographic Society, that will more than double the number of Old World species, and for some islands or island groups increase the known fauna by ten-fold or more, e.g. New Guinea, the Solomons, Borneo and Celebes.

Locality Data

The area covered by this revision includes the islands of Borneo, Celebes, Halmahera, Bacan, Morotai, Obi, and Ambon. Borneo is divided between three countries; Malaysia, Indonesia, and the tiny sultanate of Brunei; all of the remaining islands are completely within the boundaries of Indonesia. Malaysian Borneo, referred to as East Malaysia in this report, occupies the western portion of the island and is divided into two states, Sarawak in the southwest and Sabah in the north. Indonesian Borneo is known as Kalimantan and is divided into four provinces, of which we have seen material from only one, Kalimantan Timur (East Kalimantan). Indonesian provinces, which are the equivalent of American states, are further subdivided into administrative units known as kabupatens, which are roughly equivalent to American counties. Where possible we have included the names of the kabupatens in our locality data to aid future researchers in more accurately locating our collecting sites. A locality reading "INDONESIA, Ambon, Maluku Prov., Kab. Maluku Tengah" thus gives the country, the island, the province and the kabupaten.

Several of the islands in the Moluccas have alternative names or spellings in the older literature. Halmahera was formerly referred to as Gilolo, and Bacan has been variously spelled as Batchan, Bachian, Batjan, and Batchian. Similarly, Amboina is a frequently encountered spelling for Ambon, and Mority is an older spelling for Morotai. In most cases we have employed the modern Indonesian spellings for islands and towns, though we have retained the name Celebes for the island the Indonesians now call Sulawesi.

Distribution maps are provided for all species treated in this report. The maps of Borneo, Celebes, and the Moluccas are all drawn to the same scale, based on a Bartholomew 1:5,800,000 map of Southeast Asia. In cases where several collection localities were in close proximity, a single symbol has been used to indicate the general area. Due to the many species present in a small area on Mt. Kinabalu, Borneo, a smaller scale map has been provided (fig. 14) to show the collection sites there.

CL numbers following collection localities refer to data codes used by the authors to reference ecological

notes. Institutional codes for specimen depositories are indicated in the acknowledgements.

Morphology

An excellent treatment of the morphology of the infraorder Gerromorpha has been provided by Andersen (1982) thus our purpose here is to explain those features unique to *Rhagovelia* and characters used in the key. Figures 1-9 illustrate the basic morphology of the genus.

The head has few diagnostic characters, however the morphology of the jugum (J) separates some closely related species. The presence or absence of minute dark conical setae (denticles) on the sides of the jugum is also diagnostic in some cases, but when present they are also evident on the proepisternum (Pe), where they are easier to see (fig. 1).

The morphology of the thoracic and abdominal segments of apterous *Rhagovelia* has not been treated in detail by any author, although Matsuda (1956) described these structures for alate *Rhagovelia*. Various other Veliidae have been analyzed in some detail, e.g. Andersen (1982), Dupuis (1970), Esaki and Miyamoto (1955). The interpretation of the dorsal thoracic segmentation in particular has been a controversial matter; Parshley (1921), Drake and Hussey (1955) and Esaki and Miyamoto (1955) offered three different interpretations of the thorax of apterous *Microvelia*. We accept the latter work, as did Smith (1980), thus in our view apterous *Rhagovelia* have three undivided dorsal thoracic sclerites, the pronotum (P), mesonotum (Ms) and metanotum (Mt), and the first abdominal segment (I) is visible dorsally (figs. 7, 8). This same interpretation was apparently used in the species descriptions of *Rhagovelia* by Andersen (1965) and Bacon (1956), although neither author discussed the morphology.

The number of dorsally visible abdominal tergites varies from 7 to 9 in apterous females, while in apterous males it is usually 9, although the ninth visible segment may not actually be tergite IX, but rather X. The female seventh tergite is sometimes strongly modified (e.g. into an elongate medial process; see fig. 159) but no such modifications are known for tergite VIII. Abdominal segments VIII - X are involved with the genitalia and particularly in females are often modified and difficult to interpret. In males the eighth segment (the first genital segment) is usually not strongly modified but may have excellent diagnostic characters. The ninth (fig. 3) is the genital "capsule" or pygophore (Pg) and bears the parameres or claspers (Cl), whereas the tenth is the proctiger (Pr), or anal plate, which is sometimes modified (fig. 33). The female eighth abdominal tergite may appear very similar to VII (figs. 2, 8) and lie on the same plane or it may be directed downward and be invisible from above or nearly so (figs. 37, 39). Rarely it is withdrawn within tergite VII and thus barely visible except in a caudal view (fig. 188, 190). Unless tergite VIII is strongly deflected the ventrolateral parts, the first gonocoxae (Gxl), are visible (fig. 2). The female tergite IX does not form an anal lid in *Rhagovelia* (Scudder, 1959) thus the small button-like segment protruding from under tergite VIII is segment IX, with segment X lying directly beneath it; often these two appear as one segment.

The legs, especially the posterior ones, provide good specific key characters. The spines and denticles of the hind femora and tibia (fig. 6) are quite stable characters, although the complement varies somewhat. In a few species the male hind femur varies from slightly to extremely incrassate, and in the latter extreme has correspondingly stouter armature and also curvature of the hind tibia. The species illustrated in figures 1 - 9, *Rhagovelia lugubris* Lundlbad, is the only species of the genus known to posssess a stridulatory mechanism, consisting of a file (plectrum) on the dorsum of the posterior trochanter (fig. 6) and a peg field (strigil) on the abdominal sternites (fig. 5). Andersen (1982) discussed stridulatory mechanisms in Veliidae, but at that time *Stridulivelia* Hungerford and *Angilovelia* Andersen were the only veliid genera in which these structures were recognized. Since then J. and D. Polhemus (1984) have described a stridulatory mechanism in the genus *Paravelia*, very similar to the one shown here except that the plectrum on the trochanter consists of minute pegs instead of transverse ridges.

In macropterous forms the basal abdominal tergites possess paired longitudinal carinae (fig. 154) that are useful in taxonomy, especially in defining species groups. These carinae may occur only on tergite II or may extend further, in some species onto tergite IV; the length is constant for a given species and relatively constant within groups. Matsuda (1956) has illustrated these carinae for a number of New World species and discussed their variability and significance, but we disagree with his conclusion that short carinae are plesiomorphic; see discussion following group analysis.

Only the apterous and macropterous morphs are known in *Rhagovelia*. The forewing venation of macropters has been widely used in the Veliidae as a character separating higher categories, and is relied on here to delineate species groups. The basic wing venation is explained in figure 9. Various venation patterns are shown in figures 22 - 27. The simplest pattern, and in our view the apomorphic state, is a wing with two basal cells (fig. 22). When distal cells are present, the cross

vein between Sc and R + M is often weak and sometimes appears to be absent, thus in populations of a single species individuals may be found that apparently have either three or four cells, e.g. *R. sumatrensis* Lundblad. In addition adventitious veins may be present that add cells to the normal complement (fig. 23).

Species Groups

Andersen (1982) considered the Rhagoveliinae to be a clearly monophyletic group on the basis of pretarsal morphology, and to include three genera: *Trochopus*, *Tetraripis*, and *Rhagovelia*. The two former genera have only a few species each, while *Rhagovelia* is perhaps the largest genus in the Gerromorpha (only the genus *Microvelia* may be larger), with about 200 species known to us including numerous undescribed forms. Although many clearly defined subgroups can be found within *Rhagovelia*, authors have chosen to treat these as at most subgenera (Matsuda, 1956), or more typically as "species groups" (Bacon, 1956), the latter a rather loosely defined category with no official status. However, since the splitting of some of the more clearly defined subgroups of *Rhagovelia* into separate genera would also necessitate the reevaluation of the entire classification scheme within the subfamily, and since the genus as it is presently defined is clearly monophyletic, we have continued to apply the species group concept when examining intrageneric relationships. Several well defined species groups may be distinguished within the the *Rhagovelia* fauna of the Malay Archipelago and adjacent regions, as outlined below. This treatment of groups is not inclusive, since only those groups necessary for the discussion of taxonomy and zoogeography in the present paper are defined here. In particular, a number of groups endemic to Africa and New Guinea or composed of undescribed taxa have been either omitted from the present discussion or not formalized. Upon completion of our work on the remainder of the Old World species, we will present a characterization of all groups and a cladistic analysis.

1. The *sarawakensis* group.

Distinguishing characters: Fore wing with 3 or 4 closed cells which extend slightly onto the distal half (fig. 108); abdominal carinae extending posteriorly to the posterior margin of abdominal tergite III; pronotum short, length at midline usually less than the length of an eye, only about one third as long as mesonotum; males lacking modifications, except in certain species where the abdominal sternites are longitudinally carinate medially; male parameres long, slender, narrowing distally, usually with a small distal hook; females also lacking significant modifications, connexival margins rarely flattened; female abdominal tergite VIII horizontal; both sexes small, 2.5 - 3.0 mm. in length, with narrow body form; dorsal coloration uniformly dull blackish with short orange brown band anteriorly on pronotum.

Distribution: Ceylon, Indochina, Greater Sunda Islands, Andaman Is., Palawan, Ryukyus.

Included species: *R. sondaica* n. sp. (Malay Peninsula, Borneo, Java), *R. femorata* Dover (Malay Peninsula), *R. femorata hungerfordi* Lundblad (Sumatra), *R. hutchinsoni* Lundblad (Java, Burma, Thailand), *R. samarinda* n.sp. (Borneo, Celebes); *R. sarawakensis* n.sp. (Borneo), *R. tebakang* n.sp. (Borneo); *R. minutissima* Hungerford and Matsuda (Palawan); *R. karunaratnei* J. Polhemus (Ceylon), *R. esakii* Lundblad (Ryukyu Is.).

Comments: The synapomorphy for this group is the characteristic fore wing venation (shown in fig.108). In addition to the above we have an undescribed species from the Andaman Islands that belongs to this group.

2. The *sumatrensis* group.

Distinguishing characters: Fore wing with 3 or 4 closed cells on the basal half (fig. 25); pronotum short, length at midline less than the dorsal length of an eye, about one third the length of the mesonotum; abdominal carinae extending to the posterior margin of abdominal tergite II; males and females without significant modifications; male parameres long, slender, with a distal hook, similar to *sarawakensis* group; female abdominal tergite VIII horizontal; both sexes small, length 2.5 - 3.0 mm.; coloration dull blackish, with a short orange brown band anteriorly on the pronotum. Male middle femur basally with thickened spines, much stouter than the normal setae.

Distribution: North India, Indochina, Greater and Lesser Sunda Islands, southern China, Formosa.

Included species: *R. sumatrensis* Lundblad (India, Sikkim, Thailand, Burma, Malaysia, China, Hong Kong, Formosa, Sumatra, Java, Bali, Flores, Sumbawa, Lombok).

Comments: The single taxon in this monotypic group, *R. sumatrensis*, is very widespread. Although allied to the *sarawakensis* group, it has certain characters that set it aside, such as the wing venation and the presence of thick spines on the base of the male middle femur (apomorphic); the latter characterisitic is relatively common in African species allied to the *papuensis* group, but not seen in any other Asian species.

3. The *nigra* group.

Distinguishing characters: Fore wing with 3 or 4 closed cells which extend slightly onto the distal half (fig. 24); abdominal carinae extending posteriorly to the middle of abdominal tergite IV; pronotum of intermediate length, about twice or more as long as mesonotum, which is broadly exposed; males with abdominal sternite VII flattened or sculptured but without hair tufts or tumescences; male parameres spatulate, broad and truncate distally; apterous females with connexival margins abruptly incurved along tergite IV; female abdominal tergite VIII sharply downturned; size 3.0 - 3.2 mm. in length, with broad body form; dorsal coloration uniformly dull blackish with short orange brown band anteriorly on pronotum.

Distribution: Sumatra

Included species: *R. bipennicillata* Lundblad (Sumatra), *R. nigra* Hungerford (Sumatra).

Comments: This group was recognized by Lundblad (1936).

4. The *papuensis* group.

Distinguishing characters: Fore wing with 3 or 4 closed cells, the distal two formed on the distal half of the wing (figs. 27, 153); pronotum long, covering all or nearly all of mesosternum; dorsal abdominal carinae extending to posterior margin of abdominal tergite III; males without significant modifications, except occasionally on the legs; male parameres variable; females with or without modifications, but those present include a projection from tergite VII and sinuate connexiva; length 2.6 - 5.3 mm.; coloration variable.

Distribution: Ceylon, India, Formosa, Borneo, Celebes, Moluccas, Australia, New Guinea, Philippines.

Included species: *hamdjahi* n. sp., *unica* n. sp., *pruinosa* n. sp., *sulawesiana* n. sp., *wallacei* n. sp., *minahasa* n. sp., *grayi* n. sp., *lorelinduana* n. sp. (all from the Celebes); *meikdelyi* n. sp.(Ambon); *ambonensis* Lundblad (Ambon); *samardaca* n. sp., *christenseni* n. sp.(both from Borneo); *agilis* Polhemus (Luzon); *luzonica* Lundblad (Luzon); *usingeri* Hungerford & Matsuda (Leyte, Mindanao); *lundbladi* Hungerford & Matsuda (Mindanao); *kawakamii* (Matsumura) (Formosa, Japan, Luzon, Palawan, Borneo); *tibialis* Lundblad (India); *ceylanica* Lundblad (Ceylon); *papuensis* Lundblad and several undescribed species (New Guinea); *australicus* Kirkaldy (Australia).

Comments: This widespread group is most closely allied to the *crassipes* group of the New World (see Bacon, 1956). It is close to the ground plan for the genus *Rhagovelia* in our view, and as construed here may not be monophyletic since it contains a set of species possessing plesiomorphic wing venation and abdominal carinae. Apomorphies distinguishing this group include an elongate body, shield-like pronotum covering the mesosternum, and in some species male and female abdominal modifications as noted above, and dorsoventral flattening of the middle and hind femora. The Papuan fauna contains additional regionally distinctive subgroups, some of which may deserve separate group status.

No attempt has been made to list all of the species for each region that belong to this large group, except that for the Celebes, Borneo and the Moluccas the list is inclusive. We have, however, listed species from every region where the group occurs, except the Solomons which has only undescribed species that appear to belong in this group.

The *papuensis* group is also closely related to a set of species occurring in Africa, the Seychelles, the Comores, the Mascarenes and Madagascar which were recognized by Lundblad in 1933 as the *nigricans* group. These species from the Indian Ocean region, however, possess thick setose spines on the base of the male mid femur, a character which sets them apart from Asian taxa. Several other groups from this region are also more closely related to the *papuensis* group than to the other groups characterized here.

5. The *novacaledonica* group.

Distinguishing characteristics: Fore wing with four closed cells, the two along costal margin extending onto the distal fourth of the wing (fig. 23; note adventitious fifth cell); pronotum short, length at midline subequal to the dorsal length of an eye, mesonotum mostly exposed; abdominal carinae extending at most to the posterior margin of abdominal tergite II and onto the intersegmental suture, but frequently much shorter, extending barely onto anterior margin of tergite II; males and females without significant modifications, except for reflexed connexivum; male parameres spatulate, usually broad distally; length 3.4 - 5.3 mm.; coloration dark brownish with a short transverse orange brown band anteriorly on the pronotum.

Distribution: New Caledonia, New Guinea.

Included species: *R. novacaledonica* Lundblad (New Caledonia), *R. biroi* Lundblad (New Guinea).

Comments: A synapomorphy for this group is the short abdominal carinae in the winged form. In addition to the species above, we have seen an undescribed species of this group from New Caledonia and several

undescribed species from New Guinea. Three other described taxa also appear to belong here, but cannot be conclusively placed because we lack winged specimens for comparison; these are *R. pidaxa* Polhemus and Herring from New Caledonia, plus *R. hoogstraali* Hungerford and Matsuda and *R. werneri* Hungerford and Matsuda, both from Mindanao. We may find it necessary to further subdivide this group after our analysis of the species from New Guinea and the Philippines is completed.

6. The *borneensis* group.

Distinguishing characteristics: Fore wing with two closed cells in basal third (figs. 22, 94); pronotum short, length along midline subequal to or shorter than the dorsal width of an eye, and one half to one third the length of the exposed metanotum; abdominal carinae extending to the posterior margin of abdominal tergite III or onto the base of tergite IV; males with modifications consisting of hair tufts or tumescences laterally to either side of midline on abdominal sternite VII (but absent in *R. incognita*) and a modified proctiger; male parameres usually broad and hooked distally; females broad and short, without significant modifications, and with abdominal tergite VIII horizontal; both males and females of moderate size, length 3.0 - 3.5 mm.; coloration blackish, with light dorsal markings restricted to a short transverse orange brown band anteriorly on the pronotum.

Distribution: Borneo, Java, Sumatra, Palawan.

Included species: *R. borneensis* n.sp. (Borneo), *R. melanopsis* n.sp. (Borneo), *R. incognita* n.sp. (Borneo), *R. silau* n.sp. (Borneo), *R. simulata* n.sp. (Borneo), *R. ranau* n.sp. (Borneo), *R. tawau* n.sp. (Borneo), *R. lugubris* Lundblad (Java, Sumatra).

Comments: The synapomorphy for this group is the fore wing venation with two closed cells on the basal third. In addition to the species listed above, we have an undescribed species from Palawan which belongs to this group.

7. The *orientalis* group.

Distinguishing characters: Fore wing with 3 closed cells (or rarely 4) with the 2 cells along the costal margin reaching to the distal fourth of the wing (fig. 26); pronotum long, covering all or nearly all of the mesonotum; abdominal carinae not reaching further than the posterior margin of abdominal tergite II; male modifications slight, consisting of tufts of setae medially on the abdominal sternites, and occasionally depressions laterally on sternites VI and VII; male parameres quite variable in form; females variable in shape, ranging from broad and stout bodied species to those in which the abdomen is narrowed or constricted distally, occasionally with bizarre modifications (such as in *R. aberrans*); females with abdominal tergite VIII horizontal to sharply downturned; both sexes of small to moderate size, length 2.7 - 3.3 mm.; coloration generally dark, with light dorsal markings restricted to a short orange brown band anteriorly on the pronotum.

Distribution: Philippines, Celebes.

Included species: *R. orientalis* Lundblad (= *R. mindanaoensis* Hungerford & Matsuda, new synonymy) (Mindanao, Negros, Leyte), *R. aberrans* Andersen (Mindanao); *R. philippina* Lundblad (Luzon); *R. minuta* Lundblad (Luzon); *R. celebensis* n.sp. (Celebes).

Comments: The synapomorphy for this group is the fore wing venation with three closed cells as described above. In addition to the taxa listed above we have another undescribed species from the Philippines (Mindanao, Leyte, and Luzon) which belongs to this group.

8. The *bacanensis* group.

Distinguishing characteristics: Fore wing with 3 or 4 closed cells, the distal 2 formed on the distal half of the wing (fig. 48); pronotum of medium length, length along midline 1.5 - 2 times the dorsal length of an eye; abdominal carinae extending to posterior margin of abdominal tergite III; males without significant modifications, male parameres narrow or broad basally, narrow distally, without apical hook; females with connexiva either straight or sinuate, abdominal tergite VIII horizontal to sharply downturned; both sexes of medium size, length 3.1 - 3.4 mm.; coloration variable, ranging from orange brown to dark brown.

Distribution: Northern Moluccas.

Included species: *R. bacanensis* n.sp. (Bacan, Halmahera, Morotai); *R. obi* n.sp. (Obi); *R. sabela* n.sp. (Bacan).

Comments: This species group is very close to the *papuensis* group, differing primarily by the relatively short pronotum which covers only about half of the mesonotum, a synapomorphy for the group. When additional material is available from Irian Jaya, Ceram, Buru and the other islands of the Moluccas it may show that this is a subgroup of the latter.

Discussion: Matsuda (1956) established the subgenus *Neorhagovelia* to hold all New World *Rhagovelia* having a short pronotum that never completely covers the mesonotum, (i.e., where the exposed part of the mesonotum is at least 2/3 as long as the pronotum). The in-

cluded species he further characterized by "forewing with apical cells more or less obliterated; one or two apical cells always formed in the proximal half of the wing; subcosta not extending beyond the middle of the wing. Distinct longitudinal carinae always occur on second abdominal segment, more or less obliterated and not reaching to intersegmental groove when they occur on third segment." To delineate subgenera and groups Matsuda also used a few other characters that we have not, including the shape of the pronotum in macropters (monotonous in all Old World taxa), hind leg segment ratios, and the nature of the seventh connexival segment in winged females. We agree with Matsuda that the reduced venation of the wing is an apomorphic state, but we disagree concerning the dorsal abdominal carinae. He maintained that the occurrence on fewer segments is plesiomorphic, but we maintain the opposite view. Andersen (1982) established the ground plan for the Veliidae (see discussion on p. 177) and noted the similarity of structures shared by unspecialized primitive members of diverse components of the Gerromorpha including *Ocellovelia* (Veliidae), Macroveliidae, and *Veliometra* (Hydrometridae). All of these possess similar abdominal carinae extending onto tergite IV, suggesting that long carinae represent the plesiomorphic state.

Matsuda included two groups (of Bacon 1956) in *Neorhagovelia*, the *abrupta* and *angustipes* groups, but he was only able to study a limited number of winged forms in each group. As far as we can determine from examination of additional macropterous species of each group, all species of the *angustipes* group settle comfortably into the subgenus *Neorhagovelia* as he defined it, but the *abrupta* group has members that do not conform. Matsuda studied macropters of only three species of the latter group and they fit his subgeneric description, but we have studied macropters of three additional species (*Rhagovelia lucida* Gould, *R. trepida* Bacon and *R. secluda* Drake & Maldonado) that do not conform. These have the subcosta extending well beyond the proximal half of the wing, and the distal cell extending onto the distal fourth of the wing, character states that would exclude them, but the abdominal carinae extend only to the posterior margin of tergite II or barely onto tergite III, which matches his concept. It thus appears that the *abrupta* group should be divided and that the length of the pronotum is useful but not definitive for groups. This correlates with our analysis of Old World groups wherein the relative length of the pronotum is quite constant within a group but rarely defines it uniquely. We have placed primary emphasis on wing venation and the abdominal carinae in our group analysis, but this at once creates a dilemma because macropters are not available for all taxa. In spite of this problem we have been able to establish above what we consider to be monophyletic groups (except perhaps the *papuensis* group) and have included some species known only from the apterous form, thus predicting the nature of macropters for certain species in which this morph is not yet known. Within some of our groups (especially the *papuensis* group) there are tightly knit regional or altitudinal subgroups defined on the basis of one or more of the following characters: shape of the first male genital segment (fusiform vs. quadrate or subtriangular), paramere shape, modifications of female abdominal tergites or connexiva, degree of coverage of mesonotum by the pronotum, nature of the light colored anterior pronotal band or fasciae, and general body coloration (black or dark brown vs. orange brown). Some of these subgroups will be alluded to in the sections on ecology and zoogeogaphy.

Hungerford and Matsuda (1961) placed several Philippine *Rhagovelia* (i.e., *hoogstaali*, *minutissima*, *werneri*) in the subgenus *Neorhagovelia* solely on the basis of the short pronotum, but they did not have winged specimens of these species to check what we consider to be the most important characters used by Matsuda (1956) in establishing the subgenus. Our group anlaysis presented above, plus additional studies based on thousands of specimens including almost all Old World species, many of them winged, does not support the inclusion of any Old World species in *Neorhagovelia* at present, a matter of some importance in zoogeography as it establishes a Neotropical versus a transpacific distribution for the subgenus (see also Andersen 1982, p. 182). Unfortunately we too lack winged material of *hoogstaali* or *werneri*, but for these species we have on other grounds tentatively placed these species in the *novacaledonica* group that definitely includes species from New Caledonia and New Guinea. We have placed *minutissima* in our *sarawakensis* group.

An unnamed group that contains only undescribed species has several representatives in northern New Guinea and another on Negros in the central Philippines. This group, which probably deserves at least subgeneric rank, is characterized by a very short pronotum, relatively broad flat body, relatively long middle tarsi, and phoretic behavior resulting in distinct sexual dimorphism in body size; the small males have strongly curved fore legs fitted for grasping the females. At first we thought this group should be placed in the subgenus *Neorhagovelia* but we have since concluded that the similarities are due to convergence. Species of this New Guinea group, the *angustipes* group of the New World, and another unnamed group from Madagascar typified by *R. diabolica* Poisson skate on open midstream

waters and have a very characteristic appearance as a result, with short compact bodies, frosty gray coloration, long middle legs, and a short pronotum. The latter is presumably a consequence of the increased musculature of the mesothorax necessary to power the middle rowing legs.

Zoogeography

Humphries and Parenti (1986) recognized two phases of historical biogeography, narrative and analytical. The first involves the integration of historical events, both geological and climatic, and various assumptions regarding the dispersal or vicariance of faunas to generate hypotheses that would explain modern distribution patterns. The second involves cladistic analysis of the groups involved and comparison of the phylogenetic trees thus generated to the phylogenies proposed for other groups or to proposed earth history models in a search for congruent biogeographical patterns. The two methods as such are not exclusive but instead represent the different ends of a methodological continuum based on the degree of knowledge of a group's distributions and relationships.

Schuh and Stonedahl (1986) presented a cladistic biogeographical analysis using concordant cladograms for various groups of phytophagous insects in the Indo-Pacific region and urged a broader application of these methods across other groups. Endler (1982), however, has claimed to have shown by computer simulation and statistical analysis that concordant cladograms can only result from shared geographic patterns of selection on characters and thus he asserts that they contain no information about shared biogeographical history. We note that his work would also indicate, though, that if selection patterns and vicariance patterns are concordant then they would generate concordant cladograms that would give a relatively accurate indication of the sequence of vicariance events. We believe that cladistic analyses of individual groups may be quite informative, since Schuh and Polhemus (1980) have demonstrated congruence between morphological, ecological and biogeographical data sets for the hemipteran infraorder Leptopodomorpha. Endler's simulations indicated that if vicariance events were relatively recent then the probability was high that a cladogram would accurately reflect their sequence, and since many water gaps in the Malay Archipelago have appeared since the Pleistocene it seems likely that cladistic analyses of individual groups can provide valuable biogeographical data for this region in cases where vicariance has affected distributions.

Plant and animal distributions in the Malay Archipelago are the result not only of vicariance, though, but of a complex interplay of factors including dispersal over water gaps, mergers of previously discrete land masses, and extinction. A synthetic method incorporating all these factors is thus required to gain any accurate picture of historical biogeography in the region. Cladistic biogeographers have tended to downplay the importance of dispersal in particular as a source of disjunct distributions, but in the Malay Archipelago it is obvious that dispersal has played a major (if not almost exclusive) role in the colonization of many isolated volcanic islands. As a vivid example one need only look to the carefully documented recolonization of Krakatau following the devastating volcanic eruption of 1883 (Dammerman, 1948).

A complete cladistic analysis of *Rhagovelia* on the species level for the Malay Archipelago region is many years away, due in no small part to the large number of species still awaiting description from the Philippines, New Guinea, the Lesser Sundas, the Solomons, and other zoogeographically important areas. Some of these undescribed taxa are important in regard to outgroup comparisons, and until they are described and in some cases cladistically analyzed themselves a cladistic interpretation of the *Rhagovelia* fauna in the eastern Malay Archipelago is premature. Thus an analytical approach to the historical biogeography of *Rhagovelia* in this region is precluded by the need for further work at the alpha taxonomic level to establish whether the putative outgroups are truly monophyletic (an understated problem in many cladistic analyses). This does not mean, however, that a meaningful discussion of the zoogeography of the group is impossible, or must be put off until some indefinite point in the future. Rather it must be recognized that the zoogeographical treatment below has been done at the narrative level, and that many of the scenarios proposed are hypotheses that are open to future testing by analytical biogeographical methods once sufficiently detailed taxonomic information becomes available.

The genus *Rhagovelia* is diversely represented in all the tropical regions of the world, and has penetrated northward into the temperate zone of North America but not Europe. The presently documented range includes North and South America, the Caribbean Islands, Africa, Arabia, Turkey, Madagascar, Ceylon, India, many Indian Ocean Islands (Mauritius, Rodriguez, Reunion, Comores, Seychelles), Japan, Southeast Asia, Formosa, the Malay Archipelago, New Guinea, Australia, the Solomon Islands, and New Caledonia. Species are present on isolated island groups of both

continental and oceanic origin, including the Seychelles and the Mascarenes in the Indian Ocean and the Ryukyus in the Pacific. This broad pattern of distribution indicates that the group has had a long history influenced by both vicariance and dispersal events. The absence of the genus in temperate Eurasia and its evident penetration of North America from the south via Mexico and Central America indicates that it originally occupied Gondwanaland and reached the continents that formerly constituted Laurasia only in the Tertiary following the establishment of the Central American land bridges and the collision of India and Africa with southern Eurasia. Given this hypothesis, it is of interest to understand how the diverse *Rhagovelia* fauna of the eastern Malay Archipelago came to exist, considering the relatively sparse representation of the genus in surrounding continental regions.

Theories of island biogeography generally assume that colonizing species arrive on islands from source areas on adjacent continents (MacArthur and Wilson, 1967), and we believe this to have been the case with *Rhagovelia* in the eastern Malay Archipelago. The situation here is complicated, though, by the presence of three potential continental source areas from which *Rhagovelia* species could have entered the region: continental Asia, or the old Gondwanaland fragments of Australia and New Caledonia. In addition, not all of the colonized islands in question are equivalent, since Borneo was previously connected by land to continental Southeast Asia via the exposed Sunda Shelf in the Pleistocene, and New Guinea to Australia in a similar fashion across the Torres Strait, while Celebes and the Moluccan islands have apparently lacked any land connections to either Asia or Australia-New Guinea.

The *Rhagovelia* fauna of continental southeast Asia is presently composed of species belonging to the *sarawakensis* and *sumatrensis* groups, and is remarkable for its relatively low number of species and their lack of striking morphological differentiation. The *sarawakensis* group is almost certainly of Asian origin, possibly derived from ancestors introduced on drifting India. This group, composed of many very similar species, has radiated eastward through Sumatra and Java and into southern Borneo. The monotypic *sumatrensis* group is also of Asian origin and has a distribution pattern similar to the *sarawakensis* group except that it has spread farther beyond the present Asian continent, being nearly ubiquitous from India to China and extending along the southern volcanic arc of the Malay Archipelago as far as Flores in the Lesser Sundas. Sumatra also harbors the *nigra* group, which is apparently endemic to that island and has not radiated beyond it.

Continental southeast Asia has thus contributed very little to the diverse array of *Rhagovelia* species groups found on Borneo and in the islands farther to the east. The *Rhagovelia* fauna of the eastern Malay Archipelago appears instead to have radiated northward and westward from New Guinea, and to be derived from lineages that originally inhabited either Australia or New Caledonia and which are lacking on continental Asia and along the outer Banda Arc.

Australia presently has but a single species of *Rhagovelia*, *R. australica* Kirkaldy, occurring in the rain forests of Queensland. This species is a member of the relatively primitive *papuensis* group, which has its closest relatives in the Southern Hemisphere on the Gondwanaland fragments of Africa, India, and Madagascar. Australia lay between 30° and 60° south of the equator in the Cretaceous, and has only entered the tropics in the Tertiary as the result of progressive northward drift after separating from Antarctica approximately 55 million years ago (Barron et al., 1981). When east Gondwanaland was still intact the bulk of the continent thus lay in latitudes too cold to permit the survival of the warm adapted *Rhagovelia* species except perhaps in pockets along its very northern margin (no *Rhagovelia* species presently occurs more than 35° south of the equator), even supposing a milder climate in the Cretaceous than presently exists in these latitudes. It therefore seems unlikely, in light of both geological history and the present impoverished *Rhagovelia* fauna, that Australia originally harbored a more diverse array of *Rhagovelia* species when it was part of Gondwanaland than it does today. Instead, we hypothesize that the single species presently on the continent either survived in warm refugia in the north or dispersed there from New Guinea. The shallow Torres Strait separating New Guinea from Australia was above sea level in the Pleistocene, and *Rhagovelia* could have entered New Guinea from Australia at this time, or vice versa. This land bridge, however, was characterized by a dry savannah environment (Nix and Kalma, 1972) that is very atypical habitat for *Rhagovelia* species in present day Australasia. In addition, if *Rhagovelia* first entered New Guinea via this route in the Pleistocene, then the tremendous differentiation of groups and species now seen on the island must have occurred in a remarkably short period of time. Alternatively, *Rhagovelia* could have dispersed at some earlier time between northern Australia and islands that previously existed to the north along the edge of the subducting Pacific plate and were later incorporated into New Guinea. In either case, we hypothesize that some portion of the Australian continent is indeed the source area from which the plesiomorphic *papuensis* lineage colonized New Guinea,

and subsequently the Philippines and the eastern Malay Archipelago.

New Caledonia, though much smaller than Australia, contains three *Rhagovelia* species; two are described, *R. novacaedonica* Lundblad and *R. pidaxa* Polhemus and Herring, and one is undescribed. These species belong to the *novacaledonica* group, which has other members occurring in New Guinea and perhaps in the southern Philippines (see previous group analysis). Geological and phytogeographical evidence indicates that New Caledonia was connected to eastern Australia as part of the Gondwana continent in the early Cretaceous, at which time it lay near latitude 35° S (Raven and Axelrod, 1972). New Caledonia was apparently separated from Australia in the late Cretaceous, and like that continent has drifted steadily northward into progressively warmer climatic zones, but due to its more northerly position it has had a milder climate than Australia throughout most of its history. Typically Asian elements of the New Guinea flora and fauna have dispersed down the Solomon and New Hebrides island chains to New Caledonia (Gressitt, 1982), and it is reasonable to assume that similar dispersals of Gondwana taxa could have operated in the opposite direction. We have no records of *Rhagovelia* from the New Hebrides, where collecting has been scant, but in the Solomons the genus is represented by several species, and we hypothesize that New Caledonia is the source area from which *Rhagovelia* species of the *novacaledonica* group reached New Guinea, island hopping northwestward along the intervening archipelagos.

Both New Caledonia and Australia are thus old Gondwana fragments from which *Rhagovelia* could have colonized New Guinea and the rest of the eastern archipelago, and it is likely that both have acted as continental source areas harboring remnants of the old Gondwana *Rhagovelia* fauna. Although the Solomon and New Hebrides archipelagos are both of Miocene age, and would thus have provided a potential dispersal corridor northward from New Caledonia long before the exposure of the Torres Strait in the Pleistocene, it is the *papuensis* group of apparently Australian origin that has diversified most greatly on New Guinea and given rise to numerous other species complexes occurring on that island and beyond.

A tremendous late Tertiary radiation of species and groups has occurred among New Guinea *Rhagovelia*, similar to that seen among other aquatic insects including the heteropteran family Naucoridae and the mayfly family Baetidae. The entire *Rhagovelia* fauna of New Guinea is endemic, and must have originated primarily since the Oligocene, before which the portion of the Australian continental shelf comprising the island was subsea. An older Tertiary island arc including portions of what is now the Bismarck Archipelago extended in a roughly east-west direction along the edge of the subducting Pacific plate ahead of advancing New Guinea when the main body of that island was still submerged, and portions of this arc have been incorporated into the north coast of the modern island. This arc would correspond to the "outer arc" concept of Holloway (1984), and may formerly have been continuous with the Solomons and New Hebrides (Hamilton, 1979); if so it is possible that *Rhagovelia* species, most likely of the *novacaledonica* group, could have been distributed along its length and thus introduced into northern New Guinea when the two collided. The few members of the *novacaledonica* group in New Guinea are presently known only from the north coast ranges and the Papuan Peninsula, a distribution consistent with this scenario. By contrast, the *papuensis* group and other species groups derived from it have radiated extensively in the younger and more rugged central ranges, and thus the evolution of the large number of species and groups on the island today must still be interpreted as a very recent event linked to the rise of these mountain chains. We hypothesize that dispersal of members of the *papuensis* group westward from this rich area of endemism has been the basis for the diverse array of species now seen in the Moluccas, Celebes, and Borneo; this hypothesis also accounts for the progressive decline in the number of species of this group as one approaches Asia. The route of faunal migration seems to have occurred through the central Moluccas (Ceram, Buru), since members of the *papuensis* group occur in this region on the island of Ambon but are absent in the adjoining north Moluccas and Lesser Sunda islands. The suggestion by certain authors that northwestern New Guinea contains terranes derived from the Lesser Sundas is not supported by *Rhagovelia* distributions, since the species groups present in the two regions are completely different.

The Philippines also contain a rich *Rhagovelia* fauna including representatives of the *papuensis* and *orientalis* groups, and perhaps of the *novacaledonica* group as well. There has been much speciation within the Philippine archipelago, with particular areas of endemism in the mountains of northern Luzon and in the region surrounding Mt. Apo on Mindanao. The *orientalis* group seems to have arisen within the Philippine region, while the remainder of the Philippine taxa are closely allied to species occurring on New Guinea. The Philippines and New Guinea also share strong similarities in other elements of their aquatic insect biotas (Polhemus and Polhemus, 1987), indicating that a greater

degree of faunal interchange has occurred between these two areas than between both of them and the remainder of the archipelago. A geological explanation that would account for such interchanges on the basis of vicariance via tectonic mechanisms is not evident.

Considerable evidence, however, indicates that portions of Celebes and the Moluccas contain crystalline rocks representing continental fragments that have been transported westward from New Guinea along the left-lateral Sorong Fault (Hamilton, 1979). These include portions of Ambon, Ceram, Buru, the Sula Archipelago, and possibly Bacan and Obi, as well as the tip of the Banggai Peninsula on Celebes and its associated islands. Such a geological hypothesis would be compatible with the present distributions of *Rhagovelia* species in the region. Celebes is a geological composite, with its western portion rifted from Borneo, its eastern arms formed of subduction melange and westward drifting continental fragments, and its northern arm comprising a recently attached portion of the Sangihe volcanic arc. The basement rocks of eastern Borneo and western Celebes are similar, and the Makassar Strait appears to have opened via rifting of western Celebes from Borneo in the middle Tertiary. The portion of Celebes that was detached from Borneo at this time, however, was subsea, as evidenced by thick limestone beds of late Eocene to early Miocene age presently exposed in the southwestern arm, thus it is unlikely that this rifting represented a vicariance event that would have incorporated Bornean taxa into the fauna of Celebes. We consider it more likely that Bornean groups on Celebes and groups of Papuan origin on Borneo attained their present distributions by dispersal in either direction across the relatively narrow Macassar Strait after its formation.

Borneo is an enormous island that is still quite poorly surveyed biologically, and we anticipate that many more species of *Rhagovelia* will be discovered there, thus any discussion of its zoogeographical relationships is based on admittedly limited information. Paleomagnetic data indicate that the island has occupied an equatorial position for at least 80 million years (Haile et al., 1977), and the Cretaceous granites of its southwestern portion appear to be correlative with those of Indochina, indicating that it has had a roughly similar relationship to the present Asian continent over this time span. Collections on Borneo by ourselves and others have been mainly centered in the former British colonies of Sarawak and Sabah, though in 1985 we also made several collections in East Kalimantan in the Mahakam River basin.

The known *Rhagovelia* fauna of Sarawak consists entirely of species belonging to the *sarawakensis* group, which appears to have undergone a secondary radiation in this region. The presence of one member of this group, *R. sondaica*, in both Sarawak and the Malay Peninsula strongly suggests an old Sundaland distribution which was fragmented by the post-Pleistocene flooding of the Asian continental shelf. This same distribution pattern is seen in the gerrids *Ventidius malayensis* Hungerford and Matsuda and *Esakia johorensis* Cheng and in many species of birds and mammals, so its existence among Bornean *Rhagovelia* species is not surprising. In contrast to this is the monophyletic complex of species in the *borneensis* group centered around Mt. Kinabalu in the north of the island, a granite pluton rising to 4102 m. (13455 ft.) and uplifted only in early Pleistocene time. The *borneensis* group appears to have arisen on Borneo, and has established only a few outlying species on the nearby islands of Java, Sumatra, and Palawan, all of which had Pleistocene land connections with Borneo. Members of the *papuensis* group are also present on Borneo, but the number of species is small in comparison to Celebes or New Guinea. The *papuensis* group is absent in Java, Sumatra, the Lesser Sundas, the Malay Peninsula and Indochina, and it appears that its members reached Borneo from the east, either from Mindanao via the Sulu Archipelago or from Celebes across the Makassar Strait. A Philippine connection seems particularly likely for *R. kawakamii*, which occupies an interesting distribution on the islands of Borneo, Palawan, Luzon and Formosa that form the eastern rim of the present South China basin.

In contrast to Borneo, Celebes supports a *Rhagovelia* fauna composed primarily of species in the *papuensis* group, and lacking any members of the *borneensis* group. The island's odd shape, with four converging peninsulas producing geographical bottlenecks, coupled with the existence of numerous rugged ranges that form montane islands, has fostered the persistence of distinct species in various parts of the island. At present we know *R. minahasa*, *R. unica*, and *R. grayi* only from the northern Minahasa peninsula, *R. lorelinduana* and *R. hamdjahi* only from the Lore Lindu region in the center of the island, and *R. sulawesiana* and *R. pruinosa* only from the south Peninsula near Ujung Pandang. Two other species on Celebes have broader distributions, *R. celebensis* being found both in Minahasa and Lore Lindu regions and *R. wallacei* occurring in all the areas of the island so far sampled. The latter species occurs over a wide altitudinal range (figs. 11, 12), suggesting colonization of most of the mountain ranges on the island by dispersal across intervening areas of low terrain. We have seen no collections from the eastern Banggai and Kendari peninsulas, but would anticipate that they too support endemic *Rhagovelia* species.

All of the *Rhagovelia* species on Celebes are members of the *papuensis* group with the exceptions of *R. celebensis* and *R. samarinda*. The former species is a member of the *orientalis* group, and the only species in that group known to occur outside the Philippines. The mayfly fauna of the northern Minahasa peninsula of Celebes shows affinities to that of Mindanao (G. F. Edmunds, pers. comm.), containing species of *Platybaetis* and the *Jubabaetis* complex, and it seems likely that these mayflies and the ancestor of *R. celebensis* entered the island via dispersal along the Sangihe Archipelago, a still active volcanic arc of Miocene age. The islands comprising the Sangihe Archipelago are presently quite small, but bathymetric maps indicate that they occupy an extensive and shallow submarine platform, so that during the lowered sea levels of the Pleistocene this arc would have consisted of several large islands separated by narrow water gaps, providing a series of stepping stones between southern Mindanao and the tip of the Minahasa Peninsula.

R. samarinda, a member of the *sarawakensis* group, is known from Celebes on the basis of a single winged female collected by us at high elevation in the Lore Lindu region. This same location in the central part of the island also yielded the only specimens of the typically Bornean gerrid genus *Metrocoris* taken on Celebes. These distribution patterns suggest that central Celebes has had a greater degree of faunal interchange with Borneo in comparison to some of the more isolated peninsulas such as Minahasa, thus lending support to the hypothesis of a composite geological origin for Celebes. If populations of *R. samarinda* have become established in central Celebes then they appear not to have dispersed within the island, since we did not discover this species or any other member of the *sarawakensis* group on the northern or southwestern peninsulas. The presently known distribution of *R. samarinda* could be explained on the basis of a vicariance pattern involving western Celebes and eastern Borneo, but given its limited distribution and lack of differentiation we believe it more likely that it has arrived in Celebes relatively recently by dispersal across the Makassar Strait.

With the possible exception of Bacan, all of the northern Moluccan islands appear to be of Tertiary age and primarily volcanic in origin. Bacan and Obi may contain portions of an older Tertiary volcanic arc, or be continental fragments broken from New Guinea, as noted above. Bacan, though small in size, contains a richer *Rhagovelia* fauna than any of the surrounding islands, thus supporting the hypothesis that it may be of greater age or separate geological origin. A vicariance hypothesis could thus be invoked to account for the origin of *Rhagovelia* species on Bacan and Obi, but Halmahera and its associated islands have had no other land connections and must have received their faunas via dispersal. All of the *Rhagovelia* species known from the region are members of the endemic *bacanensis* group, an isolated offshoot of the *papuensis* group most closely allied to taxa occurring on the central Moluccas, Celebes and New Guinea. This pattern of relationship suggests that the group originated from a single founding species, followed by subsequent radiative speciation. The entire stream insect fauna of the northern Moluccas is impoverished and disharmonic by comparison with surrounding areas such as Celebes, New Guinea, and the Philippines, further indicating that most of the taxa present are the result of dispersal over water gaps.

We have seen no specimens of *Rhagovelia* from Ceram, Buru, or the Sula and Banggai archipelagos, but we are confident that the genus occurs on all these islands. Two species of the *papuensis* group closely related to taxa occurring on Celebes, *R. meikdelyi* and *R. ambonensis*, are known from the island of Ambon, which was continguous with Ceram in the Pleistocene. Ceram and Buru lie on the outer arc ridge of the Banda Arc and are geologically complex, incorporating subduction melange and possibly crystalline continental fragments from New Guinea. Both islands have areas of high relief over 2500 meters, and thus likely support altitudinally zoned *Rhagovelia* assemblages similar to those seen on Celebes and Bacan. Knowledge of the species present in the Sula and Banggai island groups, especially on the large and mountainous islands of Taliabu and Peleng, would be especially valuable, since these islands are composed of Paleozoic granitic rocks apparently correlative to those of similar age in the Vogelkop region of New Guinea. We believe that these central Moluccan islands represent the route by which *Rhagovelia* species of the *papuensis* group reached Celebes from New Guinea, either through tectonic rafting or via dispersal across island stepping stones, but without further collecting in the region this hypothesis cannot be confirmed.

Zoogeographical summary:

1. Three source regions are hypothesized to have contributed to the *Rhagovelia* fauna of the eastern Malay Archipelago: continental Southeast Asia, Australia, and New Caledonia. The *Rhagovelia* fauna of the region is thus a composite of lineages derived from various sources, which have arrived via differing routes.
2. The *sarawakensis* group is of Asian derivation, and exhibits a predominantly Sundaland distribution, oc-

curring on the the Asian continent, the Greater Sunda islands, and Palawan, with one extralimital species on Celebes. Particularly strong relationships are seen between species in Sarawak and in the lower Malay Peninsula.

3. The *sumatrensis* group contains one widespread species which occurs on continental Asia and along the outer volcanic arc as far as Flores, but has not penetrated any other portion of the archipelago.
4. The *orientalis* group is centered in the Philippines, with one species having reached Celebes, probably via dispersal along the Sangihe Archipelago.
5. The *novacaledonica* group occurs in New Caledonia and New Guinea, with other possible members in the Solomons and southern Philippines. This group is hypothesized to have originated on New Caledonia, and to have subsequently dispersed northward along the intervening island arcs to New Guinea. We propose New Caledonia as a generally overlooked reservoir of tropical Gondwanaland taxa that have contributed southern elements to the present biota of New Guinea.
6. The *papuensis* group occurs in Australia, New Guinea, the Philippines, the central Moluccas, Celebes and Borneo, reaching its western limit on the latter island. Its ancestral species are hypothesized to have reached New Guinea from Australia, and to have subsequently radiated northward into the Philippines and westward through the central Moluccas to Celebes and Borneo.
7. The *bacanensis* group is endemic to the north Moluccas, and is hypothesized to be the result of a monophyletic radiation from a single member of the *papuensis* group which reached the region from New Guinea or Celebes.

Ecology

Collectors frequently observe repeated patterns in nature that they consider to be important in the organization of animal communities but for which they lack the time or resources to gather supportive numerical data. Because of this the insights gained by systematists who work closely in the field with live organisms often go unpublished and are thus lost to workers in ecology. With this in mind we present below various observations on *Rhagovelia* ecology in Southeast Asia, noted in the course of work along dozens of streams. In certain cases these include speculations, which are not intended to be construed as established facts but rather as hypotheses to be tested by future workers. Although we lack extensive data tables to support some of our observations, we believe that the patterns themselves are widespread and important, and will be verified by subsequent research.

Rhagovelia species are among the most commonly encountered surface dwelling Hemiptera inhabiting the swift rocky streams of the Malay Archipelago. The numerous islands of this region, and their high relief and rugged topography, have fostered the development of numerous allopatric species. On any particular stream, though, there are likely to be several species occurring in sympatry, and different streams in the same region may often support different species assemblages. Species thus appear to partition habitats within and between streams based on differing ecological preferences and modes of behavior. Many of these patterns of community organization are similar to those noted by Hynes (1948) among *Rhagovelia* species on the West Indian islands of Trinidad and Tobago.

One of the most obvious modes of habitat partitioning exhibited by *Rhagovelia* in Southeast Asia is segregation of species by elevation. Figure 10 illustrates this pattern for the simple case of the two species present on Bacan's Mt. Sabela, *R. bacanensis* and *R. sabela*. Only *R. bacanensis* is found in lowland habitats from sea level up to 250 meters, then in a transition zone from 250 to 400 meters both species are present, and in montane environments above 400 meters only *R. sabela* occurs.

On a larger island such as Celebes, which supports a more diverse *Rhagovelia* fauna, a similar but more complicated pattern is seen (figs. 11, 12). Data from the Minahasa region, near the tip of the northern peninsula, and from the Lore Lindu National Park, near the center of the island, show three rough altitudinal zones, each usually occupied by distinct species. Although the species composition of the fauna changes somewhat between the Minahasa and Lore Lindu regions, the basic patterns are similar. In both regions *R. celebensis* is the only species occuring in lowland streams near sea level, and ranges as high as 700 meters in the Lore Lindu region, though we did not record it above 250 meters in Minahasa. At slightly higher elevations one finds *R. wallacei*, which shows a very similar altitudinal distribution in both regions, occurring between 200 and 1000 meters. Above 900 meters a completely different set of species is encountered, and unlike those at lower elevations these seem to be endemic to each region, with *R. minahasa* and *R. grayi* occurring at high elevations in Minahasa, and *R. lorelinduana* and *R. hamdjahi* occupying the same altitudinal niche in Lore Lindu. This pattern of endemism, with widespread species in marginal lowland habitats and regionally endemic species in the interior mountains has also been noted in New Guinea

for ants (Wilson, 1959) and carabid beetles (Darlington, 1971).

A similar pattern of altitudinal segregation is also seen on Mt. Kinabalu in northern Borneo, which supports a tightly related group of apparently endemic species (fig. 13). On Kinabalu there is a zone of great diversity between 300 and 600 meters, and as on Celebes there are several species restricted to elevations above 900 meters. *R. borneensis* is presently known from the mountain only at elevations of 1500 meters or higher, making it the highest ranging *Rhagovelia* species in the Malay Archipelago region outside New Guinea, where we have taken species as high as 2800 meters. Veliidae as a whole appear to have good tolerance to cold water temperatures, and are the highest ranging aquatic or semiaquatic Hemiptera in the Asian tropics. Andersen (pers. comm.) has commented to us that the development of mountain habitats appears to be a major driving force in the speciation and diversification of *Rhagovelia*, and the present observations would support this hypothesis.

Another interesting observation is that *Rhagovelia* species occurring at higher elevations tend to be predominantly orange in coloration. We have no substantiated explanation for this phenomenon, but speculate that it may be a case of cryptic coloration. Streams and streamlets at high altitudes tend to be shallow and clear, and the tropical soils of Asia are frequently reddish or orange brown in color. Black insects on the surface of a streamlet flowing over an orange bed are thus readily apparent when observed from above, while orange individuals are quite well concealed. In certain cases orange *Rhagovelia* species are nearly invisible on such streams when the motion of their swimming is masked by riffles, and can only be seen by observation at an oblique angle which produces glare on the water surface and reveals the position of the insects. At lower elevations streams become progressively deeper and thus darker, and here one finds that dark *Rhagovelia* species predominate. In both Asia and the remainder of the world, *Rhagovelia* species such as those of the *orientalis* group which occur on the unshaded waters of large rivers have a distinctive frosty gray coloration reminiscent of that seen in many marine Gerromorpha, and it appears that this may be linked to their ability to tolerate exposure to direct sunlight. We would also note that orange coloration in upland species does not appear to be a character linked to phylogeny, since it occurs in high altitude members of several different species groups, including the *papuensis* and *bacanensis* groups in Asia and several others in Madagascar, Africa and the Neotropics. It may also be a neotenic character retained into the adult stage, since many species, including those which are dark as adults, have orange immature stages.

Hynes (1948) speculated that the character of the stream habitat could have an influence on the altitudinal range of *Rhagovelia*, and that species typically found in rocky hill streams at intermediate elevations could be taken clear down to sea level where such streams flowed directly into the sea. Our experience in the Malay Archipelago supports this observation; rocky coastal streams of this type are so common in this region where steep mountains frequently drop sharply to the sea that any species taken at 200 meters or below can be assumed to occur on down to sea level. We have not discovered any particular species or species group specifically adapted to large, slow lowland rivers, even though such rivers are numerous in Borneo, and in fact streams of this type in Southeast Asia as a whole are notable for their absence of *Rhagovelia* species. Hynes also speculated that the upper altitudinal limits of species ranges were determined by temperature gradients, a contention we also support, although like Hynes we base our conclusions on field experience unsubstantiated by any experimental data. Above 900 meters in particular streams diminish in size and are heavily shaded by montane forest and this, combined with cool air temperatures and a frequent overcast of clouds and mist that further reduce insolation, leads to markedly colder water temperatures.

Within any given stream *Rhagovelia* species will also segregate according to preferred microhabitats, with members of different species groups showing predictable preferences for various parts of the stream. Species of the *orientalis* group prefer open, unshaded water where they actively skate against the current and often form into large aggregations. By contrast, species of most other species groups prefer shaded situations amid streamside rocks, and tend to stroke and glide across small pools rather than engaging in continuous rowing motion. Their favorite habitats are small pockets formed where water flows among cobbles, creating tiny interconnected pools, or on slow water beneath overhanging vegetation, but in all cases there must be some degree of current, no matter how slight. The large orange species of the *papuensis* group tend to aggregate in dark cavities beneath logs or overhanging rocks, and surprising numbers may often be extracted from a single spot by diligent and repeated scoops of the net. In this regard their behavior resembles that of the larger (body size) veliid genus *Angilia*, also found the the Asian tropics, and the Neotropical *Paravelia*. Like the latter, their behavior and negative phototactic response strongly suggest a nocturnal habit.

Intraspecific habitat partitioning between sexes also seems to occur, since we have observed that males of some species favor swiftly flowing midstream sections while the females are aggregated in quieter areas near the shore. To test this hypothesis we took two large and approximately equal sized samples of *R. celebensis* from midstream and near shore locations in the Tumpah River of northern Celebes. The specimens were later sexed in the lab, and the results were striking; males comprised 97.0 percent of the midstream sample but only 22.6 percent of the near shore sample. Although this analysis was based on only two unreplicated samples, we feel confident that a set of replicates would produce similar, statistically significant results.

Observations on males of *R. celebensis* swimming in midstream on the Tumpah River showed that they would hold station at a single spot by swimming upstream against the current. If a likely food item or a potential mate appeared they would cease rowing to inspect it, thus being carried backward, but after a brief examination they would usually break away and swim back upstream to approximately the same position they formerly occupied. Individuals appeared to be rather uniformly distributed across the stream surface, but it was difficult to ascertain if each had a clearly defined foraging territory. If a receptive female was encountered by a male the pair would tumble for several moments until the male was able to climb on top of the female, then the two would take up station at the point where they had drifted to and once again maintain station against the flow.

We assume that *Rhagovelia* species experience more intense competitive interactions with congeners than with other aquatic Hemiptera species, and that this may account for the patterns of habitat partitioning noted above. The streams of Southeast Asia, however, support a very diverse array of Gerridae and Veliidae that could also compete with *Rhagovelia* for food resources. Such competitive interactions are also likely to vary in intensity on an annual basis in many areas, since the monsoon climate typical of the Malay Archipelago causes great annual variations in stream flow, and during the dry season large numbers of aquatic insects are concentrated along the permanently flowing watercourses. This pattern was especially evident in southern Celebes, which experiences a pronounced dry season from July to November. Incredible numbers of *Rhagovelia pruinosa* and *R. sulawesiana* were found on spring fed pools at the Pattunuang River in this region, in company with equally huge populations of the gerrids *Ptilomera laelaps* Breddin and *Cylindrostethus persephone* Kirkaldy, and various species of *Tenagogonus* (Gerridae), *Limnogonus* (Gerridae), *Ventidius* (Gerridae), *Hydrometra* (Hydrometridae), and *Microvelia* (Veliidae). The surface of this stream was quite literally black with water striders of various kinds, and it is difficult to imagine how all of the individuals present could find sufficient food. Certainly a more intensive study of this system could shed light on the importance of competitive interactions in structuring tropical stream surface communities.

Additional notes on habitat preferences and behavior may be found under the discussions of individual species.

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Both authors contributed substantially to all aspects of this report and most tasks were shared, however the taxonomic descriptions were largely prepared by the first author, and the zoogeographical analysis was mostly prepared by the second author. The illustrations were prepared by the second author, and any errors in their rendition are his responsibility alone.

Key to the *Rhagovelia* of Borneo, Celebes and the Moluccas

(This key is for apterous specimens. Macropterous specimens should be identified to group, then compared to key characters for species within that group. Lengths are for apterous specimens; macropterous specimens are longer)

1. Length of pronotum subequal to or shorter than length of an eye, mesonotum exposed (fig. 7) 2
1'. Length of pronotum longer than the length of an eye, covering part or all of mesonotum (figs. 28, 43) 12
2(1). Middle coxae black 3
2'. Middle coxae mostly or entirely light colored. 5
3(2). First antennal segment entirely black. Male seventh abdominal venter unmodified, without callosities or hair tufts (Sabah) (fig. 57) .. .. *incognita* n. sp. (p. 179)
3'. First antennal segment light basally. Male seventh abdominal venter modified, with hair tufts, callosities or ridges laterally, or large callosities near midline (figs. 71, 86) 4
4(3'). Eye length equal to or slightly shorter than length of pronotum (7 or 8:8). Male seventh abdominal venter not strongly modified, with slight callosities laterally, but not large callosities near midline (figs. 69, 71) (Sabah) .... *ranau* n. sp. (p. 180)
4'. Eye length clearly greater than length of pronotum (10:8). Male seventh abdominal venter strongly modified, with two (1+1) large callosities, one on either side near midline (fig. 86) (Sabah) ..... *melanopsis* n. sp. (p. 181)
5(2'). Larger species, at least 3 mm long; pronotum approximately 1/2 as long as mesonotum; male seventh sternite modified, with hair tufts, callosities or ridges near midline or laterally (figs. 71, 95, 97) 6
5'. Smaller species, clearly less than 3 mm long; pronotum approximately 1/3 as long as mesonotum; male seventh sternite not modified, except *tawau* which has tufts (1+1) of fine setae laterally each set on a low ridge (fig. 18) ... 8
6(5). Middle coxae mostly light colored; middle trochanters completely dark; basal 1/3 of first antennal segment light colored; male seventh abdominal venter with low longitudinal ridge on each side of median depressed area (fig. 66) (Sabah, Mt. Kinabalu) .... *simulata* n. sp. (p. 182)
6'. Middle coxae completely light colored; middle trochanters usually mostly light colored, never completely dark; basal 1/3 or (usually) more of first antennal segment light colored; male seventh abdominal venter with small callosities set within hair tufts laterally (fig. 103), or with two (1+1) large callosities near midline (fig. 97) 7
7(6'). Proepisternum without evident tiny black denticles, or with only a few laterally. Basal 1/3 to 1/2 of first antennal segment light, the light/dark transition sharp. Male seventh abdominal venter with two (1+1) large callosities near midline (Sabah, Mt. Kinabalu) .... *borneensis* n. sp. (p. 183)
7'. Proepisternum with tiny black denticles thickly scattered over entire surface, including medially between coxal cavities. Basal 2/3 (rarely 1/2) or more of first antennal segment light, the light/dark transition not sharp but diffuse. Male seventh abdominal venter with small callosities set within hair tufts laterally (Sabah; Mt. Kinabalu) ..... *silau* n. sp. (p. 184)
8(5'). Juga broad, presenting a more or less flat ventral surface, touching antennal tubercles laterally (fig. 117). Coxae set with tiny black denticles (visible at 40x), especially noticeable on posterior distal part of middle coxae 9
8'. Juga narrower, not presenting a flat ventral surface, not touching antennal tubercles laterally (fig. 109). Coxae without tiny black denticles 10
9(8). Male hind trochanter armed with several small black teeth; hind femur with 8 or 9 small basal teeth, and one large spine before middle followed by about 10 smaller teeth distally (fig. 127). Female hind femur with 3 small basal teeth, and 1 large spine before middle followed by 7 or 8 much smaller teeth decreasing in size distally (fig. 126) (Sarawak) .... *tebakang* n. sp. (p. 186)

9'. Male hind trochanter unarmed; hind femur unarmed basally or with 1 to 4 basal teeth before middle, and one large curved spine beyond middle followed by 7 or 8 smaller teeth distally (fig. 121). Female hind femur with 3 basal teeth increasing in size toward middle, and 1 curved spine past middle followed by 4 or 5 smaller teeth distally (fig. 120) (Sarawak; East Kalimantan) ... *samarinda* n. sp. (p. 186)

10(8'). Male abdominal sternite VII weakly carinate distally, with tufts of fine setae laterally, far removed from midline; hind femur with 9-10 small basal teeth, one long spine at middle and about 6 smaller teeth distally (fig. 20). Female with a posteriorly directed tuft of setae on inner side of connexiva along tergite VII; hind femur with a long spine at middle followed by 6 or 7 smaller teeth distally (fig. 21) .... *tawau* n. sp. (p. 187)

10'. Male abdominal sternite VII either strongly carinate or not carinate, without tufts of fine setae laterally; hind femur has as many as 12 small basal teeth, but with only 2-4 small distal teeth beyond median spine. Female may have posteriorly directed setae on connexiva, but without a posteriorly directed tuft of setae on inner side of connexiva along tergite VII; hind femur with a median spine plus at most 3 smaller teeth distally 11

11(10'). Male abdominal sternite VII longitudinally carinate medially; hind femur with 2 to 4 small basal teeth, and 1 larger curved spine beyond middle followed by 3 to 6 smaller teeth distally (fig. 113). Female connexiva not thickened or setose along margin; hind femur unarmed or with 1 or 2 teeth beyond distal 2/3 (fig. 114) (Sarawak; Malaya) ... *sondaica* n. sp. (p. 188)

11'. Male abdominal sternite VII not carinate; hind femur with 10-12 small basal teeth, and 1 moderate length spine at middle followed by 2 to 4 smaller teeth distally (fig. 133). Female connexiva thickened along margin, set with short stiff posteriorly directed setae; hind femur unarmed or with 1 to 3 teeth beyond middle (fig. 132) (Sarawak) ... *sarawakensis* n. sp. (p. 190)

12(1'). Pronotum covering only about 1/2 of mesonotum (fig. 28) 13

12'. Pronotum covering most or all of mesonotum (fig 43) 15

13(12). Ground color orange brown; female mid-femur not dorsoventrally flattened (Bacan) .. .. *sabela* n. sp. (p. 191)

13'. Ground color black; female mid-femur dorsoventrally flattened 14

14(13'). Male hind femur basally with about 23-30 tiny black teeth in a closely packed row (fig. 35). Female seventh abdominal tergite shining medially; connexiva glabrous (hair free) and flattened dorsally along tergite IV only (North Moluccas) ..... *bacanensis* n. sp. (p. 192)

14'. Male hind femur basally with about 10 tiny black teeth in a sparsely set row (fig. 42). Female seventh abdominal tergite not shining medially; connexiva glabrous (hair free) and flattened dorsally along tergites IV & V (Obi) ..... *obi* n. sp. (p. 193)

15(12'). Anterior transverse light-colored pronotal stripe short, not extending laterally beyond eye margins 16

15'. Anterior transverse light-colored pronotal stripe long, extending laterally beyond eye margins and onto propleura 21

16(15). Male with abdominal sternite VII (sixth visible ventrally) not longitudinally carinate (fig. 140). Female with both middle and hind femur dorsoventrally flattened, hind femur curved (fig. 139) (Celebes) ..... *hamdjahi* n. sp. (p. 194)

16'. Male with abdominal sternite VII longitudinally carinate (fig. 148). Female with at most middle femur dorsoventrally flattened, hind femur not curved 17

17(16'). Female connexiva margined with yellowish brown and set with long setae (longer than width of hind tibia) along entire length (fig. 44); male unknown (Celebes) . *unica* n. sp. (p. 195)

17'. Female connexiva not margined with yellowish brown or set with long setae along entire length (*pruinosa* has long setae on connexiva along distal part of tergite V and along tergites VI-VIII) 18

18(17'). Male abdominal sternite VII with a sharply pointed tuft of stiff setae arising at basal 1/3 of longitudinal median carina (fig. 155). Female with dorsal surface of abdominal tergite VIII continuing on same plane as tergite VII (fig. 150) (Celebes) .....*pruinosa* n. sp. (p. 195)

18'. Male abdominal sternite VII without a sharply pointed tuft of stiff setae arising at basal 1/3 of longitudinal median carina. Female with abdominal tergite VIII distinctly directed ventrad (fig. 164) 19

19(18'). Male hind femur incrassate, usually twice or more the diameter of the middle femur (fig.

167). Female with connexiva produced posteriorly into semi-triangular plates, meeting over tergite VII (fig. 166) (Ambon) ..... *ambonensis* Lundblad (p. 197)

19'. Male with hind femur not incrassate, diameter not more than 1.5 x that of middle femur (figs. 160, 185). Female connexiva not produced posteriorly into semi-triangular plates, not meeting over tergite VII (figs. 180, 183) 20

20(19'). Male abdominal tergite VII long and narrow (length: basal width, 18:10) (fig. 158); sternite VI not modified (fig. 161). Female abdominal tergite VII with a posteriorly directed finger-like process (fig. 159) (Celebes) ..... *sulawesiana* n. sp. (p. 198)

20'. Male abdominal tergite VII more quadrate (length: basal width, 15:13) (fig. 179); sternite VI depressed on each side of midline. Female abdominal tergite VII not modified (fig. 180) (Celebes) ..... *celebensis* n. sp. (p. 199)

21(15'). Abdominal tergites I-V with distinct bright silver- gray pruinose areas laterally 22

21'. Abdominal tergites I-V without distinct bright silver-gray pruinose areas laterally 23

22(21). Ground color yellow-brown to brown; proepisternum with a broad field of tiny black denticles; female mid femur not distinctly flattened dorsally (Sabah) .... *samardaca* n. sp. (p. 200)

22'. Ground color orange brown to brownish black; proepisternum without black denticles, or with very few in a narrow field adjacent to head at antennal sockets; female mid femur distinctly flattened dorsally (East Kalimantan) ..... *christenseni* n. sp. (p. 201)

23(21'). Male first genital segment (abdominal segment VIII) produced postero-ventrally (fig. 176). Female connexiva distally rounded, not produced or angulate (fig. 177) (Ambon) ..... *meikdelyi* n. sp. (p. 202)

23'. Male first genital segment unmodified (fig. 191). Female connexiva distally produced or angulate (fig. 190) 24

24(23'). Body mostly covered with tiny black denticles, very evident on upper part of thoracic pleura 25

24'. Body with tiny black denticles ventrally, at least on proepisternum, but not covering most of body, not on upper part of thoracic pleura 26

25(24). Male with postero-ventrally directed tufts of long stiff setae on abdominal sternites V-VI (fig. 191); posterior trochanters each with 3-5 stout teeth. Female connexiva distally forming an obtuse angle, not touching over tergite VII (figs. 188, 190) (Celebes) ..... *wallacei* n. sp. (p. 203)

25'. Male without postero-ventrally directed tufts of long stiff setae on abdominal sternites V-VI, with only normal pubescence (fig. 221); posterior trochanters each with 2-3 stout teeth. Female connexiva distally produced as an acute plate-like projection, touching over tergite VII (figs. 217, 220) (Celebes) ..... *minahasa* n. sp. (p. 205)

26(24'). Male hind femur greatly incrassate, usually 2.5 to 3 times or more the diameter of the middle femur; ventrally with numerous stout teeth scattered over entire surface (fig. 80). Female with connexiva straight, not sinuate, without glabrous areas dorsally and with abdominal tergites VIII-IX on same plane as tergite VII (figs. 75, 77) (Sabah) ..... *kawakamii* (Matsumura) (p. 206)

26'. Male hind femur incrassate, about twice or less the diameter of the middle femur; ventrally armed with a single row of small teeth basally, followed by at most two more or less regular rows of stout teeth on distal half (fig. 192). Female with connexiva touching distally, sinuate medially, with narrow glabrous areas dorsally along tergites IV-V (fig. 209); or connexiva straight, not sinuate, without glabrous areas dorsally and abdominal tergites VIII-IX directed ventrad and recessed into tergite VII (figs. 188, 190) 27

27(26'). Male with postero-ventrally directed tufts of long stiff setae on abdominal sternites V-VI (fig. 191). Female connexiva straight, not sinuate, without glabrous areas dorsally, distally forming an obtuse angle, not touching over tergite VII (figs. 188, 190) (Celebes) ..... *wallacei* n. sp. (p. 203)

27'. Male without postero-ventrally directed tufts of long stiff setae on abdominal sternites V-VI, with only normal pubescence (fig. 213). Female with connexiva touching distally, sinuate medially, with narrow glabrous areas dorsally along tergites IV-V 28

28(27'). Male hind femur beneath with a basal row of about 30 tiny dark teeth extending to large median tooth; distally with a row of 7-9 stout teeth, and a second parallel row of 7-9 stout teeth (fig. 211). Female connexiva distally form-

ing an acute triangle, not strongly produced (figs. 209, 212); middle and hind femora not dorsoventrally flattened (Celebes) .... *grayi* n. sp. (p. 207)

28'. Male hind femur beneath with a basal row of about 16- 22 tiny dark teeth not reaching large median tooth; distally with a row of 8-10 stout teeth, and at most a second parallel row of 1-3 stout teeth (fig. 145). Female connexiva distally strongly produced into an acuminate plate-like structure (figs. 142, 144); middle and hind femora dorsoventrally flattened (Celebes) ... . *lorelinduana* n. sp. (p. 208)

Species Descriptions

In the species descriptions that follow, all measurements are given in mm. The mean length and width for each known sex and morph are given in millimeters, where s = standard deviation and N = the number of specimens measured; where N=1 we have still used this format for the sake of uniformity, recognizing that the mean is the same as the measurement. The leg segment ratios are given only for the apterous male if one was available. The figure numbers pertaining to each taxa are given under the species heading and not referenced in the description unless a structure is described or understood primarily by use of a figure. The institutional abbreviations given under material examined refer to the origin of the material; if there is sufficient material, paratypes will be distributed to other organizations as well, as stated in the Acknowledgments section.

Rhagovelia incognita, new species Figures 54-60

Description. Apterous male. Ground color black, with a grayish cast over most of the dorsum; abdominal tergites not shining; anterior transverse band on pronotum orange brown, narrow, extending only along vertex of head between eyes. Venter dull gray, including coxal cavities. Legs and antennae black, except anterior and posterior coxae and trochanters luteous. Pronotum short, equal to the length of an eye, mesonotum broadly exposed; length:width, 0.20: 0.83. Length of mesonotum on midline, 0.58; length of metanotum on midline, 0.10. Abdominal tergites I-VI subequal in length (0.13-0.15), tergite VII longer (0.30).

Proepisternum without evident black denticles. Dorsum clothed with fine silvery pubescence and many long black erect setae. Venter clothed with short to moderately long golden pubescence. Legs and antennae clothed with stiff black setae, rarely exceeding diameter of leg where they arise, longer on antennae. Posterior trochanter armed with 4 or 5 tiny black teeth. Posterior femur armed with about 8 basal teeth (difficult to see in the dense pubescence) reaching long spine near middle, which is followed by about 9 shorter spines of decreasing length distally. Posterior tibia beneath armed with numerous black teeth along entire length. Downcurving arolia of hind tarsi slender, flattened, narrowing distally.

Antennal formula I: II: III: IV; 0.70: 0.35: 0.38: 0.40.

Proportions of Legs

	femur	tibia	tarsal 1	tarsal 2	tarsal 3
Anterior	0.80	0.83	0.03	0.23	-
Middle	1.23	0.98	0.05	0.40	0.65
Posterior	1.05	0.98	0.03	0.03	0.28

Abdominal sternite VII shining medially, not modified; sternite VIII weakly carinate on midline. Parameres symmetrical, shape as shown in figure 56.

Length: mean = 2.59 mm s = 0.06 N = 10.
Width: mean = 1.11 mm s = 0.04 N = 10.

Macropterous male. Coloration and most other characteristics as in apterous form. Long dorsal setae on pronotum absent on disc. Pronotum prolonged to cover wing bases, narrowly rounded posteriorly; humeri prominent. Wings dark smoky gray, extending beyond tip of abdomen, with two closed cells on basal half; abdominal carinae extending to posterior margin of tergite III.

Length: mean = 2.93 mm s = 0 N = 1.
Width: mean = 1.16 mm s = 0 N = 1.

Apterous female. Coloration and general structure similar to male but dorsum much less hirsute; abdominal tergites not shining. Connexiva raised but not vertical or reflexed; distally truncate.

Proepisternum without black denticles. Posterior trochanter unarmed or armed with 1 small tooth. Posterior femur armed at middle with a long spine, followed by a row of 7 smaller spines decreasing in length distally. Posterior tibia basally with a row of small black pegs along entire length. Abdomen distally truncate (fig.55). Tergite VIII on same plane as VII; proctiger projecting posteriorly

Length: mean = 2.83 mm s = 0.05 N = 10.
Width: mean = 1.27 mm s = 0.05 N = 10.

Macropterous female. Coloration and most other characteristics as in apterous form. Long dorsal setae on pronotum absent on disc. Pronotum prolonged to cover wing bases, narrowly rounded posteriorly; humeri prominent. Wings dark smoky gray, extending

beyond tip of abdomen, with two closed cells on basal half. Connexiva and abdominal tergites as in apterous form.

Length:	mean = 3.03 mm	s = 0	N = 1.	
Length:	mean = 2.93 mm	s = 0	N = 1 (dealated).	
Width:	mean = 1.29 mm	s = 0.04	N = 2.	

Material examined. Holotype, apterous male, and allotype, apterous female: EAST MALAYSIA, Borneo, **Sabah**, Tempasuk River, 27 km. S. of Kota Belud, CL 2029, VIII-4- 1985, J. T. & D. A. Polhemus (USNM).

Paratypes as follows: EAST MALAYSIA, Borneo, **Sabah**: 11 apterous males, 14 apterous females, 1 macropterous male, 2 macropterous females, same data as holotype; 14 apterous males, 21 apterous females, 1 macropterous female, Samalang River, 7 km. S. of Ranau, CL 2026, VIII-3-1985, J. T. & D. A. Polhemus; 1 apterous female, Liwagu River at Ranau, 335 m. (1100 ft.), CL 2025, VIII-2-1985, J. T. & D. A. Polhemus (all JTPC). Also paratypes: 11 apterous males, 15 apterous females, Poring Hot Springs, X-8 to X-11-58, L. W. Quate. EAST MALAYSIA, Borneo, **Sarawak**: 2 apterous males, 5 apterous females, Kapit District, Merirai Valley, 300 m. (985 ft.), VIII-1 to VIII-6-58, T. C. Maa; 11 apterous males, 25 apterous females, Sadong, Kampong Tapuh, 300-450 m. (985-1475 ft.), VII-10-58, T. C. Maa (all BPBM).

Discussion. This species, known from the mountains of western Borneo, belongs to the *R. borneensis* group (see discussion under *borneensis*). The entirely black middle coxae and trochanters ally this species with *R. ranau* and *R. melanopsis*. *R. incognita* can immediately be separated from all other members of the group by the entirely black first antennal segments and unmodified male abdominal sternite VII. The species name *incognita* (L.) means unknown.

Rhagovelia ranau, new species Figures 68-73

Description. Apterous male. Ground color black, abdominal tergites not shining; anterior transverse band on pronotum orange brown, extending only along vertex of head between eyes. Venter dull gray; coxal cavities, mesosternum medially marked with brownish. Legs and antennae black to black brown, except basal 1/4 of first antennal segment, anterior and posterior coxae and trochanters, luteous. Pronotum short, slightly shorter than the length of an eye, mesonotum broadly exposed; length:width, 0.18: 0.83. Length of mesonotum on midline, 0.53; length of metanotum on midline, 0.8. Abdominal tergites I-VI subequal in length (0.13-0.15), tergite VII longer (0.28).

Proepisternum with scattered black denticles. Dorsum clothed with short silvery pubescence and longer black erect setae. Venter clothed with short to moderate length golden pubescence. Legs and antennae clothed with stiff black setae, rarely exceeding diameter of leg where they arise, longer on antennae and fore legs. Posterior trochanter armed with 4 to 6 small black teeth. Posterior femur armed with about 7 or 8 basal teeth reaching to long spine before middle, which is followed by 6 or 7 shorter spines of decreasing length distally. Posterior tibia beneath armed with numerous black teeth. Downcurving arolia of hind tarsi slender, flattened, narrow distally.

Antennal formula I: II: III: IV; 0.68: 0.30: 0.38: 0.43.

Proportions of Legs

	femur	tibia	tarsal 1	tarsal 2	tarsal 3
Anterior	0.75	0.80	0.03	0.20	-
Middle	1.20	0.95	0.05	0.38	0.63
Posterior	0.95	1.00	0.03	0.05	0.20

Abdominal sternite VII with a small low tumescence on each side, far from midline, set with short stiff posteriorly directed setae; sternite VIII not modified. Parameres symmetrical, shape as shown in figure 68.

Length:	mean = 2.54 mm	s = 0.11	N = 10.
Width:	mean = 1.07 mm	s = 0.04	N = 10.

Macropterous male. Coloration and most other characteristics as in apterous form. Long dorsal setae on pronotum absent on disc except along posterior margin. Pronotum prolonged to cover wing bases, narrowly rounded posteriorly; humeri prominent. Wings deep smoky gray, lighter basally, extending beyond tip of abdomen, with 2 closed cells on basal half; veins basally set with moderate length curved setae.

Length:	mean = 3.01 mm	s = 0.19	N = 10.
Width:	mean = 1.18 mm	s = 0.07	N = 10.

Apterous female. Coloration and general structure similar to male, but less hirsute; abdominal tergites not shining, V-VIII without long setae. Connexiva increasingly upturned posteriorly, but not vertical or reflexed; distally with a posteriorly directed tuft of stiff black setae.

Proepisternum with scattered black denticles. Posterior femur armed before middle with a long spine, followed by a row of 5 to 7 smaller spines decreasing in length distally. Posterior tibia with a row of small black pegs along entire length. Abdomen distally truncate (fig. 70). Tergite VIII on same plane as VII; proctiger projecting posteriorly

Length: mean = 2.91 mm s = 0.09 N = 10.
Width: mean = 1.16 mm s = 0.03 N = 10.

Macropterous female. Coloration and most other characteristics as in apterous form. Pronotum and wings as in macropterous male. Connexiva and abdominal tergites as in apterous female.

Length: mean = 3.15 mm s = 0.04 N = 10.
Width: mean = 1.19 mm s = 0.04 N = 10.

Material examined. Holotype, apterous male, and allotype, apterous female: EAST MALAYSIA, Borneo, **Sabah**: Samalang River, 7 km S. of Ranau, CL 2026, VIII-3-1985, J. T. & D. A. Polhemus (USNM).

Paratypes as follows (all in JTPC unless otherwise noted): EAST MALAYSIA, Borneo, **Sabah**: 35 apterous males, 43 apterous females, 2 macropterous males, same data as holotype; 3 apterous males, 3 macropterous males (dealated), 1 apterous female, 3 macropterous females (dealated), Langanan River at Poring Hot Springs, 550 m. (1800 ft.), CL 2022, VIII-2-1985, J. T. & D. A. Polhemus; 4 apterous males, 1 macropterous male (dealated), 8 apterous females, 2 macropterous females (dealated), stream 1 km. S. of Poring Hot Springs, CL 2023, VIII-2-1985, J. T. & D. A. Polhemus; 9 apterous males, 1 macropterous male (dealated), 4 apterous females, Liwagu River at Ranau, 335 m. (1100 ft.), CL 2025, VIII-2-1985, J. T. & D. A. Polhemus; 4 apterous males, 4 apterous females, 2 macropterous females, Nukakatan River, 26 km. S. of Ranau, CL 2028, VIII-3-1985, J. T. & D. A. Polhemus; 38 apterous males, 26 apterous females, 2 macropterous males, 6 macropterous females, Moyog River nr. km. 18 on Keningau Hwy., CL 2038, VIII-6-1985, J. T. & D. A. Polhemus; 1 apterous female, trib. to Moyog River nr. km. 12 on Keningau Hwy., CL 2039, VIII- 6-1985, J. T. & D. A. Polhemus (all JTPC); 5 apterous males, 4 macropterous males, 3 apterous females, 4 macropterous females, 10 km. SW of Tambunan, IX-2-1983, G. F. Hevel & W. E. Steiner (JTPC, USNM); 1 macropterous male, 2 apterous females, 1 macropterous female, Paginatan, VIII-18-1983, G. F. Hevel & W. E. Steiner (USNM); 2 apterous males, 1 apterous female, 3 immatures, Tambunan, I-7-59, T. C. Maa (BPBM); 13 apterous males, 9 apterous females, 7 macropterous males, 11 macropterous females, Poring Hot Springs, X-8-1958, L. W. Quate, T. C. Maa (BPBM).

Discussion. This species, which belongs to the *borneensis* group, is very similar to *R. incognita* (see key). The primary differences lie in the coloration of the antennae and the slight modification of the male sternite VII in *ranau*. In dorsal view the two species appear quite similar (see figs. 54, 55), however the female of *ranau* is slightly narrower. The species name is derived from the place of origin, near the town of Ranau in Sabah, north Borneo.

The Samalang River at the type locality is a broad, rocky, unshaded stream flowing through steep hills and surrounded by disturbed primary and secondary rain forest. *R. ranau* was found here in sheltered spots near the edges of the stream.

Rhagovelia melanopsis, new species
Figures 81-88

Description. Apterous male. Ground color velvety black, abdominal tergites not shining; anterior transverse band on pronotum orange brown, narrow, extending only along vertex of head between eyes. Venter dull gray; coxal cavities narrowly brown on margins. Legs and antennae black, except basal 1/4 to 1/3 of first antennal segment, anterior and posterior coxae and trochanters, luteous. Pronotum short, equal to the length of an eye, mesonotum broadly exposed; length: width, 0.25: 0.93. Length of mesonotum on midline, 0.58; length of metanotum on midline, 0.08. Abdominal tergites I-VI subequal in length (0.10-0.13), tergite VII longer (0.33).

Proepisternum with a few tiny black denticles. Dorsum clothed with short silvery pubescence and longer black erect setae. Venter clothed with short to moderate length golden pubescence. Legs and antennae clothed with stiff black setae, rarely exceeding diameter of leg where they arise, longer on antennae. Posterior trochanter armed with 6 or 7 small black teeth. Posterior femur armed with about 11 basal teeth reaching long spine before middle, which is followed by about 8 shorter spines of decreasing length distally. Posterior tibia beneath armed with numerous black teeth. Downcurving arolia of hind tarsi slender, flattened and dilate distally.

Antennal formula I: II: III: IV; 0.75: 0.35: 0.45: 0.50.

Proportions of Legs

	femur	tibia	tarsal 1	tarsal 2	tarsal 3
Anterior	0.85	0.88	0.05	0.25	-
Middle	1.40	1.08	0.05	0.45	0.65
Posterior	1.13	1.10	0.05	0.05	0.25

Abdominal sternite VII with a large tumescence on each side of midline set with stiff posteriorly directed setae, similar in morphology to that of *R. borneensis* (see fig. 86); sternite VIII depressed beneath basally, directed slightly ventrad. Parameres symmetrical, shape as shown in figure 83.

Length:	mean = 2.82 mm	s = 0.03	N = 4
Width:	mean = 1.19 mm	s = 0.03	N = 4

Macropterous male. Unknown.

Apterous female. Coloration, general structure and hairiness similar to male; abdominal tergites not shining, VI and VII almost naked. Connexiva increasingly upturned posteriorly, vertical or slightly reflexed over tergites VII-VIII; distally with a posteriorly directed tuft of stiff black setae.

Proepisternum with a few black denticles. Posterior femur armed before middle with one long spine, followed by a row of 8 smaller spines decreasing in length distally. Posterior tibia with a row of small black pegs along entire length. Abdomen distally truncate (fig. 82). Tergite VIII on same plane as VII; proctiger projecting posteriorly

Length:	mean = 3.09 mm	s = 0.06	N = 6
Width:	mean = 1.31 mm	s = 0.03	N = 6

Macropterous female. Unknown

Material examined. Holotype, apterous male, and allotype, apterous female: EAST MALAYSIA, Borneo, **Sabah**: Liwagu River at Ranau, 335 m. (1100 ft.), CL 2025, VIII-2-1985, J. T. & D. A. Polhemus (USNM).

Paratypes as follows (all apterous unless otherwise noted): EAST MALAYSIA, Borneo, **Sabah**: 1 male, 1 female, Langanan River at Poring Hot Springs, 550 m. (1804 ft.), CL 2022, VIII-2-1985, J. T. & D. A. Polhemus (JTPC); 1 male, 2 females, stream 1 km. S. of Poring Hot Springs, 535 m. (1755 ft.), CL 2023, VIII-2-1985, J. T. & D. A. Polhemus (JTPC); 1 male, 2 females, Mamut River, Kinabalu Nat. Park, Poring Hot Springs Station, VIII-12-1972, W. M. Beck, Jr. (JTPC); 12 apterous males, 18 apterous females, 3 macropterous males, 5 macropterous females, British North Borneo, W. Coast Residency, Ranau, 8 km. N. Poring Hot Springs, 500 m., X-8 to X-11-58, T. C. Maa (BPBM).

Discussion. This species, known only from the slopes of Mt. Kinabalu, is very similar to *R. borneensis*, the primary difference being in the coloration of the middle coxae and trochanters (see key and discussion under *borneensis*). The species name *melanopsis* (Gr.) refers to the black appearance.

Rhagovelia simulata, new species
Figures 61-67

Description. Apterous male. Ground color black, abdominal tergites not shining; anterior transverse band on pronotum yellowish to orange brown, extending only along vertex of head between eyes. Venter dull gray including coxal cavities. Legs and antennae black to black brown, except basal 1/3 of first antennal segment, anterior and posterior coxae and trochanters, part of middle coxae, basal 1/3 of fore femur, extreme base of hind femur, luteous to yellow brown. Pronotum short, slightly shorter than the length of an eye, mesonotum broadly exposed; length:width, 0.25: 0.90. Length of mesonotum on midline, 0.53; length of metanotum on midline, 0.10. Abdominal tergites I-VI subequal in length (0.15-0.18), tergite VII longer (0.33).

Entire prosternum with many black denticles Dorsum clothed with short silvery pubescence and many longer black erect setae. Venter clothed with short to moderate length golden pubescence. Legs and antennae clothed with stiff black setae, rarely exceeding diameter of leg where they arise, some longer on antennae. Posterior trochanter armed with about 4 small black teeth. Posterior femur armed with 10 to 13 basal teeth reaching to long spine at middle, which is followed by about 9 shorter spines of decreasing length distally. Posterior tibia beneath armed with numerous black teeth along entire length. Downcurving arolia of hind tarsi slender, flattened, narrow distally.

Antennal formula I: II: III: IV; 0.73: 0.35: 0.48: 0.45.

Proportions of Legs

	femur	tibia	tarsal 1	tarsal 2	tarsal 3
Anterior	0.85	0.88	0.03	0.23	-
Middle	1.38	1.05	0.05	0.33	0.63
Posterior	1.13	1.08	0.03	0.05	0.28

Abdominal sternite VII with low ridges (1+1) laterally, each flanking an oblique longitudinal depression on either side of midline; each ridge set with stiff moderate length setae, forming a dense tuft in the same position as the tumescences of *R. ranau* but not as prominent (see fig. 66); sternite VIII not modified. Parameres symmetrical, shape as shown in figure 63.

Length:	mean = 2.91 mm	s = 0.05	N = 10
Width:	mean = 1.17 mm	s = 0.04	N = 10

Macropterous male. Coloration and most other characteristics as in apterous form. Long dorsal setae on pronotum absent on disc. Pronotum prolonged to cover wing bases, narrowly rounded posteriorly; humeri not prominent. Wings deep smoky gray brown, lighter basally, extending beyond tip of abdomen, with 1 or 2 closed cells on basal half; veins not prominent, basally set with moderate length curved setae.

Length:	mean = 3.54 mm	s = 0.07	N = 2
Width:	mean = 1.41 mm	s = 0	N = 2

Apterous female. Most coloration and general structure similar to male, but less hirsute; abdominal tergites not shining, pruinose gray laterally, without long setae, IV-VII almost bare. Connexiva sinuate, increasingly upturned posteriorly; incurved and with margins very narrowly flattened and glabrous along tergites V-VII; distally with a small posteriorly directed tuft of stiff black setae.

Proepisternum with black denticles as in male. Posterior femur basally with 0 to 3 teeth, then armed at middle with a long spine, followed by a row of about 8 smaller spines decreasing in length distally. Posterior tibia armed with a row of small black pegs along entire length. Abdomen distally truncate (fig. 62). Tergite VIII directed very slightly ventrad; proctiger projecting posteriorly

Length:	mean = 3.14 mm	s = 0.05	N = 10
Width:	mean = 1.26 mm	s = 0.02	N = 10

Macropterous female. Coloration and most other characteristics as in apterous form. Pronotum and wings as in macropterous male. Connexiva not as in apterous female, not sinuate, not flattened or glabrous on margin. Dealated specimen showing dorsal abdominal carinae extending to posterior margin of tergite IV.

Length:	mean = 3.61 mm	s = 0.11	N = 2
Width:	mean = 1.36 mm	s = 0	N = 2

Material examined: Holotype, apterous male, and allotype, apterous female: EAST MALAYSIA, Borneo, **Sabah**: stream 1 km. S. of Poring Hot Springs, CL 2023, VIII-2-1985, J. T. & D. A. Polhemus (USNM).

Paratypes as follows (all JTPC): EAST MALAYSIA, Borneo, **Sabah**: 35 apterous males, 39 apterous females, 2 macropterous males, 4 macropterous females (2 dealated), same data as holotype; 25 apterous males, 16 apterous females, Langanan River at Poring Hot Springs, 550 m. (1800 ft.), CL 2022, VIII-2-1985, J. T. & D. A. Polhemus; 1 macropterous male (dealated), 12 km. S. of Ranau, CL 2027, VIII-3-1985, J. T. & D. A. Polhemus; 1 apterous male, 1 apterous female, km. 60 on Keningau Hwy., CL 2036, VIII-6-1985, J. T. & D. A. Polhemus; 11 apterous males, 5 apterous females, Moyog River nr. km 12 on Keningau Hwy., CL 2038, VIII-6-1985, J. T. & D. A. Polhemus; 1 apterous male, Mamut River at Poring Hot Springs, 365 m. (1200 ft.), VIII-12-1972, W. M. Beck Jr.; 1 macropterous male, Samalang River, 7 km. S. of Ranau, CL 2026, VIII-3-85, J. T. and D. A. Polhemus.

Also paratypes from Poring Hot Springs; 4 apterous males, 3 apterous females, 1 macropterous male, IX-26-1969, K. Schon (ZMUC); 9 apterous males, 13 apterous females, 2 macropterous females, X-11-1958, T. C. Maa (BPBM)

Discussion: This species belongs to the *borneensis* group; in coloration and male abdominal structure it is close to *R. tawau*, but differs from the latter by the more hairy dorsum, larger size and longer pronotum. *R. simulata* is closest in appearance to *R. ranau* (see key), but has more basal teeth (10-13) on the posterior femur than *ranau* (7- 8), and the middle coxae are differently colored. The modifications of the seventh male sternites are very similar in *R. simulata*, *tawau*, *ranau* and *silau*; the lateral ridges of former two are similar in position to the tumescences seen on the male sternite VII in *R. ranau* and *R. silau* (see fig. 71), but not as well defined anteriorly as in the latter two species. The species name (from *similis*, L., like) refers to the great similarity with the other species of the group.

Rhagovelia borneensis, new species
Figures 89-98

Description. Apterous male. Ground color velvety black, abdominal tergites not shining; anterior transverse band on pronotum orange brown, narrow, extending only along vertex of head between eyes. Venter dull gray, including coxal cavities. Legs and antennae black, except basal half of first antennal segment, coxae, anterior and posterior trochanters, basal half of middle trochanter, basal half of anterior femur, narrow basal part of posterior femur, luteous. Pronotum short, equal to the length of an eye, mesonotum broadly exposed; length:width, 0.25: 0.98. Length of mesonotum on midline, 0.58; length of metanotum on midline, 0.08. Abdominal tergites I-VI subequal in length (0.13-0.18), tergite VII longer (0.43).

Proepisternum without evident black denticles. Dorsum clothed with short silvery pubescence and longer black erect setae. Venter clothed with short to moderate length golden pubescence; thoracic venter essentially bare. Legs and antennae clothed with stiff black setae, rarely exceeding diameter of leg where they arise, longer on antennae. Posterior trochanter armed with 9 or 10 small black teeth. Posterior femur armed with about 12 or 13 basal teeth not reaching long spine near middle, which is followed by 7 or 10 shorter spines of decreasing length distally. Posterior tibia beneath armed with numerous black teeth. Downcurving arolia of hind tarsi slender, flattened and dilate distally.

Antennal formula I: II: III: IV; 0.65: 0.40: 0.53: 0.53.

Proportions of Legs

	femur	tibia	tarsal 1	tarsal 2	tarsal 3
Anterior	0.88	0.93	0.05	0.23	-
Middle	1.40	1.15	0.05	0.50	0.60
Posterior	1.10	1.25	0.05	0.10	0.30

Abdominal sternite VII with a large tumescence on each side of midline set with stiff posteriorly directed setae; sternite VIII depressed beneath basally, directed slightly ventrad. Parameres symmetrical, shape as shown in figure 93.

Length: mean = 3.43 mm s = 0.07 N = 10
Width: mean = 1.33 mm s = 0.04 N = 10

Macropterous male. Coloration and most other characteristics as in apterous form. Long dorsal setae on pronotum absent on disc. Pronotum prolonged to cover wing bases, narrowly rounded posteriorly; humeri prominent. Wings broken off in both specimens; abdominal carinae extending onto base of tergite IV.

Length: mean = 3.43 mm s = 0.07 N = 2 (dealated).
Width: mean = 1.57 mm s = 0.07 N = 2

Apterous female. Coloration, general structure and hairiness similar to male; abdominal tergites not shining, VI and VII almost naked. Connexiva increasingly upturned posteriorly, vertical or slightly reflexed over tergites VII-VIII; distally with a posteriorly directed tuft of stiff black setae.

Proepisternum without black denticles. Posterior femur armed at middle with a moderate length (7) spine, followed by a row of 7 smaller spines decreasing in length distally. Posterior tibia basally with a row of small black pegs. Abdomen distally truncate (fig. 90). Tergite VIII on same plane as VII; proctiger projecting posteriorly.

Length: mean = 3.57 mm s = 0.06 N = 10
Width: mean = 1.46 mm s = 0.04 N = 10

Macropterous female. Unknown

Material examined. Holotype, apterous male and allotype, apterous female: EAST MALAYSIA, Borneo, **Sabah**: Mesilau River, 8 km. N. of Kundesan, 2100 m. (6900 ft.), CL 2020, VIII-1-1985, J. T. & D. A. Polhemus (USNM).

Paratypes as follows: EAST MALAYSIA, Borneo, **Sabah**: 10 apterous males, 2 macropterous males (dealated), 10 apterous females, same data as holotype (JTPC); 1 apterous female, Liwagu River at Liwagu Cave, SE of Headquarters (Kinabalu Nat. Park), 1525 m. (5000 ft.), VII-15-1972 (S7e), G. F. & C. H. Edmunds (JTPC); 2 apterous males, 2 apterous females, Silau Silau, Kinabalu, 1500 m. (4920 ft.), VIII-28-69, K. Schon (ZMUC).

Discussion. This species, along with *R. melanopsis*, *incognita*, *ranau*, *simulata*, *silau* and *tawau* form the *borneensis* group, characterized by the short pronotum (subequal to or shorter than the length of an eye, about 1/3 to 1/2 as long as mesonotum), robust body and size 2-1/2 to 3mm. long, the males have broad truncate parameres and usually have modifications on abdominal sternite VII (hair tufts, callosities), and in macropters each wing has 2 closed cells in the basal half. Species of the *sarawakensis* group are usually smaller, narrrower, and have a shorter pronotum (see key); the males of this group usually have narrow elongate male parameres, and in macropters each fore wing has 4 closed cells extending onto the distal half. *R. borneensis*, known only from the slopes of Mt. Kinabalu, is very similar to *R. melanopsis*; the primary difference is the coloration of the middle coxae and trochanters. In *borneensis* the tumescences of sternite VII are slightly larger, with slightly longer setae than in *melanopsis*. Also, compared to *borneensis*, *melanopsis* has a deeper transverse basal sulcus on the first genital segment (tergite VIII), the light portion of the first antennal segment is shorter (1/4 rather than 1/2), and it is slightly smaller and less robust. Winged females are particularly difficult to separate in species of this group; *borneensis* and *silau*, for instance, occur together and may be separated only by the presence of numerous tiny black denticles on the prosternum and lighter first antennal segment of the latter. The species name *borneensis* is derived from the island of origin, Borneo.

The Mesilau River at the type locality is a swift upland stream in a bed of granite boulders, heavily shaded by moss forest. Collections were made both above and below a water intake for a new golf course near Kundesan, and the insects appeared to be more abundant in the downstream section where the surrounding forest had been disturbed and sunlight was able to reach the water. In all cases the insects frequented sheltered spots along the banks and out of the main current, often in the lee of large rocks.

Rhagovelia silau, new species
Figures 99-105

Description. Apterous male. Ground color black, abdominal tergites not shining; anterior transverse band on pronotum orange brown, extending only along vertex of head between eyes. Venter dull gray including coxal cavities. Legs and antennae black to black brown, except basal 2/3 (rarely 1/2) or more of first antennal segment, all coxae, anterior and posterior trochanters, part of middle trochanter, extreme base of hind femur,

luteous. Pronotum short, slightly shorter than the length of an eye, mesonotum broadly exposed; length: width, 0.30: 1.05. Length of mesonotum on midline, 0.58; length of metanotum on midline, 0.10. Abdominal tergites I-VI subequal in length (0.15- 0.18), tergite VII longer (0.38).

Entire prosternum with many black denticles. Dorsum clothed with short silvery pubescence and many longer black erect setae. Venter clothed with short to moderate length golden pubescence. Legs, antennae clothed with stiff black setae, rarely exceeding diameter of leg where they arise, some longer on antennae. Posterior trochanter armed with 7 to 12 small black teeth. Posterior femur armed with 13 to 18 basal teeth reaching to long spine at middle, which is followed by about 8 shorter spines of decreasing length distally. Posterior tibia beneath armed with numerous black teeth along entire length. Downcurving arolia of hind tarsi slender, flattened, broadened distally.

Antennal formula I: II: III: IV; 0.83: 0.43: 0.53: 0.53.

Proportions of Legs

	femur	tibia	tarsal 1	tarsal 2	tarsal 3
Anterior	0.95	1.03	0.03	0.25	-
Middle	1.58	1.25	0.05	0.50	0.73
Posterior	1.30	1.30	0.05	0.05	0.30

Abdominal sternite VII with a distinct tumescence on each side of a slightly depressed median black rugose area, similar in position to those of *R. ranau* but more prominent (see fig. 103), each tumescence set with stiff moderate length setae and one longer setae; sternite VIII not modified. Parameres symmetrical, shape as shown in figure 101.

Length:	mean = 3.18 mm	s = 0.07	N = 10.
Width:	mean = 1.30 mm	s = 0.02	N = 10.

Macropterous male. Coloration and most other characteristics as in apterous form. Long dorsal setae on pronotum absent on disc. Pronotum prolonged to cover wing bases, narrowly rounded posteriorly; humeri not prominent. Wings deep smoky gray brown, lighter basally, extending beyond tip of abdomen, with 2 closed cells on basal half; veins basally set with moderate length curved setae.

Length:	mean = 4.04 mm	s = 0.11	N = 7.
Width:	mean = 1.54 mm	s = 0.05	N = 7.

Apterous female. Coloration and general structure similar to male, but less hirsute; abdominal tergites not shining, without long setae, IV-VII almost bare. Connexiva sinuate, increasingly upturned posteriorly; incurved and with margins narrowly flattened and glabrous along tergites V-VI; distally with a small posteriorly directed tuft of stiff black setae.

Proepisternum with black denticles as in male. Posterior femur armed at middle with a long spine, followed by a row of 5 to 7 smaller spines decreasing in length distally. Posterior tibia with a row of small black pegs on at least basal 1/2 plus a few distally. Abdomen distally truncate (fig. 100). Tergite VIII on same plane as VII; proctiger projecting posteriorly.

Length:	mean = 3.52 mm	s = 0.06	N = 10.
Width:	mean = 1.43 mm	s = 0.04	N = 10.

Macropterous female. Coloration and most other characteristics as in apterous form. Pronotum and wings as in macropterous male. Connexiva not as in apterous female, not sinuate, not flattened on margin. Dealated specimen showing dorsal abdominal carinae extending onto base of tergite IV.

Length:	mean = 3.98 mm	s = 0.08	N = 5.
Width:	mean = 1.58 mm	s = 0.04	N = 5.

Material examined. Holotype, apterous male, and allotype, apterous female: EAST MALAYSIA, Borneo, **Sabah**: small stream and watercress bogs, km. 62 on Keningau Hwy., CL 2035, VIII-6- 1985, J. T. & D. A. Polhemus (USNM).

Paratypes as follows (all JTPC): EAST MALAYSIA, Borneo, **Sabah**: 8 apterous males, 7 apterous females, 3 macropterous males, 5 macropterous females, same data as holotype; 2 apterous males, 3 macropterous males (dealated), 8 macropterous females (dealated), Mesilau River, 8 km. N. of Kundesan, CL 2020, 2100 m. (6890 ft.), VIII-1-1985, J. T. & D. A. Polhemus; 16 apterous males, 19 apterous females, 3 macropterous males, 3 macropterous females, Liwagu River at Kundesan, CL 2021, 900 m. (2950 ft.) VIII-1-1985, J. T. & D. A. Polhemus; 3 apterous males, 2 apterous females, km. 60 on Keningau Hwy., CL 2036, VIII-6-1985, J. T. & D. A. Polhemus; 2 apterous males, 1 apterous female, Silau Silau stream, 1585 m. (5200 ft.), VIII-11-1972, W. M. Beck, Jr.; 1 apterous male, Liwagu River at Liwagu Cave, SE of Headquarters, 1525 m. (5000 ft.), VIII-11-1972, G. F. & C. H. Edmunds. Also paratypes: 6 apterous males, 3 apterous females, Silau, 1500 m., K. Schon, VIII-28-1969 (ZMUC).

Discussion. This species, which belongs to the *borneensis* group, is closest to *R. simulata* (see key), but *R. silau* has more teeth on the posterior trochanter (7-12) than simulata (4). The tumescences are similar to those seen on the male sternite VII in *ranau*.(see figs. 69, 71, 103), but the latter has fewer basal teeth (7-8) on the posterior femur than *silau* (13- 18), and the middle coxae are differently colored. The modified connexiva of *silau* fe-

males are unique within the group. The species name, a noun in apposition, recognizes the place from which the species was first recognized, Silau, Sabah, Borneo.

Rhagovelia tebakang, new species Figures 122-127

Description. Apterous male. Ground color black; abdominal tergites black. Anterior transverse band on pronotum orange brown, extending laterally to inner eye margins. Venter black; coxal cavities very narrowly margined with testaceous. Legs and antennae black except basal third of antennal segment I, basal half of anterior femur, basal fifth of hind femur, all coxae and trochanters, leucine. Pronotum short, length much less than that of an eye; length:width, 0.15: 0.75. Length of mesonotum on midline, 0.50; length of metanotum on midline, 0.08. Abdominal tergites I-VI subequal in length (0.10-0.18), tergite VII longer (0.28).

Proepisternum with minute black denticles, difficult to see against dark background. Head with jugum broad in ventral view, touching antennal tubercles (see fig. 117). Dorsum clothed with very short recumbent setae and scattered longer setae. Venter clothed with short recumbent setae. Legs and antennae clothed with short golden setae and usual spines and scattered long setae. All coxae with scattered minute black denticles, most numerous on posterior side distally, most evident on middle coxae. Posterior trochanter unarmed or armed with 1 or 2 small black teeth. Posterior femur armed basally with 8 or 9 small teeth before middle increasing in size distally, and a large spine before middle followed by 10 smaller spines decreasing in size distally. Posterior tibia beneath armed along entire length with short stout teeth. Downcurving arolia of hind tarsi flattened dorsoventrally.

Antennal formula I: II: III: IV; 0.58: 0.30: 0.40: 0.38.

Proportions of Legs

	femur	tibia	tarsal 1	tarsal 2	tarsal 3
Anterior	0.73	0.70	0.03	0.18	-
Middle	1.25	0.93	0.05	0.38	0.55
Posterior	1.03	0.95	0.03	0.03	0.20

Abdominal sternite VII very weakly carinate on midline; sternite VIII depressed basally. Parameres symmetrical, shape as shown in figure 123.

Length:	mean = 2.63 mm	s = 0	N = 1.
Width:	mean = 0.91 mm	s = 0	N = 1.

Macropterous male. Coloration and most structural characteristics similar to apterous male. Wings deep smoky brownish black, veins prominent, extending past tip of abdomen; subcostal and medial veins basally set with moderate length setae; with three closed cells barely extending onto distal half. Wings spread, exposing dorsal abdominal carinae that extend to posterior margin of tergite III.

Length:	mean = 2.93 mm	s = 0	N = 1.
Width:	mean = 1.11 mm	s = 0	N = 1.

Apterous female. Coloration and hairiness similar to male. Connexiva slightly raised; not sinuate or hirsute. Proepisternum with minute black denticles. Posterior femur armed with 3 small basal teeth and one large spine before middle, followed by a row of 7 smaller teeth decreasing in length distally. Posterior tibia beneath armed along entire length with short stout teeth.

Abdomen not carinate; distally not modified; connexiva distally terminating in a short acute angle, not produced. Tergite VIII on same plane as VII; proctiger projecting posteriorly.

Length:	mean = 2.68 mm	s = 0	N = 1.
Width:	mean = 0.96 mm	s = 0	N = 1.

Macropterous female. Unknown

Material examined. Holotype, apterous male, and allotype, apterous female: EAST MALAYSIA, Borneo, **Sarawak**: 4 km. S. of Tebakang, CL 2044, VIII-9-1985, J. T. & D. A. Polhemus (JTPC).

Paratypes as follows: EAST MALAYSIA, Borneo, **Sarawak**: 1 macropterous male, same data as holotype; 1 apterous male, 1 apterous female, small stream, 8 km. S. of Tebakang, CL 2045, VIII-9-1985, J. T. & D. A. Polhemus (JTPC); 3 apterous females, Mt. Santubong, nr. Kuching, VI-18 to VI-30-58, T. C. Maa (BPBM).

Discussion. *Rhagovelia tebakang* may be separated from the other members of the *Rhagovelia sarawakensis* group by the characters given in the key; also see discussion under *Rhagovelia samarinda*. The habitus is quite similar to *R. samarinda*. The armed posterior trochanter of the male is unique within the group (however the winged male has only the right trochanter armed, with 1 tooth), and the broad jugum is shared only with *R. samarinda*. The name derives from the town of Tebakang, near which the type-series was collected.

Rhagovelia samarinda, new species Figures 115-121

Description. Apterous male. Ground color black; abdominal tergites black. Anterior transverse band on pronotum orange brown, extending laterally to inner eye margins. Venter black; coxal cavities very narrowly margined with testaceous. Legs and antennae black

except basal half of antennal segment I, basal 3/5 of anterior femur, basal third of hind femur, all coxae and trochanters, leucine. Pronotum short, length much less than that of an eye; length:width, 0.15: 0.70. Length of mesonotum on midline, 0.43; length of metanotum on midline, 0.08. Abdominal tergites I-VI subequal in length (0.13-0.15), tergite VII longer (0.25).

Proepisternum with minute black denticles, difficult to see against dark background. Head with jugum broad in ventral view, touching antennal tubercles (Fig. 117). Dorsum clothed with very short recumbent setae and scattered longer setae. Venter clothed with short recumbent setae. Legs and antennae clothed with short golden setae and usual spines and scattered long setae. All coxae with scattered minute black denticles, most numerous on posterior side distally, most evident on middle coxae. Posterior trochanter unarmed. Posterior femur armed basally with 1 small tooth before middle or without basal teeth; with a large spine beyond middle followed by 7 smaller spines decreasing in size distally. Posterior tibia beneath armed along entire length with short stout teeth. Downcurving arolia of hind tarsi flattened dorsoventrally.

Antennal formula I: II: III: IV; 0.48: 0.28: 0.38: 0.38.

Proportions of Legs

	femur	tibia	tarsal 1	tarsal 2	tarsal 3
Anterior	0.63	0.65	0.03	0.15	-
Middle	1.05	0.83	0.05	0.30	0.53
Posterior	0.83	0.80	0.03	0.03	0.20

Abdominal sternites II-VII carinate on midline; sternite VIII slightly depressed basally. Parameres symmetrical, shape as shown in figure 116.

Length:	mean = 2.42 mm	s = 0.09	N = 10.
Width:	mean = 0.81 mm	s = 0.03	N = 10.

Macropterous male. Unknown

Apterous female. Coloration and hairiness similar to male. Connexiva slightly raised; not sinuate or hirsute. Proepisternum with minute black denticles. All coxae with minute conical black setae as in male. Posterior femur armed with 1 to 3 basal teeth before middle, increasing in size distally, and beyond middle with a moderate length (0.13) spine, followed by a row of 4 or 5 smaller spines decreasing in length distally. Posterior tibia armed along entire length with a row of short stout black pegs.

Abdomen ventrally weakly carinate on midline; distally not modified; connexiva distally terminating in a short acute angle, not produced. Tergite VIII on same plane as VII; proctiger projecting posteriorly.

Length:	mean = 2.64 mm	s = 1.03	N = 10.
Width:	mean = 0.91 mm	s = 0.03	N = 10.

Macropterous female. Unknown

Material examined. Holotype, apterous male, and allotype, apterous female: INDONESIA: Borneo, **Kalimantan Timur Prov.**: waterfall and stream 11 km. NE of Samarinda, CL 2091, VIII-27- 1985, J. T. & D. A. Polhemus (USNM).

Paratypes as follows: (All Apterous): INDONESIA, Borneo, **Kalimantan Timur Prov.**: 29 males, 19 females, 2 nymphs, same data as holotype (JTPC). EAST MALAYSIA, Borneo, **Sarawak**: 14 males, 10 females, 7 km. N. of Tebakang, CL 2043, VIII-9-1985, J. T. & D. A. Polhemus (JTPC); 1 male, 1 female, 20 km. SE of Sematan, CL 2051, VIII-10-1985, J. T. & D. A. Polhemus (JTPC); 1 female, Kampong Pueh, Lundu Dist., VI-6 to VI-12-58, T. C. Maa (BPBM).

Also 1 macropterous female we have identified as this species from INDONESIA: Celebes, **Sulawesi Tengah Prov.**: stream 10 km. SE Kamarora, Lore Lindu National Park, CL 2156, X-8-85, 950 m., J. T. & D. A. Polhemus (JTPC).

Discussion. *Rhagovelia samarinda* belongs to the *Rhagovelia sarawakensis* group. This group is quite widespread; the other species known to occur on Borneo are *Rhagovelia sarawakensis* n. sp., *Rhagovelia tebakang* n. sp. and *Rhagovelia sondaica* n. sp. All are endemic to Borneo except the latter which has also been taken on the Malay Peninsula. *Rhagovelia samarinda* may be separated from the other members of the group by the characters given in the key. The habitus of *R. samarinda*, *R. tebakang* and *R. sondaica* are all quite similar, differing primarily in the shape and proportions of the thoracic tergites (see Figures 106, 107, 115, 122). The broad jugum is shared only with *Rhagovelia tebakang*. The name derives from the type locality.

Rhagovelia tawau, new species Figures 15-22

Description. Apterous male. Ground color black; abdominal tergites black. Anterior transverse band on pronotum orange brown, extending laterally to inner eye margins. Venter black; lightly embrowned on coxal cavities and mesosternum. Legs and antennae black except basal 2/5 of antennal segment I, basal half of anterior femur, basal fifth of hind femur, all coxae, fore and hind trochanters, base of middle trochanter, leucine. Pronotum short, length much less than that of an eye; length:width, 0.18: 0.70. Length of mesonotum on midline, 0.48; length of metanotum on midline,

0.08. Abdominal tergites I-VI subequal in length (0.13-0.15), tergite VII longer, 0.28.

Proepisternum with minute black denticles, difficult to see against dark background. Head with jugum not broadened. Dorsum clothed with very short recumbent setae and scattered longer setae. Venter clothed with short recumbent setae. Legs and antennae clothed with short golden setae and usual spines and scattered long setae. Posterior trochanter armed with 3 tiny teeth. Posterior femur armed basally with 9 to 10 small teeth increasing in size distally and a large spine just beyond middle followed by about 6 or 7 smaller spines decreasing in size distally. Posterior tibia beneath armed along entire length with short stout teeth. Downcurving arolia of hind tarsi flattened dorsoventrally, widened distally.

Antennal formula I: II: III: IV; 0.58: 0.30: 0.38: 0.38.

Proportions of Legs

	femur	tibia	tarsal 1	tarsal 2	tarsal 3
Anterior	0.68	0.68	0.03	0.15	-
Middle	1.05	0.83	0.05	0.30	0.58
Posterior	0.85	0.90	0.03	0.03	0.18

Abdominal sternite VII weakly carinate distally, with low ridges (1+1) laterally, each flanking a weak oblique depression on either side of midline; each ridge set with fine setae and most easily visible in lateral view, forming a hair tuft in the same position as in *R. simulata* but not as dense. Sternite VIII not depressed basally. Parameres symmetrical, shape as shown in figure 17.

Length: mean = 2.35 mm s = 0.03 N = 10.
Width: mean = 0.91 mm s = 0.03 N = 10.

Macropterous male. Most structural characters and color similar to apterous male. Wings smoky gray brown, with two closed cells basally (fig. 22), veins not prominent, basally set with short setae.

Length: mean = 2.83 mm s = 0 N = 2.
Width: mean = 1.11 mm s = 0.05 N = 3.

Apterous female. Coloration and hairiness similar to male. Connexiva raised but not reflexed; weakly sinuate; set with stiff black posteromedially directed setae on inner margin along tergite VI. Proepisternum with minute black denticles. Posterior femur basally unarmed or with 1 small spine adjacent to median spine, which is situated just before middle, followed by 5 or 6 smaller teeth distally. Posterior tibia armed along entire length with short stout teeth.

Abdomen not carinate; distally not modified; connexiva distally truncate, not produced, but with posteriorly projecting stiff setae. Tergite VIII on same plane as VII; proctiger projecting posteriorly.

Length: mean = 2.58 mm s = 0.03 N = 10.
Width: mean = 1.02 mm s = 0.03 N = 10.

Macropterous female. Appearance similar to macropterous male; wings with two closed cells in basal half. Abdominal carinae extending beyond middle of tergite IV; tergites V-VIII each with ovate median shining spot; connexiva straight.

Length: mean = 3.03 mm s = 0 N = 1.
Width: mean = 1.11 mm s = 0 N = 2.

Material examined. Holotype, apterous male, and allotype, apterous female: EAST MALAYSIA, Borneo, **Sabah**: North Borneo (SE), 19 km. N. of Kalabakan, XII-11-1962, Y. Hirashima (BPBM).

Paratypes as follows (all collected by Y. Hirashima, BPBM): EAST MALAYSIA, Borneo, **Sabah**: 15 apterous males, 22 apterous females, 1 macropterous male, 1 macropterous female, same data as holotype; 50 apterous males, 69 apterous females, 1 macropterous male, N. Borneo (SE), Tawau, Quoin Hill, VII-26 to IX-27-1962; 19 apterous males, 8 apterous females, 1 macropterous male, 1 macropterous female, North Borneo (SE), Tawau, Quoin Hill, Forest Camp 1, 3-5 km WSW of Cocoa Res. Sta., VII-9 to VII-20-1962. (Paratypes in JTPC, ZMUC, BPBM)

Discussion *Rhagovelia tawau* belongs to the *Rhagovelia borneensis* group. The broad truncate paramere, setose lateral ridges on male abdominal sternite VII, and coloration of the middle coxae and trochanters place this species very close to *Rhagovelia simulata*, from which it differs by the less hairy dorsum, smaller size, and shorter pronotum. It may be separated from the other members of the group by the characters given in the key. The species name is derived from the area of origin; all known specimens were taken in the vicinity of Tawau, Sabah.

Rhagovelia sondaica, new species
Figures 106-114

?*Rhagovelia femorata*, Lundblad 1933, nec Dover 1928. Arch. Hydrobiol., Suppl. 10 (Trop. Binnengewass. 4): 290. Redescription based on specimens from Java; several varieties proposed. Misidentified.

?*Rhagovelia femorata*, Hungerford 1933. Misc. Zoologica Sumatrana.75: 1. Lists from Sumatra; possibly a misidentification.

?*Rhagovelia femorata*, Lundblad 1936. Ark. Zool. 28A (21): 15. Redescription based on specimens from Java. Misidentified.

Description. Apterous male. Ground color black; abdominal tergites black. Anterior transverse band on pronotum orange brown, extending laterally to inner eye margins. Venter black; coxal cavities very narrowly margined with testaceous. Legs and antennae black except basal third of antennal segment I, basal 2/3 of anterior femur, basal 2/5 of hind femur, all coxae and trochanters, leucine. Pronotum short, length much less than that of an eye; length:width, 0.13: 0.75. Length of mesonotum on midline, 0.55; length of metanotum on midline, 0.08. Abdominal tergites I-VI subequal in length (0.10-0.18), tergite VII longer (0.25).

Proepisternum with minute black denticles, difficult to see against dark background. Jugum of head not broadened. Dorsum clothed with very short recumbent setae and scattered longer setae. Venter clothed with short recumbent setae. Legs and antennae clothed with short golden setae and usual spines and scattered long setae. Posterior trochanter unarmed. Posterior femur armed basally with 4 small teeth before middle and a large curved spine beyond middle followed by 5 or 6 smaller teeth decreasing in size distally. Posterior tibia beneath armed along entire length with short stout teeth. Downcurving arolia of hind tarsi flattened dorsoventrally.

Antennal formula I: II: III: IV; 0.55: 0.25: 0.33: 0.33.

Proportions of Legs

	femur	tibia	tarsal 1	tarsal 2	tarsal 3
Anterior	0.60	0.63	0.03	0.15	-
Middle	1.15	0.83	0.05	0.43	0.55
Posterior	0.85	0.85	0.03	0.03	0.18

Abdominal sternite VII distinctly carinate on midline; sternite VIII carinate on midline basally, slightly depressed on either side of carina. Parameres symmetrical, shape as shown in figure 110.

Length: mean = 2.61 mm s = 0.14 N = 10.
Width: mean = 0.87 mm s = 0.02 N = 10.

Macropterous male. Coloration and most structural characteristiscs similar to apterous male. Wings deep smoky brownish black, veins prominent, extending past tip of abdomen (Fig. 108); subcostal and medial veins basally set with moderate length setae; with four closed cells extending onto distal half.

Length: mean = 3.03 mm s = 0 N = 1.
Width: mean = 1.11 mm s = 0 N = 1.

Apterous female. Coloration and hairiness similar to male. Connexiva slightly raised; not sinuate or hirsute. Proepisternum with minute black denticles, difficult to see against dark background. Posterior femur unarmed, or at most armed with 1 or 2 small teeth beyond distal 2/3. Posterior tibia unarmed. Abdomen not carinate; distally not modified; connexiva distally terminating in a short acute angle, not produced. Tergite VIII on same plane as VII; proctiger projecting posteriorly.

Length: mean = 2.60 mm s = 0.04 N = 10.
Width: mean = 0.97 mm s = 0.03 N = 10.

Macropterous female. Unknown

Material examined. Holotype, apterous male, and allotype, apterous female: EAST MALAYSIA, Borneo, **Sarawak**: 7 km. N. of Tebakang, CL 2043, VIII-9-1985, J. T. & D. A. Polhemus (USNM).

Paratypes as follows: (All apterous unless otherwise noted): EAST MALAYSIA, Borneo, **Sarawak**: 16 males, 6 females, same data as holotype (JTPC); 4 males, 1 macropterous male, 2 km. W. of Tubeh, CL 2047, VIII-9-1985, J. T. & D. A. Polhemus (JTPC); 6 males, 20 females, 1 macropterous female, Kampung Tapuh, 300-450 m. (985-1475 ft.), VII-10-58, T. C. Maa (BPBM). WEST MALAYSIA, **Selangor**: 4 males, 3 females, Templar Park, N. of Kuala Lumpur, CL 2070, VIII-17-1985, J. T. and D. A. Polhemus (JTPC). WEST MALAYSIA, **Perak**: 5 males, 1 female, Kerunai River, 9 km. N. of Grik at bridge, CL 2078, VIII-19-1985, J. T. & D. A. Polhemus (JTPC).

Discussion. *Rhagovelia sondaica* n. sp., along with *Rhagovelia femorata* Dover, *Rhagovelia samarinda* n. sp., *Rhagovelia sarawakensis* n. sp. and *Rhagovelia tebakang* n. sp. comprise the *Rhagovelia sarawakensis* group of which only *sondaica* is widespread; see notes under *R. samarinda*. *Rhagovelia sondaica* may be separated from the other members of the group by the characters given in the key.

We initially accepted Lundblad's concept of *Rhagovelia femorata* Dover (Lundblad 1936, p.16), but with grave reservations. Lundblad apparently did not study Dover's type material, which was said to be in the Federated Malay States Museum, and because Dover identified mixed series as being this species, there was considerable doubt that the Java specimens, identified by Dover as *femorata* and redescribed as such by Lundblad, were conspecific with the species Dover described from Klang Gates (in the city of Kuala Lumpur, Malaysia). Very fortunately type material was found in the British Museum (Natural History); it consisits of two specimens, both *femorata* males, one from Sungai Jahan labelled as "holotype", the other from the type-locality at Klang Gates labelled as "type"; our label has been added to the latter designating it as the holotype. It does not match Lundblad's concept of the species.

Dover's original description states that *femorata* is black except for certain structures that are white, which

he carefully lists; among these white structures we do not find the middle coxae, thus they should be dark and in the type they are. We collected *Rhagovelia* species at several localities in the vicinity of Kuala Lumpur and found three closely related species there. One of these matches Lundblad's redescription of *femorata*, with light colored coxae, which we believe is the new species *sondaica* described here; another is Lundblad's *Rhagovelia sumatrensis*; the third species with dark middle coxae is Dover's *femorata*, a species easily separable from the others by the broad and distally truncate male parameres in contrast to distally narrow parameres in *sondaica* and *sumatrensis*. Thus Lundblad's "*femorata*" refers to *sondaica* or a closely related species. We have so far been unable to study the material from Java upon which Lundblad based his description, but it will probably prove to be *sondaica*. This species is named for the Sunda Islands.

Rhagovelia sarawakensis, new species Figures 128-133

Description. Apterous male. Ground color black; abdominal tergites black. Anterior transverse band on pronotum orange brown, extending laterally to inner eye margins. Venter black; lightly embrowned on coxal cavities and mesosternum. Legs and antennae black except basal third of antennal segment I, basal half of anterior femur, basal fifth of hind femur, all coxae and trochanters, leucine. Pronotum short, length much less than that of an eye; length:width, 0.15: 0.80. Length of mesonotum on midline, 0.55; length of metanotum on midline, 0.08. Abdominal tergites I-VI increasing in length posteriorly, lengths of I, 0.10; II, 0.13; III, 0.15; IV-V, 0.18; VI, 0.20; VII, 0.28.

Proepisternum with minute black denticles, difficult to see against dark background. Head with jugum not broadened. Dorsum clothed with very short recumbent setae and scattered longer setae. Venter clothed with short recumbent setae. Legs and antennae clothed with short golden setae and usual spines and scattered long setae. Posterior trochanter unarmed. Posterior femur armed basally with 10 to 12 small teeth increasing in size distally and a large spine at middle followed by 2 to 4 smaller spines decreasing in size distally. Posterior tibia beneath armed along entire length with short stout teeth. Downcurving arolia of hind tarsi flattened dorsoventrally.

Antennal formula I: II: III: IV; 0.63: 0.33: 0.33: 0.35.

Proportions of Legs

	femur	tibia	tarsal 1	tarsal 2	tarsal 3
Anterior	0.70	0.68	0.03	0.13	-
Middle	1.20	1.00	0.05	0.45	0.60
Posterior	0.93	0.93	0.03	0.03	0.20.

Abdominal sternite VII not carinate; sternite VIII depressed basally. Parameres symmetrical, shape as shown in figure 129.

Length:	mean = 2.76 mm	s = 0.08	N = 10.
Width:	mean = 0.87 mm	s = 0.02	N = 10.

Macropterous male. Unknown.

Apterous female. Coloration and hairiness similar to male. Connexiva raised, reflexed over tergite VII; thickened along tergites III-IV, set with stiff black posteriorly directed setae along inner margin, setae longer along tergites VI-VIII. Proepisternum with minute black denticles. Posterior femur armed with 3 small teeth beyond middle. Posterior tibia unarmed.

Abdomen not carinate; distally not modified; connexiva distally terminating in a short acute angle, not produced, but with a posterodorsally projecting tuft of stiff setae. Tergite VIII on same plane as VII; proctiger projecting posteriorly.

Length:	mean = 2.75 mm	s = 0.06	N = 10.
Width:	mean = 0.98 mm	s = 0.03	N = 10.

Macropterous female. Unknown

Material examined. Holotype, apterous male, and allotype, apterous female: EAST MALAYSIA, Borneo, **Sarawak**: 20 km. SE of Sematan, CL 2051, VIII-9-1985, J. T. & D. A. Polhemus (USNM).

Paratypes as follows (all apterous): EAST MALAYSIA, **Sarawak**, Borneo: 17 males, 39 females, same data as holotype (JTPC); 4 males, 3 females, 4 km. S. of Tebakang, CL 2044, VIII-9-1985, J. T. and D. A. Polhemus (JTPC); 2 males, 1 female, small stream 8 km. S. of Tebakang, CL 2045, VIII-9-1985, J. T. and D. A. Polhemus (JTPC); 1 female, 8 km. S. of Tebakang, stream disappearing into cave, CL 2046, VIII-9-1985, J. T. and D. A. Polhemus (JTPC); 1 male, 4 females, Kampong Pueh, Lundu Dist., VI-6 to VI-12-58, T. C. Maa (BPBM).

Discussion. *Rhagovelia sarawakensis*, along with *Rhagovelia samarinda* n. sp., *Rhagovelia sondaica* n. sp. and *Rhagovelia tebakang* n. sp. comprise the *Rhagovelia sarawakensis* group in Borneo of which only *sondaica* is widespread; see notes under *R. samarinda*. The characters given in the key will separate *Rhagovelia sarawakensis* from the other members of the group. The species name is derived from the country of origin.

Rhagovelia sabela, new species
Figures 46-53

Description. Apterous male. Ground color orange brown; abdominal tergites same. Anterior transverse band on pronotum light orange brown, extending laterally onto propleura. Venter yellowish to orange brown. Legs and antennae luteous to yellowish, darkening distally, becoming deep brown on distal segments. Pronotum short, length subequal to that of an eye; length:width, 0.30: 1.00. Length of mesonotum on midline, 0.45; length of metanotum on midline, 0.13. Abdominal tergites I-VI subequal in length (0.20-0.23); tergite VII longer (0.33).

Proepisternum, mesosternum and metasternum laterally with minute black denticles. Dorsum clothed with very short recumbent setae and scattered longer setae. Venter clothed with short recumbent setae. Legs and antennae clothed with short golden setae and usual spines and scattered long setae. Posterior trochanter armed with 6 or 7 small to moderate size teeth. Posterior femur armed basally with 12 to 14 small teeth reaching large spine before middle, which is followed by 6 or 7 smaller spines decreasing in size distally in one row, and a more anterior row of 9 smaller teeth. Posterior tibia beneath armed along entire length with many short stout teeth. Downcurving arolia of hind tarsi flattened dorsoventrally.

Antennal formula I: II: III: IV; 0.85: 0.45: 0.55: 0.50.

Proportions of Legs

	femur	tibia	tarsal 1	tarsal 2	tarsal 3
Anterior	0.95	1.00	0.03	0.30	-
Middle	1.53	1.48	0.05	0.40	0.65
Posterior	1.40	1.40	0.03	0.13	0.33

Abdominal sternite VII not carinate, weakly raised medially on distal half; sternite VIII depressed basally on each side of a short median carina. Parameres symmetrical, shape as shown in figure 49.

Length:	mean = 3.32 mm	s = 0.09	N = 10.
Width:	mean = 1.27 mm	s = 0.05	N = 10.

Macropterous male. Unknown.

Apterous female. Coloration and hairiness similar to male. Connexiva slightly raised, not reflexed, sinuate or modified. Minute black denticles on venter as in male. Posterior femur armed with 2 small spines before middle, 1 stout spine beyond middle followed by 5 small teeth decreasing in size distally. Posterior tibia armed beneath along entire length with short stout teeth.

Abdomen not carinate; distally not modified; connexiva distally terminating in a short blunt angle, not produced, with a posteriorly projecting tuft of stiff setae. Tergite VIII on same plane as VII; proctiger projecting posteriorly.

Length:	mean = 3.45 mm	s = 0.13	N = 10.
Width:	mean = 1.38 mm	s = 0.04	N = 10.

Macropterous female. Coloration and hairiness similar to apterous female. Pronotum broadly rounded posteriorly, not produced, yellow brown along posterior margin. Abdomen and connexiva distally as in apterous form; abdominal carinae reaching onto base of tergite IV. Wings smoky gray brown, lighter basally, veins dark; long, extending beyond tip of abdomen.

Length:	mean = 3.74 mm	s = 0	N = 1.
Width:	mean = 1.41 mm	s = 0	N = 1.

Material examined. Holotype, apterous male, and allotype, apterous female: INDONESIA, Bacan, **Maluku Prov.**, Kab. Maluku Utara: upper Gambasuli River trib., Mt. Sabela, CL 2139, 450 m. (1480 ft.), IX-26-1985, J. T. & D. A. Polhemus (USNM).

Paratypes as follows (Unless otherwise noted, all apterous, all collected by J. T. and D. A. Polhemus, JTPC): INDONESIA, Bacan, **Maluku Prov.**, Kab. Maluku Utara: many males and females, 1 macropterous female, same data as holotype; many males and females, same locality as above but 700 m. (2300 ft.), CL 2140, IX-25-1985; many males and females, same locality as above but 900 m. (2950 ft.), CL 2142, IX-26-1985; 3 males, 3 females, same locality as above but 350 m. (1150 ft.), CL 2146, IX-28-1985; 3 males, 2 females, 2 nymphs, same locality as above but 250 m. (820 ft.), CL 2148, IX-28-1985; many males and females, Kampung Wayamiga, 27-31 July, 1981, A. C. Messer (USNM).

Discussion. *Rhagovelia sabela*, *R. obi* n. sp. and *R. bacanensis* n. sp. all share the same thoracic structure, e. g. pronotum of medium length, equal to or slightly greater than the length of an eye, exposed mesonotum as long or longer than pronotum. The group formed on this basis is so far known only from the Moluccas, but an unnamed group with a similar thoracic structure occurs on New Guinea. *Rhagovelia sabela* may be separated from the other members of the group by the characters given in the key; it is the only orange brown member of the group. The species name, a noun in apposition, is derived from Gunung Sabela, the mountain type locality on Bacan.

This species was abundant in shaded streamlets running through the undisturbed rain forests on Mt. Sabela at elevations above 350 meters. The insects appeared to especially prefer smoothly flowing pools without excessive turbulence.

Rhagovelia bacanensis, new species
Figures 28-35

Description. Apterous male. Ground color black; abdominal tergites same, tergite VII shining. Anterior transverse band on pronotum orange brown, not extending laterally beyond midddle of eyes, except in teneral specimens sometimes extending onto propleura. Connexiva margined with yellowish, usually only along tergites III-IV. Venter black, with dark orange brown areas laterally. Legs and antennae blackish brown, lighter basally; basal third of antennal segment I, basal half of fore femur, most of posterior femur, all coxae and trochanters yellowish. Pronotum short, length subequal to that of an eye; length:width, 0.45: 0.90. Length of mesonotum on midline, 0.33; length of metanotum on midline, 0.10. Abdominal tergites I-VI subequal in length (0.15-0.20); tergite VII longer (0.38).

Proepisternum without minute black denticles. Dorsum clothed with very short recumbent setae and scattered longer setae, more numerous and longer posteriorly. Venter clothed with short recumbent setae. Legs and antennae clothed with short golden setae and usual spines and scattered long setae. Anterior trochanters beneath with a dense tuft of short stout setae distally. Posterior trochanter unarmed or armed with a few very small inconspicuous teeth. Posterior femur armed basally with 23 to 30 small teeth reaching large spine before middle, which is followed by another large spine beyond middle and 6 or 7 smaller spines decreasing in size distally in one row, and a more anterior row of about 6 smaller teeth. Posterior tibia beneath armed along entire length with many short stout teeth. Downcurving arolia of hind tarsi flattened dorsoventrally.

Antennal formula I: II: III: IV; 0.73: 0.45: 0.50: 0.45.

Proportions of Legs

	femur	tibia	tarsal 1	tarsal 2	tarsal 3
Anterior	0.83	1.00	0.03	0.23	-
Middle	1.43	1.40	0.05	0.50	0.65
Posterior	1.33	1.28	0.05	0.10	0.30

Abdominal sternite VII strongly carinate on midline; sternite VIII depressed basally. First genital segment widened posteriorly to accomodate lateral wings of modified proctiger (Fig. 33). Parameres symmetrical, shape as shown in figure 30.

Length:	mean =	3.13 mm	s = 0.07	N = 10.
Width:	mean =	1.13 mm	s = 0.03	N = 10.

Macropterous male. Coloration and most structural characteristiscs similar to apterous male. Wings deep smoky brownish black, veins not prominent, extending past tip of abdomen; subcostal and medial veins basally set with moderate length setae; with four closed cells extending onto distal half.

Length:	mean =	3.42 mm	s = 0.09	N = 10.
Width:	mean =	1.33 mm	s = 0.05	N = 10.

Apterous female. Coloration and hairiness similar to male, tergite VII shining medially. Connexiva raised, almost vertical, sinuate medially, distinctly incurved after tergite III, margin yellowish, glabrous along tergites III-IV. Proepisternum without minute black denticles. Posterior femur armed with 1 stout spine beyond middle followed by 3 or 4 small teeth decreasing in size distally. Posterior tibia armed beneath along entire length with short stout teeth.

Abdomen not carinate; distally not modified; connexiva and tergite VII distally terminating in dense brush of long curved setae. Tergite VIII depressed, hidden beneath setae; proctiger turned ventrad.

Length:	mean =	3.26 mm	s = 0.12	N = 10.
Width:	mean =	1.28 mm	s = 0.05	N = 10.

Macropterous female. Coloration and most structural characteristics similar to apterous female. Wings deep smoky brownish black, veins not prominent, extending past tip of abdomen ; subcostal and medial veins basally set with moderate length setae; with four closed cells extending onto distal half. Wings spread in one specimen, exposing dorsal abdominal carinae that extend to posterior margin of tergite III. Connexiva not raised, not sinuate, not modified, with tufts of long setae distally. Tergites V-VIII brown medially, tergite VII without setae posteriorly, tergite VIII turned slightly ventrad.

Length:	mean =	3.52 mm	s = 0.17	N = 10.
Width:	mean =	1.39 mm	s = 0.07	N = 10.

Material examined. Holotype, apterous male, and allotype, apterous female, INDONESIA, Bacan, **Maluku Prov.**, Kab. Maluku Utara: river 3 km. S. of Labuha, CL 2134, 50 m. (160 ft.), IX-23-1985, J. T. & D. A. Polhemus (USNM).

Paratypes as follows: INDONESIA, Bacan, **Maluku Prov.**, Kab. Maluku Utara (all collected by J. T. & D. A. Polhemus, JTPC): many apterous males and females, 3 macropterous males, 2 macropterous females, same data as holotype; 3 apterous males, Babang to Desaua Road, CL 2136, IX-24-1985; many apterous males and females, 1 macropterous male, stream 8 km N. of Desaua, CL 2137, IX-24-1985; 3 apterous males, 1 apterous female, 1 macropterous male, 2 macropterous females, upper Gambasuli River, rushing tributary, Mt. Sabela, CL 2145, 410 m. (1340 ft.), IX-28-

1985; many apterous and macropterous males and females, upper Gambasuli River, Mt. Sabela, CL 2146, 350 m. (1150 ft.), IX-27- 1985; 7 apterous males, 9 apterous females, 3 macropterous males, 2 macropterous females, same as CL 2146 but 250 m. (820 ft.), IX-28-1985.

Also the following paratypes (all collected by A. C. Messer, in JTPC, USNM): INDONESIA, Halmahera, **Maluku Prov.**, Kab. Maluku Utara: many apterous males and females, 1 macropterous male, 3 macropterous females, Jailolo Dist., Jikolano (Kao Bay), 4-5 June 1981; many apterous males and females, Kao Dist., Kao River Basin, Air Kanan, Kampung Tuguis, 1-15 Apr. 1981 (Messer & P. M. Taylor); many apterous males and females, Jailolo Dist., Kampung Pasir Putih, 0° 53'N, 127° 41'E, Feb. 1981 (Messer & P. M. Taylor). INDONESIA, Morotai, **Maluku Prov.**, Kab. Maluku Utara: many apterous males and females, Cao Besar, 10 km. SE of Daruba, 25-31 Aug. 1981. INDONESIA, Bacan, **Maluku Prov.**, Kab. Maluku Utara: 7 apterous males, 2 apterous females, 1 macropterous female, Kampung Wayamiga, 27-31 July, 1981.

Discussion. *Rhagovelia sabela*, *R. obi* n. sp. and *R. bacanensis* n. sp. all belong to the group having the pronotum of medium length (see discussion under *R. sabela*). *Rhagovelia bacanensis* is very closely related to *R. obi* n. sp., differing in the morphology of the female connexiva, abdominal tergite VII, and the armature of the hind femora; see key. The species name is derived from the type locality, Bacan island, but this species is also distributed on nearby Halmahera and Morotai islands as well.

The type locality was a swift clear river, shaded only along the margins, which came down to the sea just beyond the Labuha police station through a wide bed of gravel and metamorphic boulders. *R. bacanensis* was abundant here in quiet pockets along the banks and in sheltered areas behind large rocks.

Rhagovelia obi, new species Figures 36-42

Description. Apterous male. Ground color black; abdominal tergites same, tergite VII shining. Anterior transverse band on pronotum orange brown, evanescent or much darker laterally beyond midddle of eyes, except in teneral specimens sometimes extending onto propleura. Connexiva margined with yellowish. Venter black, with orange brown areas laterally. Legs and antennae blackish brown, lighter basally; basal half (basal 1/3 dorsally) of antennal segment I, basal 2/3 of fore femur, basal half of middle femur, most of posterior femur except dorsally, all coxae and trochanters yellowish. Pronotum short, length subequal to that of an eye; length:width, 0.50: 0.93. Length of mesonotum on midline, 0.30; length of metanotum on midline, 0.13. Abdominal tergites I-VI subequal in length (0.18-0.20); tergite VII longer (0.38).

Proepisternum without minute black denticles. Dorsum clothed with very short recumbent setae and scattered longer setae, more numerous and longer on abdominal tergites. Venter clothed with short recumbent setae. Legs and antennae clothed with short golden setae and usual spines and scattered long setae. Anterior trochanters beneath with a dense tuft of short stout setae distally. Posterior trochanter armed with 5 very small dark teeth. Posterior femur armed basally with about 10 small teeth reaching large spine before middle, which is followed by another large spine beyond middle and 6 or 7 smaller spines decreasing in size distally in one row, and a more anterior row of 3 or 4 smaller teeth. Posterior tibia beneath armed along entire length with many short stout teeth. Downcurving arolia of hind tarsi flattened dorsoventrally.

Antennal formula I: II: III: IV; 0.75: 0.43: 0.50: 0.43.

Proportions of Legs

	femur	tibia	tarsal 1	tarsal 2	tarsal 3
Anterior	0.80	0.85	0.03	0.18	-
Middle	1.40	1.08	0.05	0.50	0.63
Posterior	1.30	1.15	0.03	0.08	0.25

Abdominal sternite VII strongly carinate on midline; sternite VIII depressed basally. First genital segment widened posteriorly to accomodate lateral wings of modified suranal plate, similar to *bacanensis*. Parameres symmetrical, shape as shown in figure 38.

Length: mean = 3.15 mm s = 0.07 N = 10.
Width: mean = 1.12 mm s = 0.03 N = 10.

Macropterous male. Unknown.

Apterous female. Coloration and hairiness similar to male, tergite VII not shining medially. Connexiva raised, vertical to slightly reflexed along tergites IV-VII, sinuate medially, distinctly incurved after tergite III, margin yellowish, glabrous along tergites III-IV. Proepisternum without minute black denticles. Posterior femur armed with 1 stout spine beyond middle followed by 3 or 4 small teeth decreasing in size distally. Posterior tibia armed beneath along entire length with short stout teeth.

Abdomen not carinate; distally not modified; connexiva and tergite VII distally terminating in dense brush of long curved setae. Tergite VIII turned ventrad, hidden beneath setae; proctiger turned ventrad.

Length:	mean =	3.39 mm	s = 0.09	N = 10.
Width:	mean =	1.27 mm	s = 0.04	N = 10.

Macropterous female. Coloration and most structural characteristics similar to apterous female. Wings deep smoky brownish black, veins not prominent, extending past tip of abdomen; subcostal and medial veins basally set with moderate length setae; with four closed cells extending onto distal half. Connexiva with tufts of long setae distally. Tergites V-VIII brown medially, tergite VII without setae posteriorly, tergite VIII turned slightly ventrad.

Length:	mean =	3.64 mm	s = 0	N = 2.
Width:	mean =	1.34 mm	s = 0.04	N = 2.

Material examined. Holotype, apterous male, and allotype, apterous female, INDONESIA, Obi, **Maluku Prov.**, Kab. Maluku Utara: 12 km. SW of Jikodolong on logging road, VIII-5-1985, A. C. Messer (USNM).

Paratypes: many apterous males and females, 2 macropterous females, same data as holotype (USNM, JTPC).

Discussion.
Rhagovelia sabela, *R. obi* n. sp. and *R. bacanensis* n. sp. all belong to the group having the pronotum of medium length (see discussion under *R. sabela*). *Rhagovelia obi* is very closely related to *R. bacanensis* n. sp., differing in the morphology of the female connexiva, abdominal tergite VII, and the armature of the hind femora (see key). The species name is derived from the type locality, the island of Obi, to which this species appears to be endemic.

Rhagovelia hamdjahi, new species
Figures 134-140

Description. Apterous male. Ground color black; abdominal tergites black, not shining; anterior transverse band on pronotum orange brown, narrow (width about 1/2 of eye length), short, reaching inner eye margins. Venter black, sternite VII medially and genital segments brown; coxal cavities luteous. Legs and antennae dark brown except all coxae, all trochanters, basal third of antennal segment I, basal third of fore femur, posterior femur basally beneath, leucine to yellow brown. Pronotum long, covering mesonotum; length:width, 0.98: 1.08. Length of metanotum on midline, 0.10. Abdominal tergites I-VI subequal in length (0.18-0.23), tergite VII longer (0.43).

Proepisternum with many minute black denticles. Dorsum clothed with short appressed golden pubescence and scattered longer setae. Venter clothed with very short pubescence. Legs and antennae clothed with usual spines and scattered long setae. Posterior trochanter armed with 4-8 small dark teeth. Posterior femur armed with about 20 tiny dark teeth basally in one row reaching almost to the large median spine, which is followed by 7 or 8 smaller spines decreasing in size distally, and a more anterior scattered field of 5 to 10 small dark teeth beginning before middle. Posterior tibia beneath set along entire length beneath with a row of short flattened black teeth, plus a few others scattered in a parallel row. Downcurving arolia of hind tarsi flattened, narrowing distally.

Antennal formula I: II: III: IV; 0.93: 0.45: 0.55: 0.55.

Proportions of Legs

	femur	tibia	tarsal 1	tarsal 2	tarsal 3
Anterior	1.15	1.13	0.05	0.30	-
Middle	1.68	1.40	0.08	0.55	0.68
Posterior	1.35	1.43	0.08	0.13	0.33

Abdominal sternite VII slightly flattened beneath, slightly depressed on each side of midline posteriorly, not significantly modified, not carinate; sternite VIII long, ventrally weakly carinate basally on midline, slightly depressed on either side of carina, each depression thickly set with a field of regularly spaced tightly appressed short setae. Parameres symmetrical, shape as shown in figure 136.

Length:	mean =	3.61 mm	s = 0.05	N = 10.
Width:	mean =	1.24 mm	s = 0.03	N = 10.

Macropterous male. Unknown.

Apterous female. Abdominal tergites III-VI almost hair free and somewhat depressed; tergites not shining. Connexiva raised, very slightly sinuate, not modified, brownish along margin. Otherwise coloration and hairiness as in male. Proepisternum with many minute black denticles. Middle femur dorsoventrally flattened, particularly beyond middle; posterior femur curved, dorsoventrally flattened, armed with one moderate length spine situated well beyond middle and at the posterior edge of the ventral face, followed by 3 or 4 smaller teeth of decreasing size distally, and several tiny teeth scattered anteriorly to this primary row. Posterior tibia unarmed, without pegs or teeth.

Abdomen distally slightly projecting; connexiva distally truncate, set with a posteriorly directed tuft of stiff black setae. Tergite VIII slightly directed ventrad; proctiger deflected ventrad at about a 45° angle.

Length:	mean =	3.78 mm	s = 0.12	N = 10.
Width:	mean =	1.41 mm	s = 0.03	N = 10.

Macropterous female. Coloration and most other characteristics as in apterous females. Dorsal setae on pronotum longer on posterior margin. Pronotum pro-

longed posteriorly, margins straight, forming almost a right angle but rounded posterioly; humeri not produced. Wings broken off at base. Connexiva only slightly raised.

Length:	mean =	3.69 mm	s = 0	N = 1.
Width:	mean =	1.52 mm	s = 0	N = 1.

Material examined. Holotype, apterous male and allotype, apterous female: INDONESIA, Celebes, **Sulawesi Tengah Prov.**, Kab. Donggala: stream 10 km. SE of Kamarora, Lore Lindu Nat. Park, 950 m. (3120 ft.), CL 2156, X-8-1985, J. T. & D. A. Polhemus (USNM).

Paratypes as follows: many apterous males and females, 1 macropterous female, same data as holotype (JTPC).

Discussion. *Rhagovelia hamdjahi* females are unique in having both the middle and hind femora flatttened, with the latter curved and the primary row of spines located at the posterior edge instead of medially on the ventral face. The males are characterized by having sternite VII flattened and weakly depressed on each side instead of medially carinate as in related species. This species is named in honor of Mr. Hamdjah, who assisted with field logistics during our stay in central Celebes.

The type series was taken along the margins of a rushing stream heavily shaded by primary montane rain forest in the upper reaches of the Palolo Valley. *R. lorelinduana* n.sp. was also present at this locality, but preferred more shaded and less swiftly flowing sections of the stream.

Rhagovelia unica, new species Figures 43-45

Description. Apterous female. Ground color dark gray to gray brown; abdominal tergites same, extensively pruinose; connexiva broadly margined with yellowish; anterior transverse band on pronotum yellowish, broad, not extending laterally beyond the middle of each eye; entire pronotum pruinose. Venter brown to gray brown; coxal cavities broadly orange brown. Legs and antennae brown to dark brown except basally; basal third of first antennal segment, basal 2/3 anterior femora, anterior and posterior trochanters and coxae luteous to light brown; middle coxa and trochanter, basal half of posterior femur infused with yellowish. Pronotum long, covering mesonotum; length:width, 0.90: 1.30. Length of metanotum on midline, 0.13. Abdominal tergites I- V subequal in length (0.23-0.28), tergites VI-VII longer (0.33, 0.43), not shining.

Proepisternum set with a few minute black denticles, extending dorsally on prothorax to behind eyes. Dorsum clothed with short appressed pubescence and scattered longer setae on head and abdomen. Venter clothed with short appressed silvery setae and a few longer setae. Legs and antennae clothed with short setae and usual scattered long setae, posterior femur with a number of long setae posteriorly. Posterior trochanter unarmed. Posterior femur armed with one stout spine at middle followed by 9 smaller spines distally Posterior tibia beneath set along entire length with black teeth. Downcurving arolia of hind tarsi long, slender.

Antennal formula I: II: III: IV; 0.98: 0.48: 0.53: 0.48.

Proportions of Legs

	femur	tibia	tarsal 1	tarsal 2	tarsal 3
Anterior	1.03	1.08	0.03	0.30	-
Middle	1.68	1.38	0.08	0.58	0.73
Posterior	1.50	1.60	0.05	0.10	0.35

Connexiva slightly raised basally, vertical along tergites VII- VIII; slightly sinuate; set with long setae along margin, more numerous along tergites VII-VIII.

Abdomen distally truncate; connexiva distally forming a small sharp angulate projection; tergite VIII on same plane as VII; proctiger directed caudad, however the ovipositor lobes are exserted so the normal orientation may be different.

Length:	mean =	4.09 mm	s = 0	N = 1.
Width:	mean =	1.57 mm	s = 0	N = 1.

Apterous male, macropterous male, macropterous female. Unknown.

Material examined. Holotype, apterous female: INDONESIA, Celebes, **Sulawesi Utara Prov.**, Kab. Bolaang Mongondow: Tumpah River tributary, Dumoga Bone Nat. Park, 0° 35'N, 123° 54'E, CL 2101, 235 m. (770 ft.), water temp. 22.30° C., IX-5-1985, J. T. & D. A. Polhemus (JTPC).

Discussion. The broadly yellow connexiva with long setae on the margin set this species apart from any other known from the region. Only the unique female is thus far known, so the position in the key may change once males are known. The name is derived from *unica*, L., only, sole, singular.

Rhagovelia pruinosa, new species Figures 149-157

Description. Apterous male. Ground color dark gray to black; abdominal tergites same, extensively pruinose; anterior transverse band on pronotum

orange brown, broad, not extending laterally beyond the middle of each eye; entire anterior part of pronotum pruinose. Venter black brown to brown; coxal cavities broadly orange brown. Legs and antennae dark except basally; basal third to half of anterior and posterior femora, all trochanters and coxae luteous to light brown. Pronotum long, covering mesonotum; length:width, 0.80: 1.05. Length of metanotum on midline, 0.10. Abdominal tergites I-VI subequal in length (0.20-0.25), tergite VII longer (0.43), shining medially.

Proepisternum, much of venter, coxal cavities, bucculae, set with many minute black denticles. Dorsum clothed with short appressed pubescence and scattered longer setae on head and abdomen. Venter clothed with short appressed silvery setae and a few longer setae. Legs and antennae clothed with short setae and usual scattered long setae. Posterior trochanter armed with 4 black teeth. Posterior femur armed with one stout spine at middle followed by about 6 smaller pegs, and a second parallel row of about 5 smaller pegs anterior to first row. Posterior tibia beneath set along entire length with black teeth. Downcurving arolia of hind tarsi long, slender.

Antennal formula I: II: III: IV; 0.70: 0.40: 0.45: 0.45.

Proportions of Legs

	femur	tibia	tarsal 1	tarsal 2	tarsal 3
Anterior	0.90	1.03	0.05	0.20	-
Middle	1.60	1.30	0.08	0.53	0.70
Posterior	1.43	1.20	0.05	0.13	0.33

Abdominal sternite VII set with a sharp projection (composed of stiff setae) at basal third, followed by a median carina distally (figs. 149, 155); sternite VIII not modified. Parameres symmetrical, shape as shown in figure 156.

Length: mean = 3.47 mm s = 0.10 N = 10.
Width: mean = 1.19 mm s = 0.04 N = 10.

Macropterous male. Similar to apterous form except that pronotum is lengthened caudad, and rounded posteriorly. Dorsal abdominal carinae as shown in fig. 154.

Length: mean = 3.74 mm s = 0.08 N = 10.
Width: mean = 1.41 mm s = 0.06 N = 10.

Apterous female. Dorsum similar to male; abdominal tergites not shining, largely hair free. Connexiva raised along entire length; incurved, slightly expanded, flattened and shining dorsally along tergites III-IV. Otherwise coloration and hairiness as in male.

Proepisternum and venter with many minute black denticles, similar to male. Middle femur somewhat flattened dorsoventrally. Posterior femur with a moderate length (0.20) spine, followed by a row of 5 smaller spines decreasing in length distally. Posterior tibia basally with a row of black pegs beneath. Abdomen and connexiva distally truncate; tergite VIII on same plane as VII; proctiger directed ventrad.

Length: mean = 3.58 mm s = 0.10 N = 10.
Width: mean = 1.33 mm s = 0.04 N = 10.

Macropterous female. Coloration and most other characteristics as in apterous females. Dorsal setae on pronotum short. Pronotum not prolonged; humeri not produced. Abdomen straight, not upturned or incurved. Wings long, extending well beyond apex of abdomen.

Length: mean = 3.75 mm s = 0.09 N = 10.
Width: mean = 1.44 mm s = 0.04 N = 10.

Material examined. Holotype, apterous male, and allotype, apterous female: INDONESIA, Celebes, **Sulawesi Selatan Prov.**, Kab. Maros: Pattunuang River at Biseang Labboro Rec. Area, 7 km. SW of Bantimurung, CL 2165, X-13-1985, 0-100 m. (0- 330 ft.), J. T. & D. A. Polhemus (USNM).

Paratypes as follows: INDONESIA, Celebes, **Sulawesi Selatan Prov.**, Kab. Maros (all collected by J. T. and D. A. Polhemus, JTPC): many apterous and macropterous males and females, same data as holotype; 5 apterous males, 3 apterous females, Maros River, Bantimurung Waterfall nature reserve, CL 2166, 0-100 m. (0-330 ft.), X-13-1985; 13 apterous males, 4 macropterous males, 7 apterous females, 5 macropterous females, Marana River, nr. Laiya, 50 km. E. of Maros, CL 2167, 450 m. (1480 ft.), X-14-1985. Also 1 macropterous female paratype, Celebes, Stevens (NHRS).

Discussion. The sharp projection medially on sternite VII of the males will immediately separate *Rhagovelia pruinosa* n. sp. from its congeners. Females are distinguished by the peculiar shape of the connexiva along tergites III-IV. Both sexes are characterized by the extensive diffuse pruinose areas on the dorsum, which is the basis of the species name.

The Pattunaung River at the type locality was a series of slowly flowing rock rimmed pools bounded by low limestone cliffs, and set into a deeper limestone canyon. The water was mostly unshaded, but was cooled by inflows from springs that gushed from the limestone walls of the channel. *R. pruinosa* occurred here in very large numbers, in company with *R. sulawesiana*, *Ptilomera laelaps* Breddin, *Cylindrostethus persephone* Kirkaldy, and many other genera and species of Gerromorpha.

Rhagovelia ambonensis
Lundblad
Figures 165-171

Rhagovelia ambonensis Lundblad 1933. Ark. Zool. 28A (21): 30. Type-locality: Ambon. (Naturhist. Mus. Leiden)

Description. Apterous male. Ground color blackish brown to black; abdominal tergites black, not shining; connexival margins brown; anterior transverse band on pronotum flavous to orange brown, broad, extending laterally to middle of eyes. Venter black except coxal cavities, jugum of head, yellow. Legs and antennae dark except basal 1/3 of first antennal segment, basal 1/2 of fore femur, basal 1/4 of hind femur, all coxae and trochanters, yellow. Pronotum long, covering mesonotum; length:width, 0.73: 0.68. Length of metanotum on midline, 0.13. Abdominal tergites increasing in length posteriorly from I (0.18) to VI (0.23), tergite VII much longer (0.38).

Proepisternum without evident black denticles. Dorsum clothed with inconspicuous appressed setae and numerous long (0.20-0.25) stiff black setae. Venter clothed with moderate length coarse golden semi-recumbent setae, scattered long black setae on sternite VII. Legs and antennae clothed with usual short setae and scattered long bristles, legs set with rows of long stiff black setae. Posterior trochanter armed with 1 or 2 small black teeth. Posterior femur armed with 8 or 9 small teeth basally, not reaching stout spine before middle, which is followed by about 7 smaller spines decreasing in size distally, and another more anterior row of 4 or 5 teeth beginning beyond middle. Posterior tibia straight, beneath with a row of stout black pegs along entire length. Downcurving arolia of hind tarsi slender, flattened, slightly widened distally.

Antennal formula I: II: III: IV; 0.65: 0.40: 0.45: 0.40.

Proportions of Legs

	femur	tibia	tarsal 1	tarsal 2	tarsal 3
Anterior	0.83	0.90	0.05	0.25	-
Middle	1.40	1.13	0.08	0.40	0.60
Posterior	1.28	1.18	0.05	0.10	0.30.

Abdominal sternite VII carinate on midline, depressed on each side of carina; segment VIII directed slightly ventrad, not modified. Parameres symmetrical, shape as shown in figure 171.

Length:	mean =	3.34 mm	s = 0.18	N = 10.
Width:	mean =	1.18 mm	s = 0.06	N = 10.

Macropterous male. Coloration and most other chartacteristics as in apterous males. Dorsal setae on pronotum long, scattered. Hind femora not as incrassate as in apterous male, about 1.75 times the width of middle femur. Pronotum not prolonged distally; humeri prominent. Connexiva straight, margin set with long black setae. Wings deep smoky gray black, lighter basally, veins dark; extending to apex of abdomen.

Length:	mean =	3.60 mm	s = 0.10	N = 10.
Width:	mean =	1.40 mm	s = 0.04	N = 10.

Apterous female. Coloration and hairiness mostly as in male; dorsum black, without long setae except along lateral pronotal margins and 6 to 8 long slender black setae medially on mesonotum and on each of the basal two tergites; abdominal tergites not shining, IV-VI almost naked; hind femur light on basal 1/6.

Proepisternum without minute black denticles. Hind femur armed at middle with a moderate length (0.18) spine, followed by a row of 4 smaller spines decreasing in length distally. Posterior tibia with a row of black pegs beneath along entire length. Connexiva upturned, almost vertical along tergites V-VI, meeting over tergite VII, produced distally as a triangular plate-like structure. Abdominal tergite VII truncate distally except connexiva; tergites VIII-IX deflected ventrad, withdrawn into segment VII, barely visible in lateral view.

Length:	mean =	3.56 mm	s = 0.07	N = 10.
Width:	mean =	1.22 mm	s = 0.05	N = 10.

Macropterous female. Coloration and most other characteristics as in apterous females. Dorsal setae on pronotum long, scattered. Pronotum not prolonged distally; humeri prominent. Abdomen straight, not upturned; tergites VIII-IX as in apterous female. Connexiva straight, not incurved, margin thickly set with long black setae; distally only slightly produced as an obtuse angle set with black posteriorly directed setae. Wings deep smoky gray black, lighter basally, veins dark; extending to apex of abdomen.

Length:	mean =	3.60 mm	s = 0.11	N = 10.
Width:	mean =	1.44 mm	s = 0.04	N = 10.

Material examined. INDONESIA, Ambon, **Maluku Prov.**, Kab. Maluku Tengah: many apterous males and females, 1 macropterous male, 1 macropterous female, Amaori River NW of Ambon, CL 2150, X-2-1985, J. T. & D. A. Polhemus; many apterous males and females, 1 macropterous male, Air Tengah Laha nr. Ambon Airport, CL 2151, 0-100 m. (0-320 ft.), X-3-1985, J. T. & D. A. Polhemus; many apterous males and females, 16 macropterous males, 16 macropterous females, Wairea River nr. Wairea, CL 2153, 50 m. (160 ft.), X-4-1985, J. T. & D. A. Polhemus; 1 apterous male, Ambon, XI-22-1962, A. M. R. Wegner (all JTPC).

Discussion. This species is most closely related to *R. sulawesiana*, but may be separated by the key characters. Apterous specimens are also similar in appearance to *Rhagovelia celebensis*, although in a different group. The males of both of the latter species have a dense brush of long posteroventrally directed setae medially on the abdominal venter terminating on the base of sternite VII, lacking in *ambonensis*. Females of *ambonensis* can be separated from congeners by the nature of the connexiva, especially the shape of the posterior projection.

Rhagovelia sulawesiana, new species Figures 158-164

Description. Apterous male. Ground color black; abdominal tergites same, not shining; anterior transverse band on pronotum yellowish, narrow, not extending laterally beyond inner eye margins. Venter dark; coxal cavities broadly margined with yellow. Legs and antennae black except basal fourth of first antennal segment, basal third of fore femur beneath, fore and hind trochanters, all coxae yellow. Pronotum long, covering mesonotum; length:width, 0.88: 1.00. Length of metanotum on midline, 0.13. Abdominal tergites increasing in length posteriorly from I (0.13) to VI (0.20), tergite VII much longer (0.45).

Proepisternum without minute black denticles. Dorsum clothed with inconspicuous appressed setae, with only two (1+1) long stiff black setae laterally on pronotum. Venter clothed with long coarse golden semi-recumbent setae, especially prominent medially on mesosternum and sternites II-VI. Legs and antennae clothed with usual short setae and scattered long bristles; posterior femora with numerous long setae beneath. Posterior trochanter armed with numerous short slender golden setae; without black pegs. Posterior femur armed with one long (0.20) stout spine at middle followed by about 6 smaller spines decreasing in size distally. Posterior tibia beneath with a row of black pegs along entire length; dorsally with about 12 long stiff spines on distal half; distally with a fan of tiny curved flattened setae with dilated tips. Downcurving arolia of hind tarsi slender, flattened.

Antennal formula I: II: III: IV; 0.83: 0.40: 0.48: 0.35.

Proportions of Legs

	femur	tibia	tarsal 1	tarsal 2	tarsal 3
Anterior	1.00	0.83	0.05	0.25	-
Middle	1.60	1.20	0.05	0.55	0.68
Posterior	1.35	1.35	0.05	0.08	0.25

Abdominal sternite VII strongly carinate on midline, excavate and shining on each side of carina; segment VIII directed slightly ventrad, basally carinate on midline. Parameres symmetrical, shape as shown in figure 163.

Length:	mean = 3.20 mm	s = 0.05	N = 10.
Width:	mean = 1.19 mm	s = 0.03	N = 10.

Macropterous male. Unknown

Apterous female. Dorsum black; abdominal tergites not shining. Connexiva abruptly incurved along tergite V, almost touching along tergite VI, slightly divergent along tergite VII. Dorsum with scattered long stiff black setae along lateral pronotal margins, and 6 to 8 long slender black setae medially on mesonotum and on each of the basal two tergites. Otherwise coloration and hairiness as in male.

Proepisternum without minute black denticles. Hind femur armed at middle with a moderate length (0.15) spine, followed by a row of 5 smaller spines decreasing in length distally. Posterior tibia with a row of black pegs beneath along entire length. Abdomen distally complex; tergite VII produced distally into a posterodorsally directed lobe tipped with long black setae; connexiva distally acute, set with stiff setae. Tergite VIII directed ventrally, with posteriorly directed tufts of stiff setae at posterolateral angles; proctiger directed ventrally.

Length:	mean = 3.34 mm	s = 0.09	N = 10.
Width:	mean = 1.29 mm	s = 0.04	N = 10.

Macropterous female. Unknown

Material examined. Holotype, apterous male, and allotype, apterous female: INDONESIA, Celebes, **Sulawesi Selatan Prov.**, Kab. Maros: Pattunuang River at Biscang Labboro Rec. Area, 7 km. SW of Bantimurung, CL 2165, X-13-85, 0-100 m. (0-330 ft.), J. T. and D. A. Polhemus (USNM).

Paratypes as follows: INDONESIA, Celebes, **Sulawesi Selatan Prov.**, Kab. Maros: 8 apterous males, 18 apterous females, same data as holotype; 1 apterous male, 7 apterous females, Marana River, near Laiya, 50 km. E. of Maros, CL 2167, 450 m. (1480 ft.), X-14-85, J. T. and D. A. Polhemus (JTPC).

Discussion. Apterous specimens of this species superficially appear closely related to *Rhagovelia celebensis* n. sp., although they are in different groups. The males of both species have a dense brush of long posteroventrally directed setae medially on the abdominal venter terminating on the base of sternite VII, the latter depressed distally.; males of *sulawesiana* may be separated by the long and narrow aspect of tergite VII (length : basal width, 0.45: 0.25 in *sulawesiana*, 0.38:

0.33 in *celebensis*), and the row of clavate setae distally on the hind tibia. Females of *sulawesiana* can be separated from all congeners by the fleshy lobe projecting posteriorly from tergite VII. The species name is derived from Sulawesi, the Indonesian name for Celebes.

Notes on the Pattunuang River type locality are given in the discussion under *R. pruinosa*, with which this species was sympatric.

Rhagovelia celebensis, new species Figures 179-186

Description. Apterous male. Ground color black; abdominal tergites black; anterior transverse band on pronotum orange brown, narrow, laterally reaching inner eye margins. Venter black; coxal cavities margined with luteous. Legs and antennae black except basal 1/3 of first antennal segment, basal 1/4 of fore femur, anterior and posterior coxae, anterior trochanter, posterior trochanter basally, yellowish. Pronotum long, covering mesonotum; length:width, 0.80: 0.95. Length of metanotum on midline, 0.08. Abdominal tergites I-VI subequal in length (0.15- 0.20), tergite VII longer (0.38).

Proepisternum without minute black denticles. Dorsum clothed with short dark recumbent setae, scattered longer fine setae. Venter clothed with moderate length golden recumbent setae, denser medially on abdomen, forming a posteriorly directed tuft projecting over the base of tergite VII. Legs and antennae clothed with usual spines and longer setae; posterior femur beneath, fore tibia anteriorly, shaggy. Posterior trochanter unarmed. Posterior femur armed beyond middle with one large spine followed by 5 smaller spines decreasing in length distally, and a more anterior parallel row of 5 or 6 small spines starting at distal 2/3. Posterior tibia beneath armed along entire length with small inconspicuous teeth, and an apical spur. Downcurving arolia of hind tarsi flattened, expanded distally.

Antennal formula I: II: III: IV; 0.85: 0.40: 0.45: 0.40.

Proportions of Legs

	femur	tibia	tarsal 1	tarsal 2	tarsal 3
Anterior	0.90	0.93	0.03	0.25	-
Middle	1.50	1.10	0.05	0.50	0.63
Posterior	1.25	1.30	0.05	0.10	0.30

Abdominal sternite VI depressed distally on each side of midline, medially densely pilose (fig. 184); sternite VII strongly carinate on midline, depressed on each side of carina; sternite VIII carinate on midline, directed ventrally at about a 30° angle. Parameres symmetrical, shape as shown in figures 181, 182.

Length: mean = 2.89 mm s = 0.09 N = 10.
Width: mean = 1.18 mm s = 0.04 N = 10.

Macropterous male. Similar to apterous form except that pronotum is lengthened caudad. Abdominal carinae reaching posterior margin of tergite II. Wings black, sometimes lighter basally, with 3 closed cells in distal half, extending beyond tip of abdomen.

Length: mean = 3.38 mm s = 0.15 N = 3.
Width: mean = 1.35 mm s = 0.03 N = 3.

Apterous female. Dorsum hair free and slightly rugose on abdominal tergites IV-VII; abdominal tergites not shining. Otherwise coloration and hairiness as in male.

Proepisternum without minute black denticles. Posterior femur armed beyond middle with a moderate length (0.15) spine, followed by a row of 5 smaller spines decreasing in length distally, and one or two tiny teeth adjacent anteriorly. Posterior tibia basally with a row of 6 black pegs, a few more distally, and a stout black apical spur. Abdomen distally truncate; connexiva raised, almost vertical along tergites VI-VII, distally forming a short broad angular projection set with a posteriorly directed tuft of stout setae; tergite VIII directed very slightly ventrad; proctiger directed ventrad.

Length: mean = 2.97 mm s = 0.07 N = 10.
Width: mean = 1.23 mm s = 0.04 N = 10.

Macropterous female. Coloration and most other characteristics as in apterous females. Pronotum similar in shape to male; humeri not produced. Abdomen similar to apterous form. Wings long, extending well beyond apex of abdomen.

Length: mean = 3.64 mm s = 0.03 N = 4.
Width: mean = 1.40 mm s = 0.05 N = 4.

Material examined. Holotype, apterous male and allotype, apterous female: INDONESIA, Celebes, **Sulawesi Utara Prov.**, Kab. Bolaang Mongondow: Tumpah River, Dumoga-Bone Nat. Park, 0° 34'N, 123° 54'E, CL 2100, IX-4-1985, 222 m. (730 ft.), water temp. 23.25° C., J. T. & D. A. Polhemus (BMNH).

Paratypes as follows (many apterous male and female specimens, all collected by J. T. and D. A. Polhemus, JTPC; only the rarer macropters are noted): INDONESIA, Celebes, **Sulawesi Utara Prov.**, Kab. Bolaang Mongondow: many apterous specimens plus 2 macropterous females, Toraut River, above Toraut Diversion Dam, 0° 34'N, 123° 54'E, 211 m. (690 ft.), CL 2099, water temp. 23.25° C., IX-3-1985; apterous specimens plus 5 macropterous males, 1 macropterous female, CL 2100, same data as holotype; apterous

specimens plus 3 macropterous males, 3 macropterous females, Tumpah River tributary, Dumoga-Bone Nat. Park, 0° 35'N, 123° 54'E, CL 2101, 235 m. (770 ft.), water temp. 22.30° C., IX-5-1985; stream 4 km S. of Inobonto, CL 2106, IX-6-1985; stream at Loban, NW of Kotamobagu, CL 2107, IX-6-1985; warm stream 8 km S. of Dolodua, on Malibagu Rd., CL 2110, IX-7-1985; Sungai Metelanga, 5 km S. of Dolodua, CL 2111, IX-7-1985; swift stream at S. end of Lake Moat, 1000 m. (3280 ft.), CL 2117, IX-10-1985; Pononontuna River at Tapakulintang, 200 m. (660 ft.), CL 2121, IX-15-1985. INDONESIA, Celebes, **Sulawesi Utara Prov.**, Kab. Minahasa: stream at Dimembe, NE of Manado, CL 2126, IX-19-1985; apterous specimens plus 1 macropterous male, Tondano River tributary, S. of Airmadidi, CL 2127, IX-20-1985; stream W. of Danowudu, E. of Manado, CL 2129, IX-20-1985. INDONESIA, Celebes, **Sulawesi Tengah Prov.**, Kab. Donggala: apterous specimens plus 5 macropterous males, 7 macropterous females, small stream 26 km. SE of Palu along Palolo Valley Road, CL 2154, 700m. (2300 ft.), X-5-1985; 1 apterous male, 3 macropterous males, 4 macropterous females, stream along Lindu Foot Path, Lore Lindu Nat. Park, 42 km. SE of Palu, CL 2155, 830m. (2720 ft.), X-5-1985; Raba River, upper Palolo Valley, Lore Lindu Nat. Park, CL 2159, 600 m. (1970 ft.), X-8- 1985; apterous specimens plus 2 macropterous males, 1 macropterous female, stream 9 km. E. of Taweli, NE of Palu on Poso Road, CL 2160, 150m. (490 ft.), X-10-1985.

Discussion. Of the Celebes species *R. celebensis* most closely resembles *Rhagovelia sulawesiana* in general appearance although they belong to different groups; see the discussion under the latter species and key. About half of the macropterous specimens have the wings broken off close to the base; only those with full length wings were measured. The species name *celebensis* is derived from the Celebes, the island of origin.

R. celebensis prefers wide, unshaded streams where it cruises in midstream in the current. Large aggregations, often composed primarily of females and immatures, were also found in sheltered but unshaded areas along the banks.

Rhagovelia samardaca, new species Figures 194-200

Description. Apterous male. Ground color yellowish brown; abdominal tergites medially brown to yellowish (on tergites V- VII), broadly pruinose laterally on metanotum and tergites III-V; anterior transverse band on pronotum luteous, broad, covering anterior third, extending onto and concolorous with venter. Venter yellowish brown to luteous with oval brownish areas laterally below spiracles; coxal cavities narrowly darker distally. Legs and antennae luteous, darker on distal segments. Pronotum long, covering mesonotum; length:width, 0.70: 1.00. Length of metanotum on midline, 0.10. Abdominal tergites I-VI subequal in length (0.15-0.20), tergite VII longer (0.33).

Proepisternum, anterior coxal cavity, mesosternum mesad of coxal cavities, abdominal sternites II-IV medially, with a few minute black denticles. Dorsum clothed with scattered long dark setae and a few shorter dark setae. Venter clothed with long semierect setae. Legs and antennae clothed with usual scattered black spines, legs with additional long setae. Posterior trochanter armed with 5 stout black-tipped pegs and a few small black teeth. Posterior femur armed with numerous small black teeth broadly scattered from base to distal end, plus one longer (0.13) spine beyond middle, 6 or 7 smaller spines distally and several smaller spines at about middle, none in an even row. Posterior tibia beneath with black teeth along entire length in several rows, one stout spine at distal three-fourths and several stout teeth at and near distal end. Downcurving arolia of hind tarsi narrow, flattened.

Antennal formula I: II: III: IV; 0.60: 0.35: 0.50: 0.45.

Proportions of Legs

	femur	tibia	tarsal 1	tarsal 2	tarsal 3
Anterior	0.90	0.90	0.05	0.23	-
Middle	1.48	1.23	0.10	0.35	0.68
Posterior	1.45	1.33	0.05	0.05	0.33

Abdominal sternites VII and VIII without evident modification. Parameres symmetrical, shape as shown in figure 200.

Length:	mean = 2.89 mm	s = 0.10	N = 10
Width:	mean = 1.09 mm	s = 0.03	N = 10

Macropterous male. Unknown.

Apterous female. Most of coloration and hairiness as in male; abdominal tergites not shining. Connexiva raised, slightly curved inward along tergite IV, vertical along tergites V-VIII, margins black and set with stiff black setae. Dorsum without setae on abdominal tergites IV-VII except on posterior margin of VII.

Proepisternum, mesosternum mesad of coxal cavities, abdominal sternites II-V medially with a few minute black denticles. Posterior femur armed at middle with a moderate length (0.13) spine, followed by a row of 6 smaller spines decreasing in length distally and about 5 additional black teeth in a ragged parallel row anterior to first row. Posterior tibia beneath set with

about 30 black pegs along entire length, not in straight rows.

Abdomen distally without significant modification (figs. 195, 199); connexiva distally truncate. Tergite VIII on same plane as VII; proctiger directed caudad.

Length:	mean =	3.04 mm	s = 0.07	N = 10
Width:	mean =	1.17 mm	s = 0.03	N = 10

Macropterous female. Coloration and most other characteristics as in apterous females. Dorsal setae on pronotum present only on anterior and lateral margins. Pronotum not prolonged, rounded posteriorly; humeri prominent but not produced. Wings long, extending well beyond apex of abdomen, with four closed cells. Connexiva straight.

Length:	mean =	3.61 mm	s = 0.25	N = 2
Width:	mean =	1.39 mm	s = 0.04	N = 2

Material examined. Holotype, apterous male and allotype, apterous female: EAST MALAYSIA, Borneo, **Sabah**: small streams in watercress bog, km. 62 on Keningau Hwy., CL 2035, VIII-6-1985, J. T. & D. A. Polhemus (USNM).

Paratypes as follows: EAST MALAYSIA, Borneo, **Sabah**: many apterous males and females, 2 macropterous females, same data as holotype (JTPC); 16 apterous males, 30 apterous females, 2 nymphs, small forest stream 12 km. S. of Ranau, CL 2027, VIII-3-1985, J. T. and D. A. Polhemus (JTPC); many apterous males and females, small forest stream at km. 60 on Keningau Hwy., CL 2036, VIII-6-1985, J. T. and D. A. Polhemus (JTPC); many apterous males and females, 1 macropterous female, Tawau, Quoin Hill, Forest Camp 1, 3-5 km. WSW of Cocoa Research Station, VII-9 to VII-20-62, Y. Hirashima (BPBM, JTPC); 1 apterous male, 1 apterous female, 1 immature, Tawau Residency, Kalabakan River, 30 mi. W. of Tawau, XI-9 to XI-18-58, T. C. Maa (BPBM); 1 apterous female, Sandakan Residency, Gomantong Caves, 20 mi. S. of Sandakan, XI-22 to XI-26-58, T. C. Maa (BPBM); many apterous males and females, Tawau, Quoin Hill Cocoa Research Station, VII-26-62, Y. Hirashima (BPBM); 1 apterous female, Forest Camp, 19 km. N. of Kalabakan, XI-13-62, Y. Hirashima (BPBM).

Discussion. *Rhagovelia samardaca* is quite closely related to *R. christenseni*, but is slightly more robust than the latter. These two species may be separated from each other by the characters given in the key, and from all other congeners in the Old World, with the exception of *R. madagascariensis*, by the distinct bright silver-gray pruinose areas on the abdominal tergites. Other *Rhagovelia* species are known with faint or diffuse grayish pruinose areas on the abdominal dorsum, but not bright contrasting pruinose areas as in these three species.

This species is found in small shaded forest streamlets at higher elevations, where it frequents still pools or sheltered areas beneath undercut banks.

Rhagovelia christenseni, new species
Figures 201-207

Description. Apterous male. Ground color orange brown to brownish black. Abdominal tergites blackish brown, VII brown; V- VI feebly shining medially, VII shining; I, III-IV broadly pruinose laterally, II and V narrowly pruinose laterally, pruinose areas bright silvery gray, sharply demarcated. Anterior transverse band on pronotum yellow, wide (width about 1/2 of eye length), long, extending onto propleura. Venter black, proepisternum mostly yellowish, mesosternum yellowish laterally, sternite VII, genital segments and connexival margins brown to yellowish brown; coxal cavities yellowish. Legs and antennae brown ventrally, blackish brown dorsally, except basal half of antennal segment I and anterior femur, hind femur basally and beneath, all coxae, all trochanters yellowish. Pronotum long, covering mesonotum; length:width, 0.55: 0.85. Length of metanotum on midline, 0.08. Abdominal tergites I-VI subequal in length (0.13-0.18), tergite VII longer (0.33).

Proepisternum without, or with only a few minute black denticles in a narrow field adjacent to head at antennal sockets. Dorsum clothed with short appressed golden setae and scattered long brown setae (length greater than width of fore femur). Venter clothed with short to medium length golden recumbent setae and scattered long brown setae. Legs and antennae clothed with usual spines and long hairs. Posterior trochanter armed with 1 or 2 tiny black teeth. Posterior femur armed with a row of about 10 tiny black teeth basally, not reaching the large median spine, which is followed by a gap then distally by about 20 much smaller teeth scattered in roughly two ragged rows, and another large spine located more posteriorly (see fig. 203). Posterior tibia beneath beneath armed along entire length with two rows of stout short teeth, one much larger tooth at distal 9/10, and a stout apical spur. Downcurving arolia of hind tarsi dorsoventrally flattened, narrowing distally.

Antennal formula I: II: III: IV; 0.63: 0.30: 0.45: 0.38.

Proportions of Legs

	femur	tibia	tarsal 1	tarsal 2	tarsal 3
Anterior	0.73	0.68	0.03	0.20	-
Middle	1.15	0.95	0.08	0.28	0.55
Posterior	1.20	1.05	0.05	0.08	0.25

Abdominal sternites VII-IX shining, unmodified. Parameres symmetrical, shape as shown in figure 207.

Length: mean = 2.65 mm s = 0.05 N = 10..
Width: mean = 0.93 mm s = 0.04 N = 10.

Macropterous male. Unknown.

Apterous female. Abdominal tergites I-II tumid, IV-VI somewhat depressed, III-VII without long setae; V-VI faintly shining, VII shining; tergites III-IV completely pruinose except a small median area anteriorly on tergite III, other tergites with pruinose areas as in male. Connexiva raised, becoming vertical posteriorly, sinuate, incurved along tergites IV-V. Otherwise coloration and hairiness as in male.

Proepisternum without, or with very few minute black denticles in a narrow field adjacent to head at antennal sockets. Posterior femur armed at middle with a moderate length (0.10) spine, followed by a row of 6 smaller spines decreasing in length distally. Posterior tibia basally with a row of about 18-20 black pegs in two rows. Abdomen distally projecting; connexiva distally truncate. Tergite VIII almost on same plane as VII; proctiger slightly deflected ventrad, projecting posteriorly.

Length: mean = 2.81 mm s = 0.12 N = 10.
Width: mean = 1.03 mm s = 0.05 N = 10.

Macropterous female. Coloration and most other characteristics as in apterous females. Dorsal setae on pronotum short. Pronotum prolonged to cover wing bases, rounded posteriorly, not modified; humeri weakly produced. Wings extending to tip of abdomen, with 2 light longitudinal light streaks on basal half, with 3 closed cells. Connexiva only slightly raised, lateral margins not sinuate.

Length: mean = 3.13 mm s = 0 N = 1.
Width: mean = 1.26 mm s = 0 N = 1.

Material examined. Holotype, apterous male and allotype, apterous female: INDONESIA, Borneo, **Kalimantan Timur Prov.**: waterfall 4 km S. of Kota Bangun, CL 2095, VIII-29-1985, J. T. & D. A. Polhemus (USNM).

Paratypes (all collected by J. T. and D. A. Polhemus, JTPC): INDONESIA, Borneo, **Kalimantan Timur Prov.**: many apterous males and females, same data as holotype; many apterous males and females, 1 macropterous female, small waterfall 4 km. NE of Kota Bangun, CL 2093, VIII-27-1985; many apterous males and females, spring and waterfall, 3 km. NE of Kota Bangun, CL 2092, VIII-27- 1985.

Discussion. *Rhagovelia christenseni* is closely related to *R. samardaca*; see key, and notes under the latter. The coloration, especially of the posterior part of the pronotum, varies from brownish black to yellowish tinged with brown. This species is named in honor of Mikkel Christensen who guided us to the type locality and other remarkable places in the Kota Bangun area.

This species was common around Kota Bangun in the small shallow streams that flowed off of low sandstone hills rising from the Mahakam River swamp forests. Although the surrounding forest was heavily disturbed, most of these habitats were deeply shaded by gallery forests. The orange insects blended in well against the orange-brown sandstone that formed the streambeds in this area.

Rhagovelia meikdelyi, new species
Figures 172-178

Description. Apterous male. Ground color orange brown; abdominal tergites orange brown; anterior transverse band on pronotum lighter, not demarcated.Venter darker medially and on pleura, abdominal sternites laterally infuscated except connexiva; abdominal venter carinate on midline, forming a sharp carina on sternite VII; coxal cavities yellowish. Legs and antennae yellowish basally, darkening to orange brown distally; antennal segments II - IV dark. Pronotum long, covering mesonotum except posteriorly (see fig. 172); length:width, 0.88: 1.13. Length of metanotum on midline, 0.10. Abdominal tergites I - VI subequal in length (0.20-0.25), tergite VII longer (0.33).

Proepisternum with numerous minute black denticles. Dorsum clothed with fine golden pubescence and numerous long black setae; venter clothed with medium length appressed golden pubescence, and laterally with long black setae; legs and antennae clothed with long slender black setae, dorsally with scattered long black stouter setae. Posterior trochanter each armed with one stout tooth and four smaller teeth; posterior femur armed with a single row of stout teeth, one large tooth before middle and about 8 or 9 smaller pegs beyond, also a single row of about 13 closely set tiny teeth in a single row basally. Posterior tibia beneath armed along entire length with black teeth. Downcurving arolia of hind tarsus long and slender.

Antennal formula I: II: III: IV; 0.83: 0.45: 0.55: 0.45.

Proportions of Legs

	femur	tibia	tarsal 1	tarsal 2	tarsal 3
Anterior	0.93	1.00	0.05	0.25	-
Middle	1.55	1.18	0.08	0.43	0.65
Posterior	1.58	1.33	0.05	0.13	0.35

Abdominal segment VIII formed as shown in figures 172, 176; ventrally carinate on midline and produced posteroventrally. Parameres symmetrical, shape as shown in figure 178.

Length: mean = 3.50 mm s = 0.29 N = 3
Width: mean = 1.23 mm s = 0.08 N = 3

Macropterous male. Unknown

Apterous female. Coloration and hairiness as in male. Proepisternum with many minute black denticles. Posterior femur armed beyond middle with a long (0.20) spine, followed by a row of nine smaller spines decreasing in length distally; without armature basally. Posterior tibia with a row of numerous black pegs along entire length. Abdomen not carinate ventrally; connexiva distally truncate (figs. 173, 177). Tergites VIII-IX directed ventrally.

Length: mean = 3.69 mm s = 0.06 N = 10
Width: mean = 1.36 mm s = 0.04 N = 10

Macropterous female. Coloration and most other characteristics as in apterous females. Dorsal setae on pronotum long along anterior and posterior margins, short medially; Pronotum not prolonged, rounded posteriorly; humeri slightly raised. Abdomen similar to apterous form. Wings long, extending well beyond apex of abdomen.

Length: mean = 3.79 mm s = 0 N = 1
Width: mean = 1.62 mm s = 0 N = 1

Material examined. Holotype, apterous male, and allotype, apterous female: INDONESIA, Ambon, **Maluku Prov.**, Kab. Maluku Tengah: Wairea River nr. Wairea, 0-100 m. (0-330 ft.), CL 2153, 4-X-1985, J. T. & D. A. Polhemus (USNM).

Paratypes: 2 apterous males, 14 apterous females, 1 macropterous female, same data as holotype (in JTPC; MZB).

Discussion. *Rhagovelia meikdelyi* n. sp. is most closely related to *Rhagovelia wallacei*, from northern and central Celebes. It occurs with *Rhagovelia ambonensis* Lundblad, but may be separated from the latter by the coloration (orange brown in *meikdelyi*, black to brown in *ambonensis* except in teneral specimens), and the shape of the male and female caudal abdominal segments. Light colored or teneral specimens of *ambonensis* are often light yellowish to yellow brown, especially ventrally, and have the light pronotal stripe continuing on the propleura, but can be distinguished by the distally dark femora and characters given above. The species name honors Meky Meikdely who helped us greatly during our stay on Ambon.

Rhagovelia wallacei, new species Figures 187-193

Description. Apterous male. Ground color blackish brown; abdominal tergites same, tergite VII shining medially; anterior transverse band on pronotum broad, yellow tinged with orange brown, widening laterally, continuous with similarly light colored propleura and prosternum. Venter dark except abdomen and metasternum medially, sternite VII, most of mesosternum brown; coxal cavities yellow. Legs and antennae luteous basally, darkening distally to brown except antennae blackish brown beyond middle of segment I. Pronotum long, covering mesonotum; length: width, 0.80: 1.03. Length of metanotum on midline, 0.10. Abdominal tergites I-VI subequal in length (0.15-0.20), tergite VII longer (0.35).

Procpisternum, jugum of head, mesosternum and metasternum, thoracic pleura and most of abdomen except sternite VII medially with numerous minute black denticles. Dorsum clothed with short appressed golden pubescence; scattered long dark semi-recumbent setae along sides of thorax, abdominal tergites (especially along hind margin); erect setae on vertex. Venter clothed with short appressed pubescence except for a brush of stiff semi-erect hairs medially on abdominal sternites V-VI; except for sternite VII, covered with minute black denticles, often difficult to see against dark background. Legs and antennae clothed with usual spines and long hairs, except anterior tibia thickly set anteriorly and posteriorly with setae about as long as width of tibia. Posterior trochanter armed with 5 or 6 short stout teeth. Posterior femur armed with a row of 10 tiny teeth basally, one larger spine before middle followed by a row of 8 spines of decreasing length distally, and another more anterior parallel row of 5 or 6 spines beginning beyond middle; all spines black- tipped. Posterior tibia curved, armed beneath with numerous black pegs over entire length, sparser distally. Downcurving arolia of hind tarsi dorsoventrally flattened.

Antennal formula I: II: III: IV; 0.68: 0.35: 0.43: 0.38.

Proportions of Legs

	femur	tibia	tarsal 1	tarsal 2	tarsal 3
Anterior	0.88	0.93	0.03	0.25	-
Middle	1.43	1.15	0.05	0.45	0.38
Posterior	1.25	1.13	0.05	0.10	0.30

Abdominal sternite VII flattened and weakly carinate on midline posteriorly; sternite VIII not modified. Parameres symmetrical, shape as shown in figure 189.

Length:	mean = 3.16 mm	s = 0.14	N = 10.
Width:	mean = 1.20 mm	s = 0.04	N = 10.

Macropterous male. Similar to apterous form except that pronotum is lengthened caudad. Wings extending beyond tip of abdomen, with 4 closed cells (2 in distal half); wing color dark gray brown, veins concolorous, with a broad longitudinal light streak along costal margin over basal 1/3, darkening posteriorly.

Length:	mean = 3.61 mm	s = 0.17	N = 7.
Width:	mean = 1.43 mm	s = 0.07	N = 7.

Apterous female. Coloration and hairiness similar to male; abdominal tergites not shining. Connexiva raised, vertical to reflexed posteriorly. Covering of minute black denticles as in male. Posterior femur armed with at most 1 or 2 tiny teeth basally, and before middle with a long spine followed by a row of 7 smaller spines decreasing in length distally, plus a more anterior row of 2 or 3 spines beginning at distal 2/3; all spines black-tipped. Posterior tibia set with numerous black pegs over entire length in several rows.

Abdomen distally truncate; connexiva distally angulate, not produced, set with a tuft of posteriorly directed setae. Tergite VIII directed downward at a sharp angle, proctiger directed ventrally, both barely visible in lateral view, withdrawn into segment VII.

Length:	mean = 3.26 mm	s = 0.17	N = 10.
Width:	mean = 1.28 mm	s = 0.07	N = 10.

Macropterous female. Coloration and most other characteristics as in apterous females except disc of pronotum darker. Pronotum not produced posteriorly, rounded at apex; humeri prominent. Abdomen straight, not upturned. Wings as in macropterous male, extending slightly beyond apex of abdomen. Connexiva and abdomen distally as in macropterous male.

Length:	mean = 3.79 mm	s = 0.35	N = 4.
Width:	mean = 1.48 mm	s = 0.05	N = 4.

Material examined. Holotype, apterous male, and allotype, apterous female: INDONESIA, Celebes, **Sulawesi Utara Prov.**, Kab. Bolaang Mongondow: Tumpah River tributary, Dumoga-Bone Nat. Park, 0° 35'N, 123° 54'E, CL 2101, IX-5-1985, 235 m. (770 ft.), water temp. 23.0° C., J. T. & D. A. Polhemus (BMNH).

Paratypes as follows (many males and females, all apterous unless otherwise noted, collected by J. T. and D. A. Polhemus, JTPC): INDONESIA, Celebes, **Sulawesi Utara Prov.**, Kab. Bolaang Mongondow: same locality as holotype; Tumpah River, Dumoga-Bone Nat. Park, 0° 34'N, 123° 54'E, CL 2100, 222 m. (730 ft.), water temp. 23.25° C., IX-4-1985; stream 4 km. S. of Inobonto, CL 2106, IX-6-1985; upper Metelanga Riv. and tributary, 10 km S. of Dolodua, CL 2108, IX-7-1985; Metelanga Riv., 5 km S. of Dolodua, CL 2111, IX-7-1985; cave spring and stream at Komangaan, NW of Kotamobagu, CL 2120, IX-14-1985; Pononontuna River at Tapakulintang, 200 m. (660 ft.), CL 2121, IX-15-1985. INDONESIA, Celebes, **Sulawesi Utara Prov.**, Kab. Minahasa: apterous specimens plus 1 macropterous male, 2 macropterous females, Tondano River tributary, S. of Airmadidi, CL 2127, IX-20-1985; stream nr. Manembonembo, E. of Manado, CL 2128, IX-20-1985; stream W. of Danowudu, E. of Manado, CL 2129, IX-20-1985; stream 3 km. SW of Rurukan, CL 2130, IX-21-1985. INDONESIA, Celebes, **Sulawesi Tengah Prov.**, Kab. Donggala: apterous specimens plus 3 macropterous males, 1 macropterous female, small stream 26 km SE of Palu along Palolo Valley Road, CL 2154, 700m. (2300 ft.), X-5-1985; apterous specimens plus 3 macropterous males, 1 macropterous female, stream along Lindu Foot Path, Lore Lindu Nat. Park, 42 km. SE of Palu, CL 2155, 830 m. (2720 ft.), X-5-1985; stream 5 km. SE of Kamarora, upper Palolo Valley, Lore Lindu Nat. Park, CL 2157, 750 m. (2460 ft.), X-8-1985; stream 9 km. E. of Taweli, NE of Palu on Poso Road, CL 2160, 150 m. (490 ft.), X-10-1985; stream SE of Oloboju, 19 km. SE of Palu, Palu Valley, CL 2162, 200 m. (660 ft.), X-10-1985. INDONESIA, Celebes, **Sulawesi Selatan Prov.**, Kab. Maros: 1 apterous male, Maros River, Bantimurung Waterfall nature reserve, CL 2166, 0-100 m. (0-330 ft.), X-13-1985.

Discussion. *Rhagovelia wallacei* n. sp. is quite closely related to *R. minahasa* n. sp., with differences as noted in the key. Aside from the hair tufts on the venter, the males are more difficult to distinguish than the females. The vestiture of minute black denticles on the pleura and upper body is quite variable; in some specimens it is extensive, whereas in others it is much reduced, similar to that seen in *R. kawakamii* (Matsumura) and *R. grayi*. The specimens from Lore Lindu National Park in the central Celebes are generally much lighter in coloration than those from the Minahasa Peninsula. This species is named in honor of Alfred Russel Wallace, the great naturalist and explorer who spent many years in the Malay Archipelago.

R. wallacei was abundant in the Tumpah River system above the Project Wallace base camp in north Celebes, especially on a tributary known as the "waterfall stream". The streams in this region are swift, clear, rocky, and well shaded by primary rain forest. *R. wallacei* here preferred sheltered situations next to the banks in shady areas, and was often found in the net-

works of small pools formed on partially flooded cobble bars.

Rhagovelia minahasa, new species Figures 216-222

Description. Apterous male. Ground color black; abdominal tergites black, not shining except a wedge on tergite VII; anterior transverse band on pronotum yellow brown, extending onto pleura and venter. Venter mosly blackish; yellowish along connexival margins; yellow brown to brown on prothorax, laterally on mesothorax, and abdominal sternite VII; coxal cavities luteous. Legs and antennae brown except beneath and basally on first antennal, anterior and posterior femora basally, luteous. Pronotum long, covering mesonotum (see fig. 216); length:width, 0.85: 1.08. Length of metanotum on midline, 0.10. Abdominal tergites I-VI subequal in length (0.23-0.25), tergite VII longer (0.45).

Proepisternum and entire body except for sternite VII medially covered with numerous minute black denticles. Dorsum clothed with fine silvery recumbent pubescence and a few scattered long black setae along pronotal margins. Venter clothed with short inconspicuous silvery pubescence; legs and antennae clothed with usual scattered long slender black setae, and a few scattered long yellowish setae. Posterior trochanter each armed with two or three small black teeth and two long (0.20) curved dark setae. Posterior femur armed with a long (0.23) stout spine before middle and 8 or 9 smaller pegs beyond in a single row, and a second parallel row of 6 or 7 smaller pegs, also a single row of about 10 closely set tiny teeth basally. Posterior tibia beneath armed along entire length with black teeth. Downcurving arolia of hind tarsus long and slender.

Antennal formula I: II: III: IV; 0.75: 0.45: 0.53: 0.40.

Proportions of Legs

	femur	tibia	tarsal 1	tarsal 2	tarsal 3
Anterior	0.95	1.08	0.05	0.28	-
Middle	1.65	1.28	0.08	0.58	0.65
Posterior	1.43	1.33	0.08	0.13	0.35

Abdominal venter weakly carinate medially on sternites VII and VIII; sternite VII slightly depressed on each side of middle. Parameres symmetrical, shape as shown in figure 222.

Length: mean = 3.27 mm s = 0.13 N = 10.
Width: mean = 1.16 mm s = 0.04 N = 10.

Macropterous male. Similar to apterous form except that pronotum is lengthened caudad, rounded posteriorly, and black except for anterior yellow band. Wings blackish brown, veins black, lighter basally between M and Sc, forming an elongate streak.

Length: mean = 3.64 mm s = 0.07 N = 6.
Width: mean = 1.42 mm s = 0.04 N = 6.

Apterous female. Coloration and hairiness as in male. Abdominal tergites not shining, frosted, almost naked. Connexiva margined with yellowish, abruptly incurved along tergite V. Vestiture of minute black denticles as in male. Middle femur flattened dorsoventrally; posterior femur armed at middle with a long (0.20) spine, followed by a row of 7 smaller spines decreasing in length distally; diameter abruptly greater proximal to middle (see fig. 219), dorsal surface of narrower part shining, hair free. Posterior tibia with a row of numerous black pegs along entire length. Abdomen not carinate ventrally, distally truncate, connexiva slightly produced distally (figs. 217, 220). Tergite VIII sharply directed ventrad, truncate; proctiger directed ventrad or forward, withdrawn into abdomen, not visible except in posterior view.

Length: mean = 3.65 mm s = 0.07 N = 10.
Width: mean = 1.24 mm s = 0.05 N = 10.

Macropterous female. Coloration and most other characteristics as in apterous females. Scattered dorsal setae on lateral and anterior margins of pronotum long, black. Pronotum not prolonged, rounded posteriorly; humeri slightly raised. Abdomen straight, connexiva not modified; tergites VIII-IX as in apterous female. Wings long, extending well beyond apex of abdomen, similar to male.

Length: mean = 3.84 mm s = 0.08 N = 5.
Width: mean = 1.50 mm s = 0.047 N = 5.

Material examined. Holotype, apterous male, and allotype, apterous female: INDONESIA, Celebes, **Sulawesi Utara Prov.**, Kab. Bolaang Mongondow: swift clear stream nr. S. end of Lake Mala, 1000 m. (3280 ft.), CL 2117, IX-9-1985, J. T. & D. A. Polhemus (BMNH).

Paratypes as follows (all collected by J. T. and D. A. Polhemus, JTPC): INDONESIA, Celebes, **Sulawesi Utara Prov.**, Kab. Bolaang Mongondow: many apterous males and females, same data as holotype; many apterous males and females, 1 macropterous male, spring and pools, S. end of Lake Mala, CL 2115, 1050 m. (3440 ft.), IX-10-1985; 5 apterous males, 8 apterous females, slow muddy stream, S. end of Lake Mala, CL 2116, 1000 m. (3280 ft.), IX-10-1985; many apterous males and females, forest stream south of Lake Mala, CL 2118, 1200 m. (3940 ft.), IX-11-1985. INDONESIA, Celebes, **Sulawesi Utara Prov.**, Kab. Minahasa: many apterous males and females, 5 macropterous males, 3

macropterous females, spring 2 km. S. of Mokabang, N. of Lake Mala, CL 2123, 950 m. (3120 ft.), IX-17-1985.

Discussion. *Rhagovelia minahasa* n. sp.is most closely related to *R. grayi* and *R. lorelinduana*, differing primarily in the vestiture of tiny black denticles that are thickly scattered over the entire body of *minahasa*. The species name, a noun in apposition, refers to the type-locality, the Minahasa Peninsula of northern Celebes.

The known localities for *R. minahasa* cluster in the vicinity of Lake Mala, a crater lake high in the rugged mountains of Minahasa. There is some confusion as to the correct name for this locality, as it is referred to variously as either Lake Mala or Lake Mooat by the local people. Our Indonesian maps are also not consistent, calling it either Lake Mooat or Lake Danau, the latter meaning literally "lake lake". The U. S. Army Map Service 1:250,000 scale chart for this region shows the large lake in question to be Lake Mala, and a much smaller lake close by to the south to be Lake Mooat, and we have accepted this latter interpretation.

Rhagovelia kawakamii (Matsumura) Figures 74-80

Kotovelia kawakamii Matsumura 1913. Thousand Insects of Japan, Additamenta 1: 99. Type-locality, Kotosho Isle, Formosa.

Rhagovelia kawakamii, Lundblad 1937. Entomol. Tidsk. 58: 1. Redescription, figs.

Rhagovelia hoberlandti Hungerford & Matsuda 1961. Kansas Sci. Bull. 42: 260. Synonymized by Polhemus & Reisen 1976, Philipp. J. Biol. 5: 275.

Rhagovelia kawakamii, Polhemus & Reisen 1976. Philipp. J. Biol. 5: 275. Distr., Luzon; synonymy.

Description. Apterous male. Ground color black to blackish brown including abdominal tergites, tergite VII shining medially; connexiva and pronotum posteriorly broadly margined with yellowish; anterior transverse band on pronotum yellow, extending onto pleura and venter laterally. Venter black, lighter laterally on mesosternum; prosternum yellow; abdominal sternite VII shining orange brown medially; coxal cavities luteous. Legs and antennae brown except basal parts and inner margins of antennal segment I, coxae and trochanters, basal and anterior faces of fore and hind femora, luteous to yellow brown. Pronotum long, covering mesonotum; length:width, 0.80: 1.10. Length of metanotum on midline, 0.15. Abdominal tergites I-VI subequal in length (0.20-0.25), tergite VII longer (0.40).

Proepisternum and mesosternum adjacent to coxal cavities with many minute black denticles. Dorsum clothed with short inconspicuous recumbent setae and a few scattered longer setae along lateral margins. Venter clothed with moderate length semirecumbent yellowish setae and many long setae medially on abdomen. Legs and antennae clothed with the usual black spines and scattered longer setae; posterior femur with many long setae beneath. Posterior trochanter armed with about 3 small black teeth. Posterior femur distally armed beneath with many short to moderately long teeth and stout spines, the anterior and posterior rows irregular, with longest spines near middle and beyond, shorter spines scattered over entire ventral surface (fig. 80). Posterior tibia curved, armed beneath with several rows of black teeth along entire length, with 4 or 5 larger stout spines beyond middle and a stout apical spur. Downcurving arolia of hind tarsi long, slender.

Antennal formula I: II: III: IV; 0.78 : 0.40 : 0.45 : 0.45.

Proportions of Legs

	femur	tibia	tarsal 1	tarsal 2	tarsal 3
Anterior	0.90	0.93	0.05	0.28	-
Middle	1.43	1.15	0.08	0.40	0.70
Posterior	1.55	1.45	0.05	0.10	0.30

Abdominal sternite VII weakly depressed on each side of midline posteriorly; sternite VIII not modified; suranal plate with slight lateral protruberances. Parameres symmetrical, shape as shown in figure 76.

Length:	mean = 3.33 mm	s = 0.16	N = 4.
Width:	mean = 1.26 mm	s = 0.09	N = 4.

Macropterous male. Coloration and most other characteristics as in apterous males. Pronotum covering wing bases, not prolonged, rounded posteriorly; humeri not produced. Wings blackish brown, with a light streak on basal 3/8 lateral to medial vein; long, extending well beyond apex of abdomen, with four closed cells similar to *Rhagovelia pruinosa*.

Length:	mean = 3.96 mm	s = 0.19	N = 3.
Width:	mean = 1.52 mm	s = 0.05	N = 3.

Apterous female. Dorsum with coloration and hairiness as in male, except shorter on abdominal tergites, V-VII almost bare; abdominal tergites not shining. Connexiva upturned, increasingly vertical posteriorly, almost straight, not modified.

Proepisternum and mesosternum with minute black denticles as in male. Middle femur armed with an occasional basal spine, a moderate length spine just beyond middle, followed by about 4 or 5 smaller spines in two rows decreasing in length distally. Posterior tibia armed with several rows of short black pegs along en-

tire length. Abdomen distally truncate (fig. 75); connexiva ending distally in a blunt angle. Tergite VIII on the same plane as VII; proctiger projecting posteriorly.

Length:	mean = 3.35 mm	s = 0.17	N = 7.
Width:	mean = 1.25 mm	s = 0.05	N = 7.

Macropterous female. Coloration and most other characteristics as in macropterous males. Abdomen straight, not upturned. Connexiva straight.

Length:	mean = 3.70 mm	s = 0.06	N = 5.
Width:	mean = 1.41 mm	s = 0.04	N = 5.

Material examined. EAST MALAYSIA, Borneo, **Sabah**: 3 apterous males, 3 macropterous males, 6 apterous females, 5 macropterous females, stream 34 km. NE of Kota Belud, CL 2033, VIII-5-1985, J. T. & D. A. Polhemus (JTPC); 1 apterous male, 1 apterous female, H45, Ranau, V-13-1983, G. F. Hevel & W. E. Steiner (USNM).

Discussion. *Rhagovelia kawakamii* (Matsumura) is most closely related to *R. lorelinduana* and *R. grayi*. In addition to the key characters, *R. kawakamii* may be separated from the latter two species by the absence of a carina on male abdominal sternite VII and the horizontal aspect of female abdominal tergites VIII and IX in lateral view.

Rhagovelia grayi, new species Figures 208-215

Description. Apterous male. Ground color brown to orange brown including abdominal tergites, connexiva broadly margined with yellowish; anterior transverse band on pronotum yellow, extending onto pleura and venter laterally. Venter yellow to orange, darker in places on pleura; coxal cavities luteous. Legs and antennae brown except basal parts and inner margins of antennal segment I, coxae and trochanters, basal and anterior faces of fore and hind femora, luteous to yellow brown. Pronotum long, covering mesonotum; length:width, 0.83: 1.15. Length of metanotum on midline, 0.15. Abdominal tergites I-VI subequal in length (0.23-0.30), tergite VII longer (0.45).

Proepisternum with many minute black denticles. Dorsum clothed with short inconspicuous recumbent setae and a few scattered longer setae along lateral margins. Venter clothed with moderate length semirecumbent yellowish setae. Legs and antennae clothed with the usual black spines and scattered longer setae. Posterior trochanter armed with about 8 small black teeth. Posterior femur distally armed beneath with two rows of stout spines, the first row consisting of a stout spine before middle followed by one stouter spine and 6 smaller spines decreasing in size distally, and a second more anterior row of about 8 smaller spines; basally with a row of about 26 tiny teeth and one slightly larger tooth near middle (fig. 211). Posterior tibia beneath armed with two rows of black teeth along entire length, and one stout spine at distal three-fourths. Downcurving arolia of hind tarsi long, slender.

Antennal formula I: II: III: IV; 0.83 : 0.48 : 0.68 : 0.55.

Proportions of Legs

	femur	tibia	tarsal 1	tarsal 2	tarsal 3
Anterior	1.10	1.18	0.05	0.35	-
Middle	1.78	1.55	0.08	0.50	0.78
Posterior	1.85	1.83	0.08	0.15	0.43

Abdominal sternite VII weakly carinate on midline; sternite VIII not modified; proctiger with lateral tubercles and protuberances (fig. 215). Parameres symmetrical, shape as shown in figure 214.

Length:	mean = 3.99 mm	s = 0.12	N = 9.
Width:	mean = 1.31 mm	s = 0.06	N = 9.

Macropterous male. Unknown.

Apterous female. Dorsum with coloration and hairiness as in male; abdominal tergites not shining. Connexiva upturned; expanded, incurved, yellow and glabrous dorsally along tergites IV and V.

Proepisternum with many minute black denticles. Middle femur armed beyond middle with a moderate length (0.20) spine, set in the middle of a row of about 9 smaller spines decreasing in length basally and distally. Posterior tibia with a few inconspicuous black pegs distally. Abdomen distally angulate (fig. 209, 212); connexiva distally forming an acute angle, tipped with stiff setae, apices touching beyond tergite VII. proctiger extending caudad from tergite VIII, the latter inclined slightly ventrad.

Length:	mean = 4.09 mm	s = 0.07	N = 7.
Width:	mean = 1.36 mm	s = 0.03	N = 7.

Macropterous female. Coloration and most other characteristics as in apterous females. Pronotum not prolonged, rounded posteriorly; humeri not produced. Abdomen straight, not upturned. Wings blackish brown, lighter basally; long, extending well beyond apex of abdomen, with four closed cells similar to *Rhagovelia pruinosa*. Connexiva straight.

Length:	mean = 4.34 mm	s = 0	N = 1.
Width:	mean = 1.67 mm	s = 0	N = 1.

Material examined. Holotype, apterous male, and allotype, apterous female: INDONESIA, Celebes, **Sulawesi Utara Prov.**, Kab. Minahasa: spring & stream 2 km. S. of Mokabang, N. of Lake Mala, CL 2123, IX-17-1985, 950 m. (3120 ft.), J. T. & D. A. Polhemus (BMNH).

Paratypes as follows: 8 apterous males, 6 apterous females, 1 macropterous female, same data as holotype (JTPC; MZB).

Discussion. *Rhagovelia grayi* is most closely related to *R. lorelinduana*. In addition to the key characters, *R. grayi* may be separated from the latter by the slightly longer carina on male abdominal sternite VII, less strongly downturned female abdominal tergites VIII and IX, more robust body and slightly darker coloration. The species name honors Andy Gray of the Project Wallace military support staff, who took us to the spring where we collected the type series and helped us in many other ways during our stay in northern Celebes.

The type series was taken in the clear outflow from a roadside spring that flowed along a small overgrown ditch and into a larger rushing stream beyond. Most of the insects were found in a dark recess beneath a board that lay across across the spring streamlet. *R. minahasa* n.sp. occurred sympatrically with *R. grayi* at this locality.

Rhagovelia lorelinduana, new species Figures 141-148

Description. Apterous male. Ground color orange brown; abdominal tergites somewhat lighter distally; anterior transverse band on pronotum yellow brown, wide, reaching onto propleura. Venter orange brown, lighter along connexiva; coxal cavities yellowish. Legs and antennae brown except antennal segment I, all coxae, all trochanters, basal half of anterior and posterior femora, all femora beneath, yellowish to luteous. Pronotum long, covering mesonotum; length: width, 0.90: 1.08. Length of metanotum on midline, 0.10. Abdominal tergites I-VI subequal in length (0.23-0.28), tergite VII longer (0.53).

Proepisternum with a small field of minute black denticles. Dorsum clothed with short appressed golden setae. Venter clothed with short appressed golden setae, longer medially. Legs and antennae clothed with usual spines and scattered long setae, with several rows of long straight golden setae on hind femora and tibia beneath; anterior face of fore tibia shaggy. Posterior trochanter armed with 8 or 9 small stout teeth. Posterior femur armed with a basal row of 16-22 tiny dark teeth, not reaching to the large median spine, which is followed by 8-10 stout teeth decreasing in length distally and a second parallel row of 1-3 small stout located anterior to first. Posterior tibia sinuate, armed beneath with several rows of dark teeth along entire length, and at distal 2/3 with one larger tooth. Downcurving arolia of hind tarsi flattened.

Antennal formula I: II: III: IV; 0.95: 0.55: 0.73: 0.58.

Proportions of Legs

	femur	tibia	tarsal 1	tarsal 2	tarsal 3
Anterior	1.10	1.25	0.05	0.30	-
Middle	1.85	1.75	0.08	0.60	0.75
Posterior	1.83	1.68	0.08	0.18	0.45

Abdominal sternite VII weakly carinate medially, excavate on each side of midline; sternite VIII not modified, very slightly directed ventrad. Parameres symmetrical, shape as shown in figure 143.

Length:	mean = 3.83 mm	s = 0.16	N = 10.
Width:	mean = 1.19 mm	s = 0.05	N = 10.

Macropterous male. Unknown.

Apterous female. Dorsum with scattered moderate length setae, except abdominal tergites IV-VII hair free and carinate on midline, especially pronounced on tergites V-VI; abdominal tergites not shining. Connexiva strongly raised or vertical, sinuate, incurved and dorsally glabrous along tergites IV-V. Otherwise coloration and hairiness as in male.

Proepisternum with a small field of minute black denticles. Middle and posterior femur somewhat flattened dorsoventrally. Hind femur armed at distal 2/3 with a moderate length (0.13) spine, followed by a row of 5 small spines decreasing in length distally. Posterior tibia unarmed.

Abdomen distally truncate except connexiva distally produced, meeting distally over tergite VII, forming a pair of acuminate plate-like structures (fig. 142). Tergites VIII-IX strongly directed ventrally.

Length:	mean = 4.10 mm	s = 0.13	N = 10.
Width:	mean = 1.20 mm	s = 0.05	N = 10.

Macropterous female. Unknown.

Material examined. Holotype, apterous male, and allotype, apterous female: INDONESIA, Celebes, **Sulawesi Tengah Prov.**, Kab. Donggala: stream 10 km. SE of Kamarora, Lore Lindu National Park, CL 2156, X-5-1985, 950 m. (3120 ft.), J. T. & D. A. Polhemus (USNM).

Paratypes as follows: Many apterous males, females and nymphs, same data as holotype (JTPC).

Discussion. *Rhagovelia lorelinduana* is most closely related to *R. grayi*; see key and discussion under *grayi*. In addition *lorelinduana* females have a median carina on abdominal tergites V-VII lacking in *grayi*, and the terminal processes of the connexiva are more pronounced in the former. These two taxa are apparently allopatric sister species. The species name is derived from the type

locality, the beautiful Lore Lindu National Park in the central Celebes.

The type series was taken from dark sheltered pools along a swift mountain stream heavily shaded by primary montane rain forest in the headwaters of the Palolo Valley. The insects were often taken by scooping with a net into protected pockets beneath the banks or along fallen logs, and appeared to be negatively phototactic. *R. hamdjahi* n.sp. occurred sympatrically with *R. lorelinduana* at this locality.

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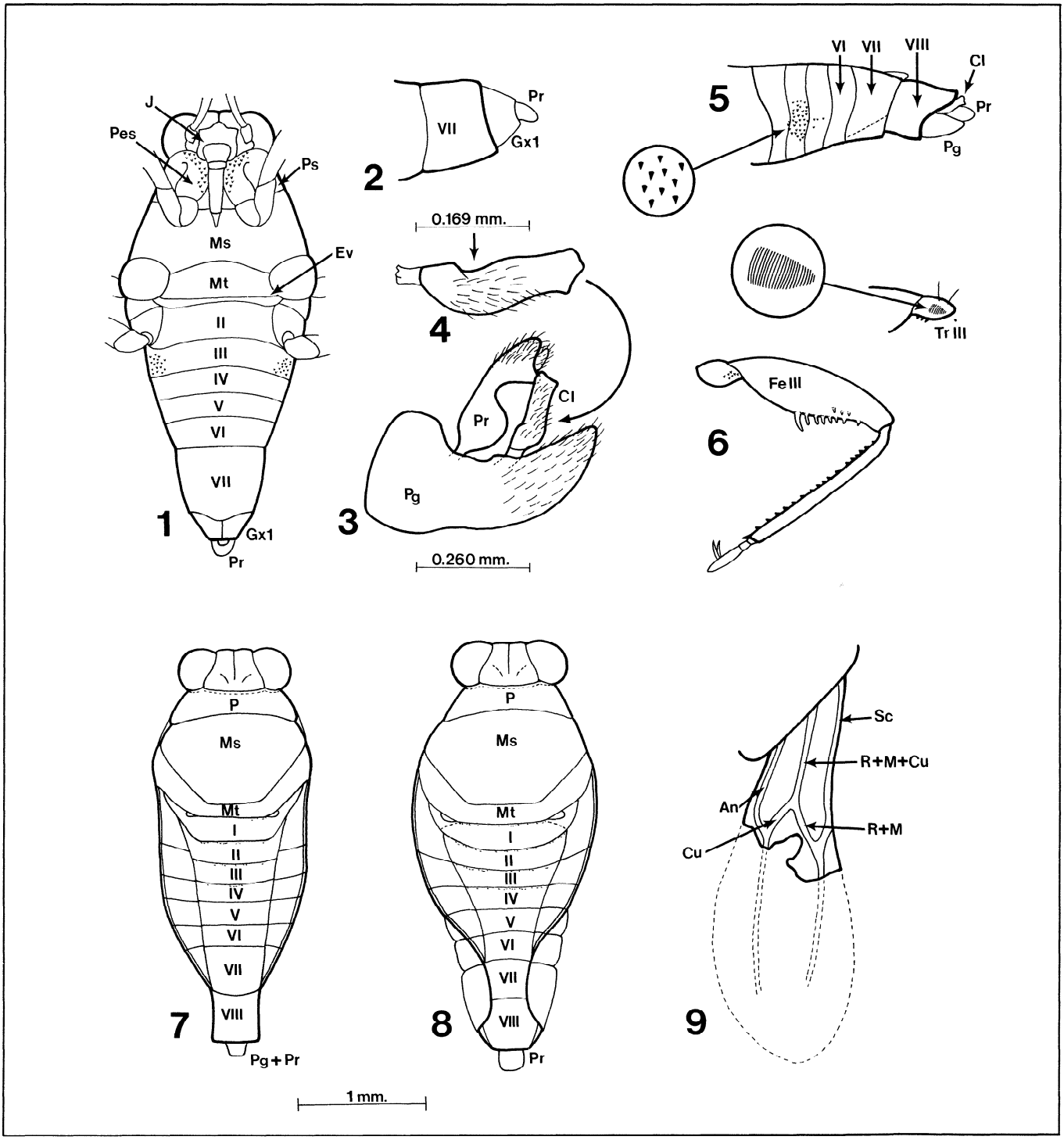


Figures 1-9. Morphology of *Rhagovelia lugubris* Lundblad (Java). 1, ventral view of female; 2, lateral view of female abdominal terminalia; 3, lateral view of male genital segments; 4, male paramere or clasper; 5, lateral view of male abdominal segments, showing segmentation and location and detail of stridulatory pegs on abdomen; 6, ventral view of male posterior leg, with auxilliary detail of stridulatory file on dorsum of trochanter; 7, dorsal view of male; 8, dorsal view of female; 9, forewing, with veins labelled. Legend: I-VIII, abdominal segments; An, anal vein; Cl, clasper or paramere; Cu, cubitus; Ev, evaporative channel; Fe III, posterior femur; Gxl, first gonocoxae; J, jugum; M, media; Ms, mesothorax (mesonotum or mesosternum); Mt, metathorax (metanotum or metasternum); P, pronotum; Pes, proepisternum; Pg, pygophore; Pr, proctiger; Ps, prosternum; R, radius; Sc, subcosta; Tr III, posterior trochanter.

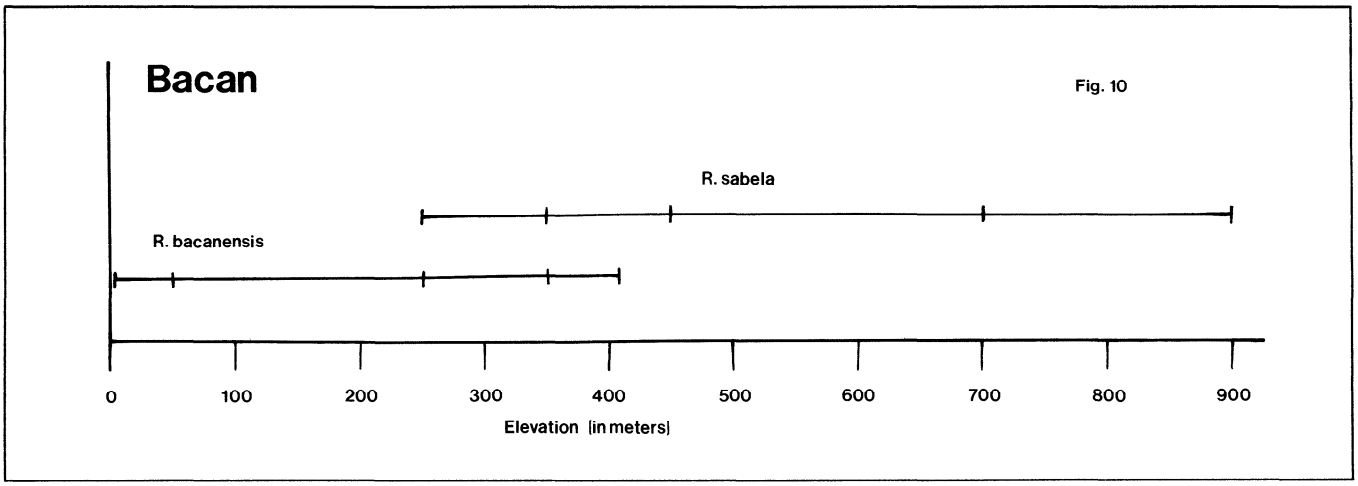


Fig. 10. Habitat partitioning by elevation of two *Rhagovelia* species on Mt. Sabela, Bacan Island (north Moluccas).

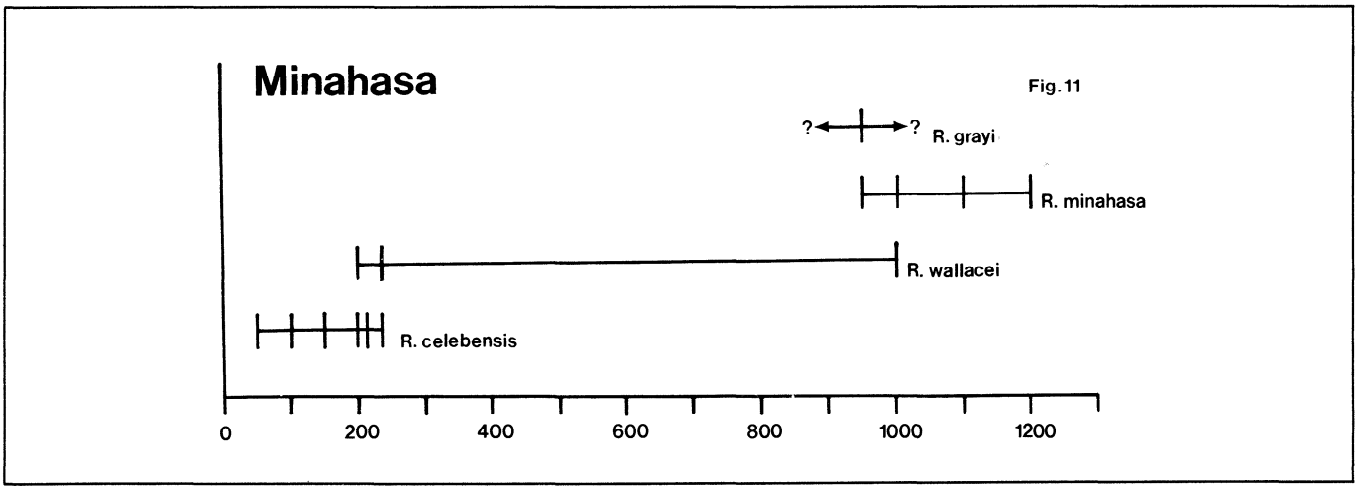


Fig. 11. Habitat partitioning by elevation of four *Rhagovelia* species in the Minahasa region (north Celebes).

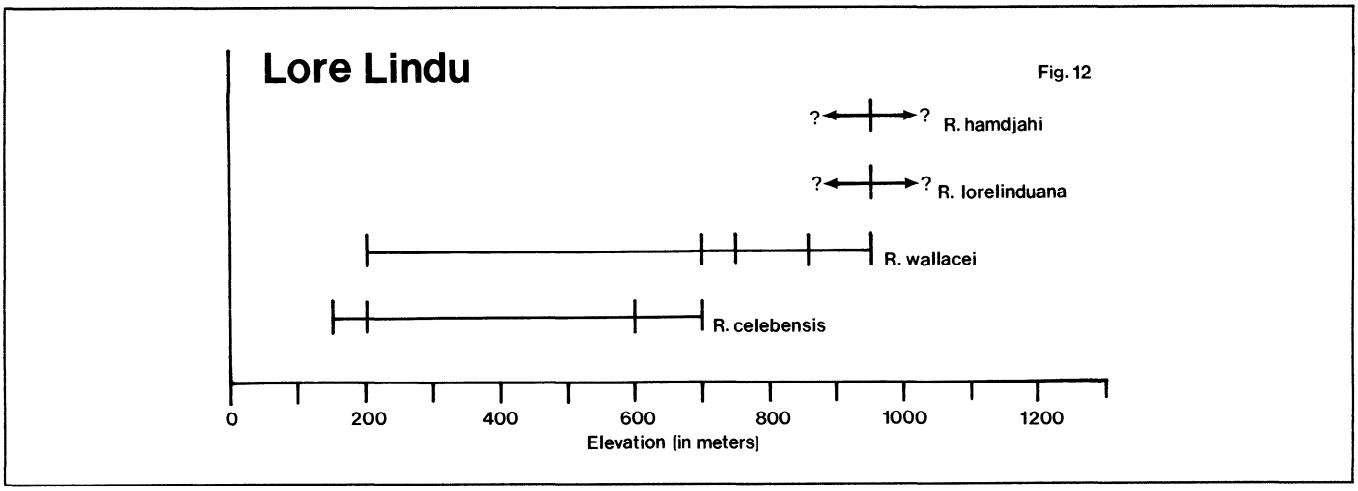


Fig. 12. Habitat partitioning by elevation of four *Rhagovelia* species in the Lore Lindu National Park area (central Celebes).

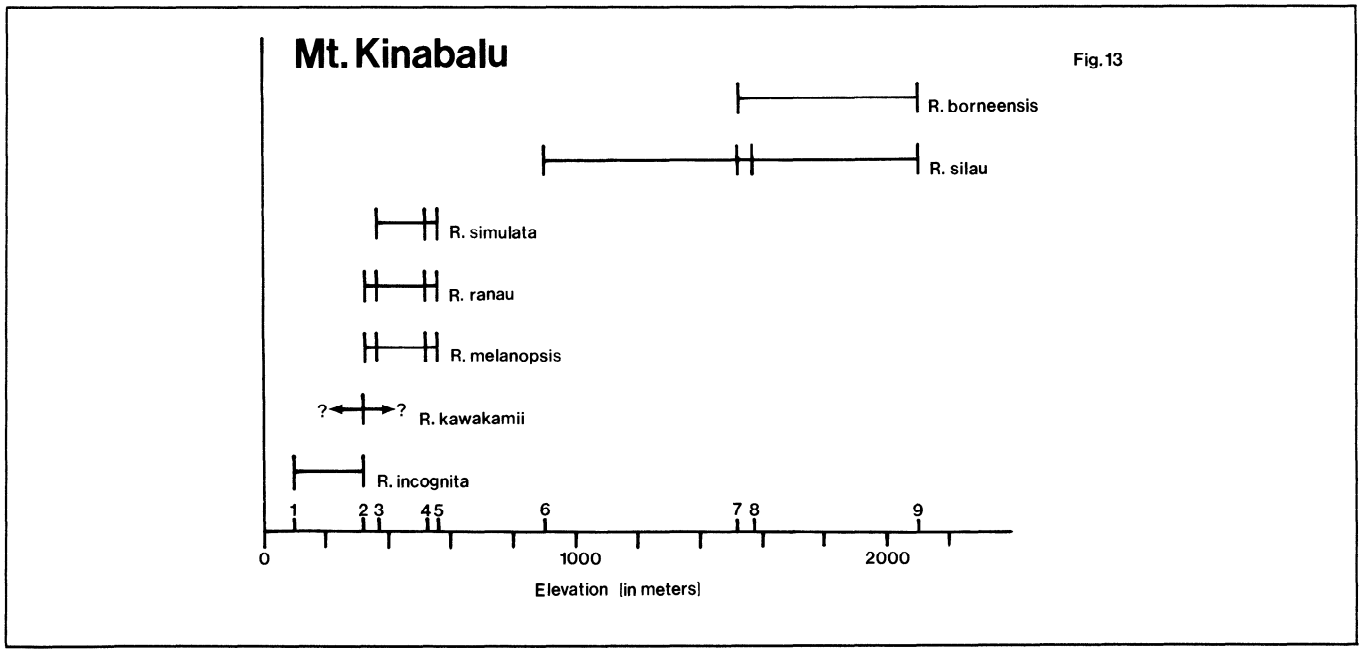


Fig. 13. Habitat partitioning by elevation of seven *Rhagovelia* species in the Mt. Kinabalu region (Sabah, north Borneo). Numbers on upper portion of lower scale correlate to numbers of collection locations in figure 14.

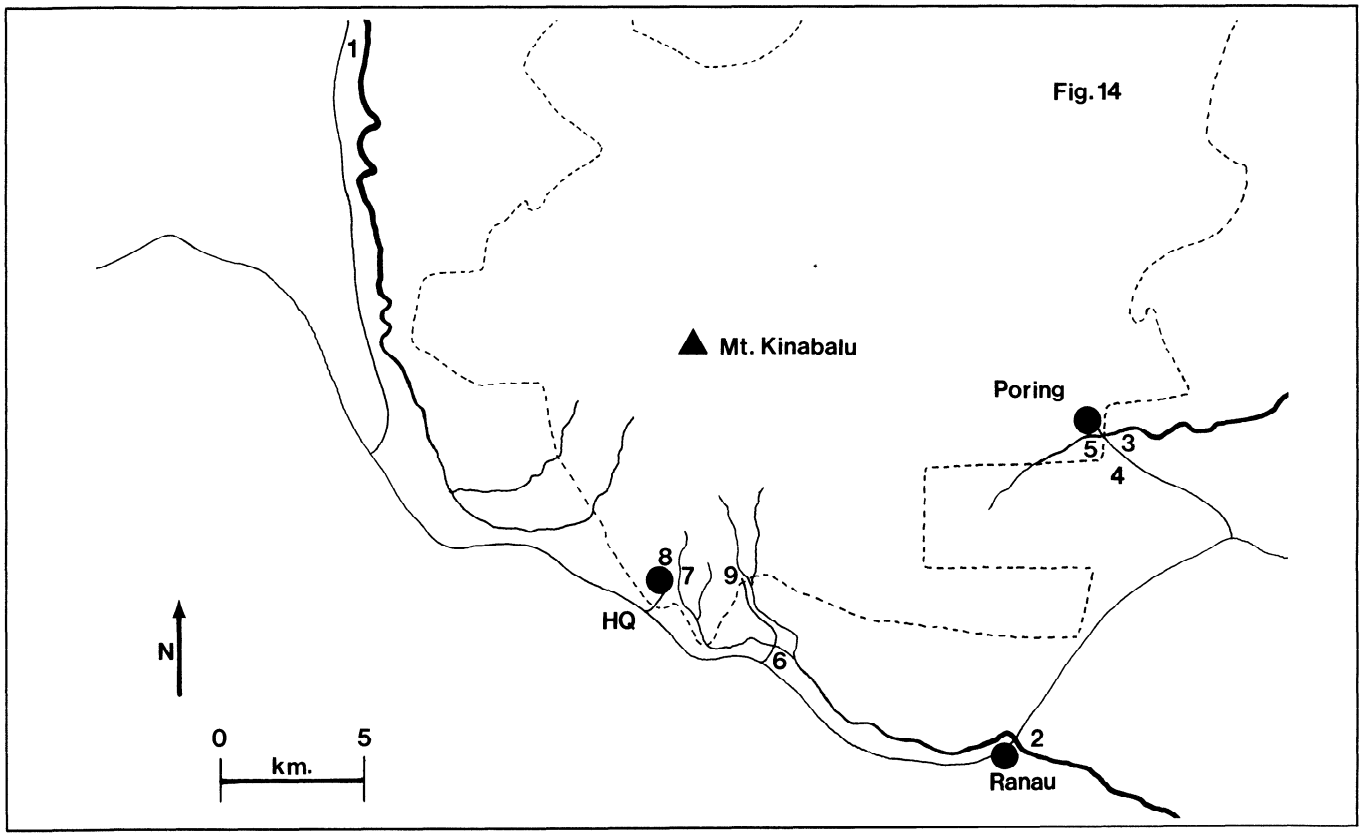
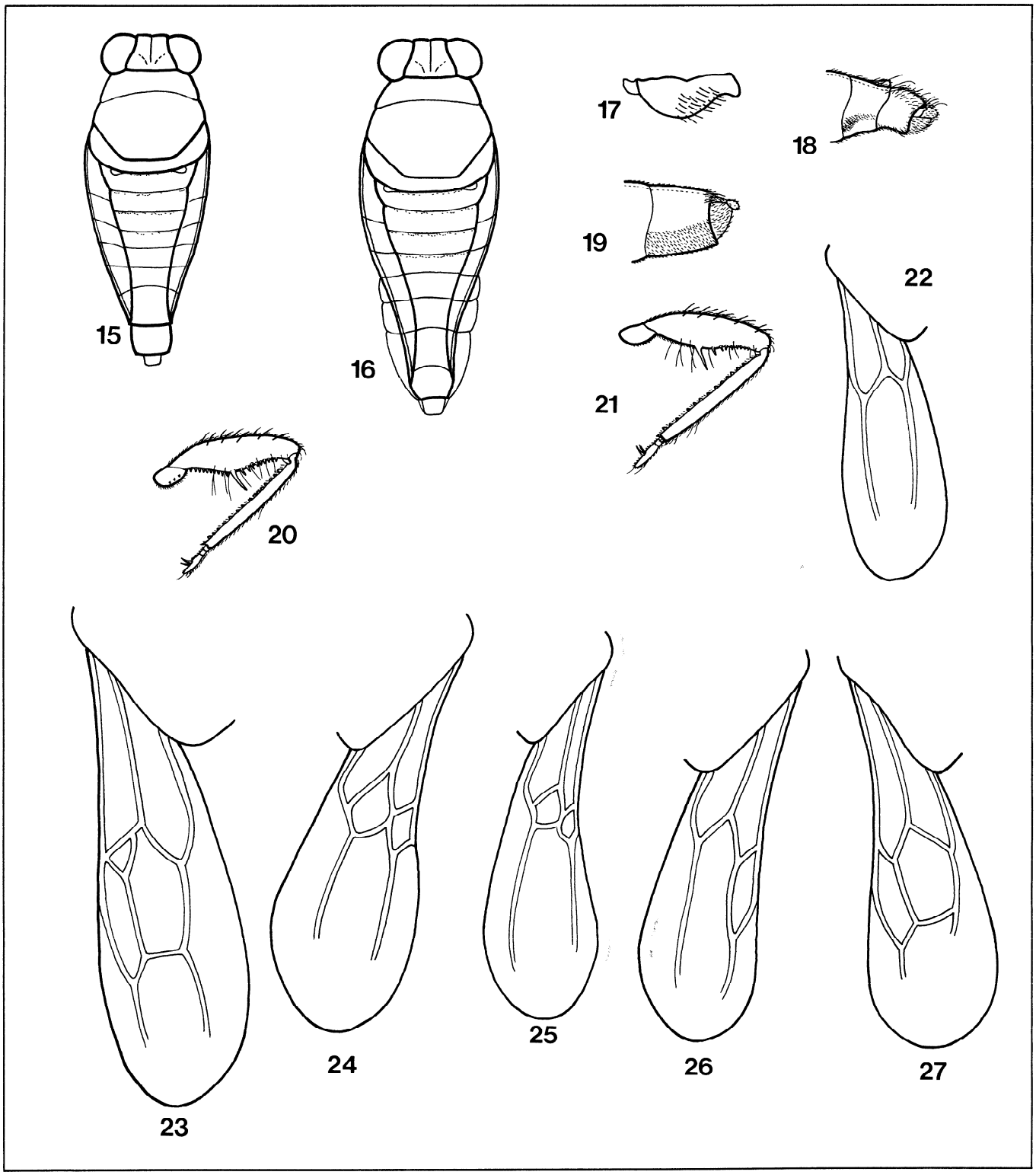
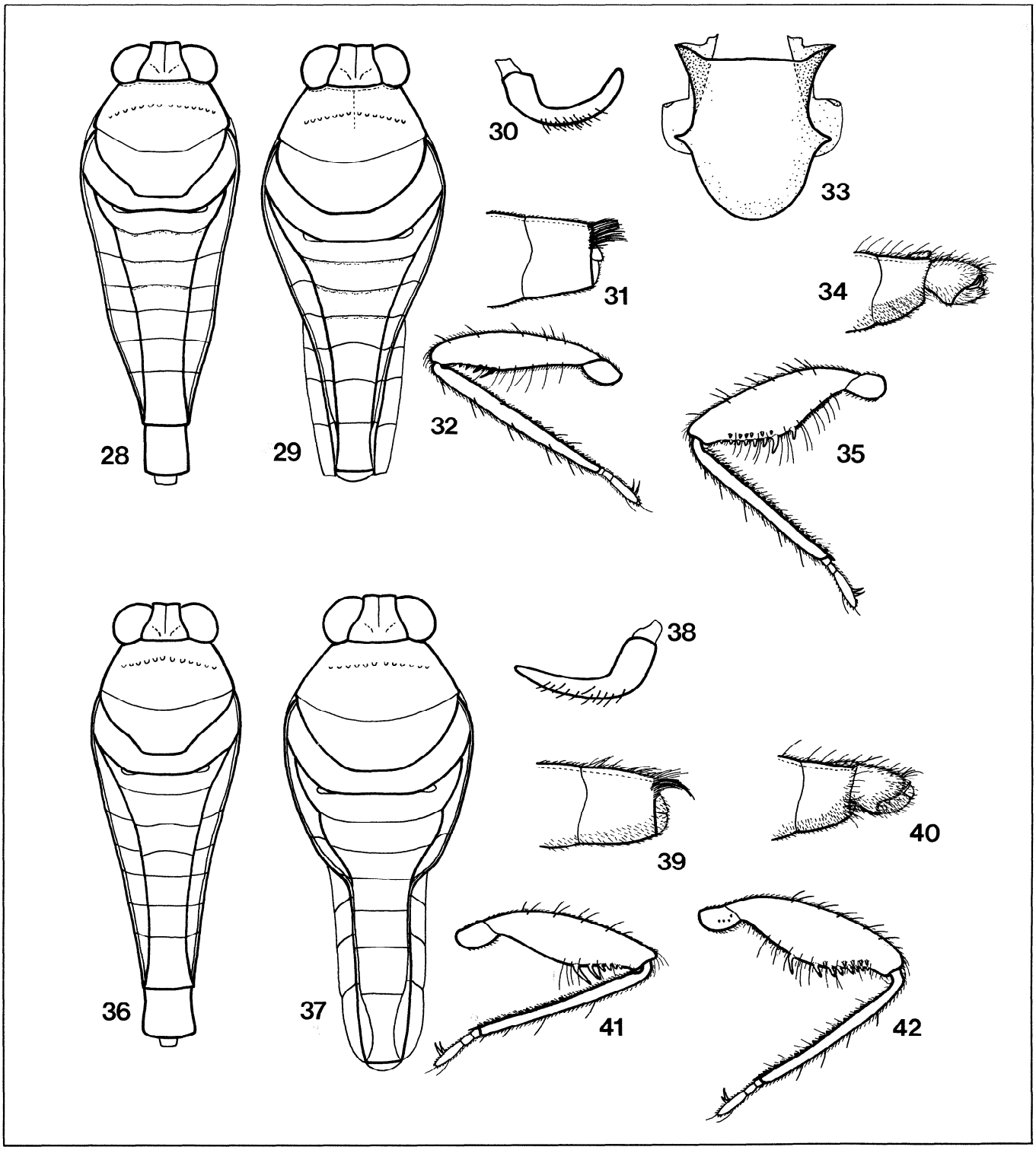


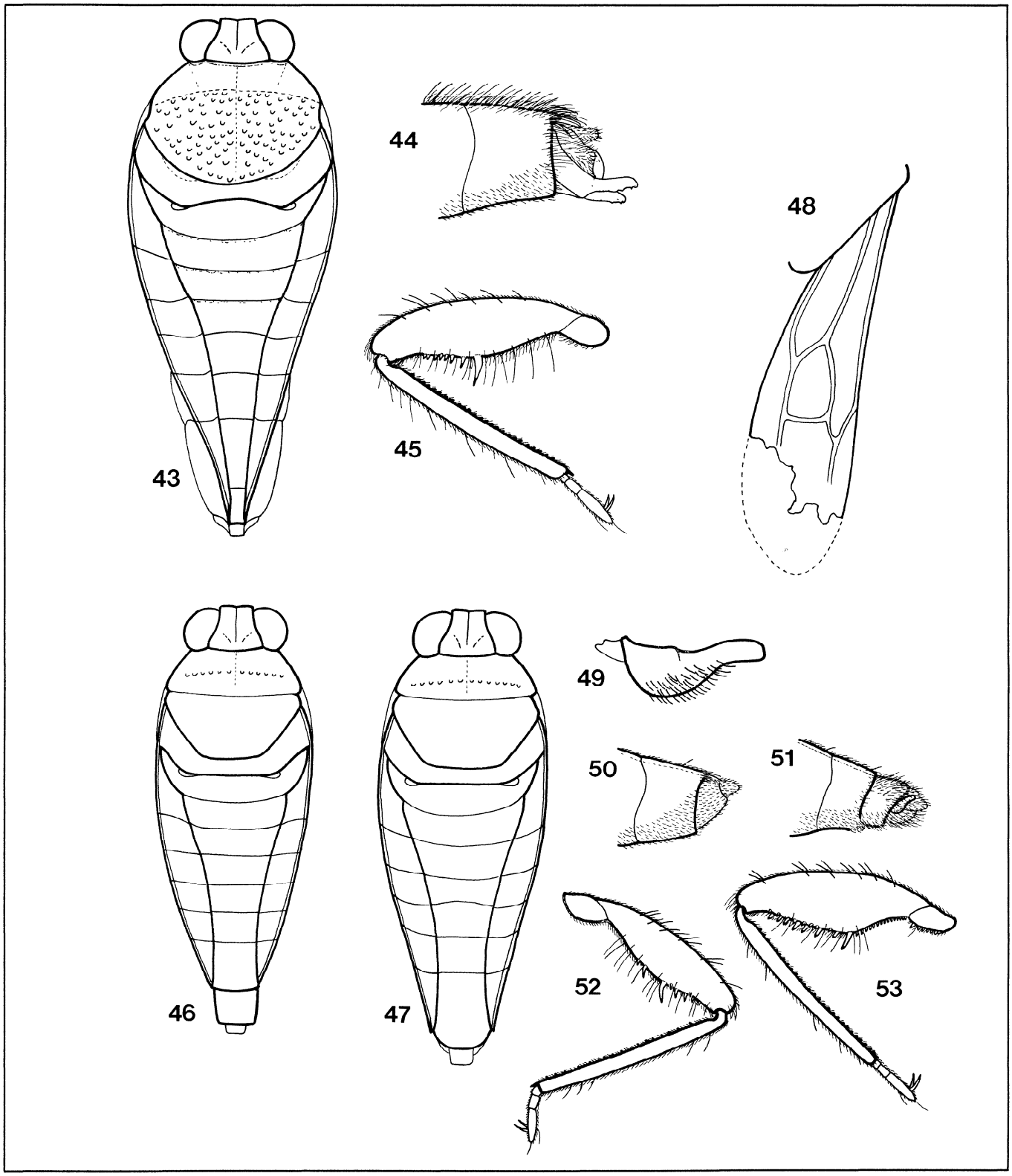
Fig. 14. Collection locations for *Rhagovelia* species on Mt. Kinabalu (Sabah, north Borneo). Dotted line indicates boundries of Kinabalu National Park. Collection locations are indicated by numbers (see individual species descriptions for further detail): 1, Tempasuk River; 2, Liwagu River at Ranau; 3, Mamut River ; 4, stream 1 km. S. of Poring Hot Springs; 5, Langanan River; 6, Liwagu River at Kundessan; 7, Liwagu River at Liwagu Cave; 8, Silau Silau stream; 9, Mesilau River.



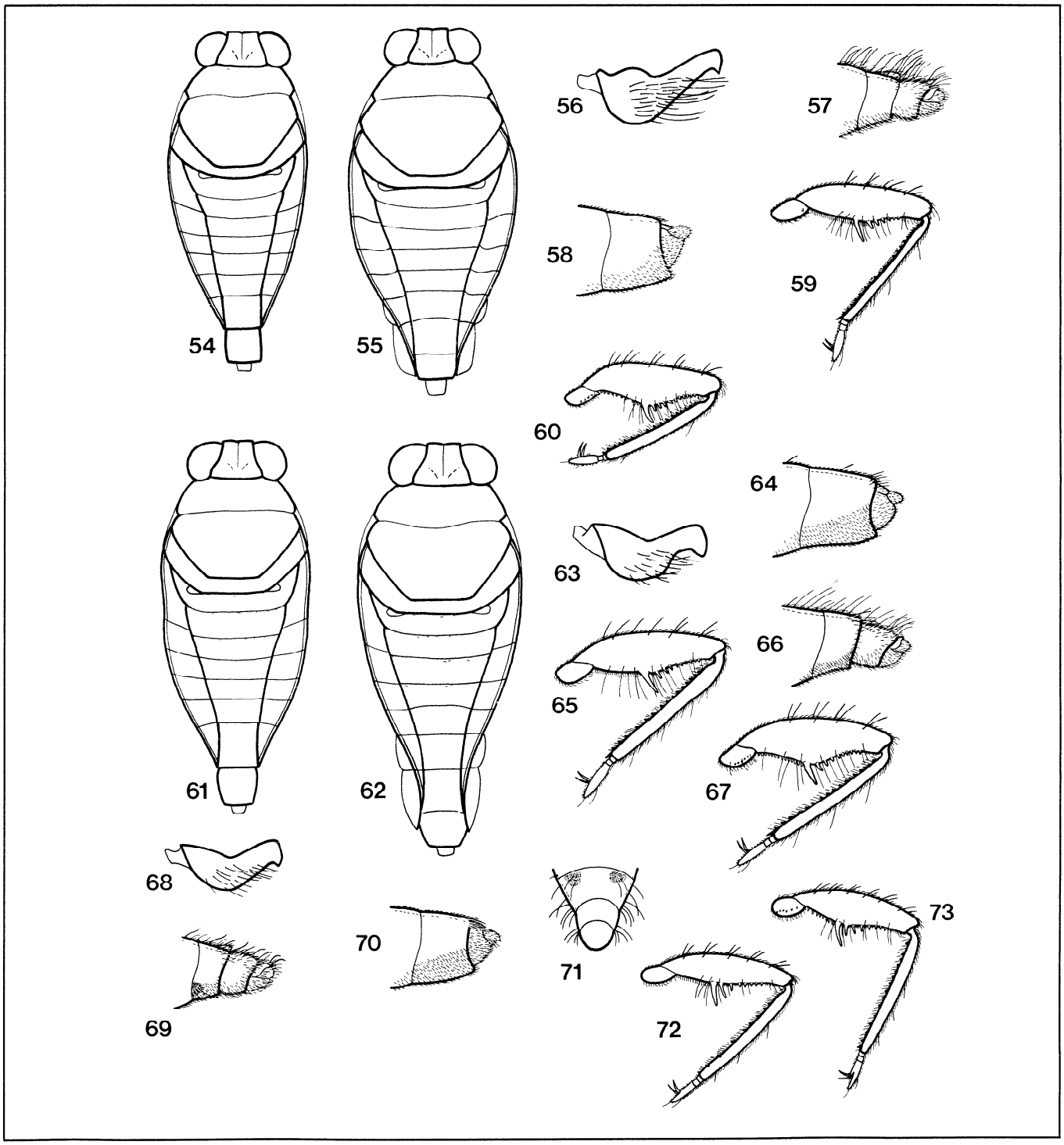
Figures 15-27. 15-22, *Rhagovelia tawau* new species (Sabah, north Borneo). 15, dorsal view of male; 16, dorsal view of female; 17, male paramere or clasper; 18, lateral view of male abdominal terminalia; 19, lateral view of female abdominal terminalia; 20, male posterior leg; 21, female posterior leg; 22, forewing. 23-27, *Rhagovelia* forewings, showing cell patterns. 23, *Rhagovelia novacaledonica* Lundblad (note adventitious fifth cell); 24, *Rhagovelia sumatrensis* Lundblad; 25, *Rhagovelia bipennicillata* Lundblad; 26, *Rhagovelia celebensis* new species; 27, *Rhagovelia wallacei* new species.



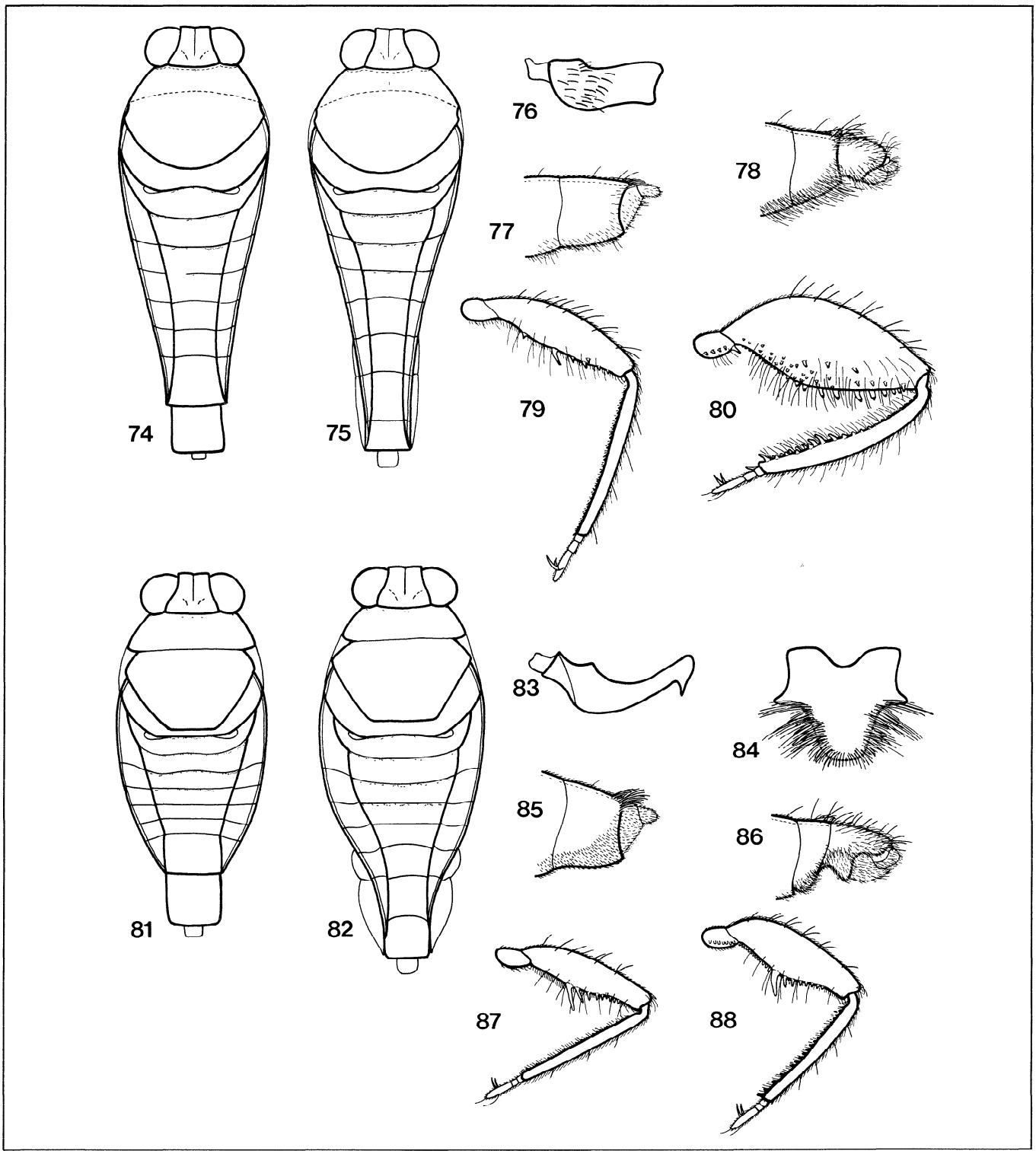
Figures 28-42. 28-35, *Rhagovelia bacanensis* new species (Bacan, north Moluccas). 28, dorsal view of male; 29, dorsal view of female; 30, male paramere or clasper; 31, lateral view of female abdominal terminalia; 32, female posterior leg; 33, dorsal view of male proctiger; 34, lateral view of male abdominal terminalia; 35, male posterior leg. 36-42, *Rhagovelia obi* new species (Obi, north Moluccas). 36, dorsal view of male; 37, dorsal view of female; 38, male paramere or clasper; 39, lateral view of female abdominal terminalia; 40, lateral view of male abdominal terminalia; 41, female posterior leg; 42, male posterior leg.



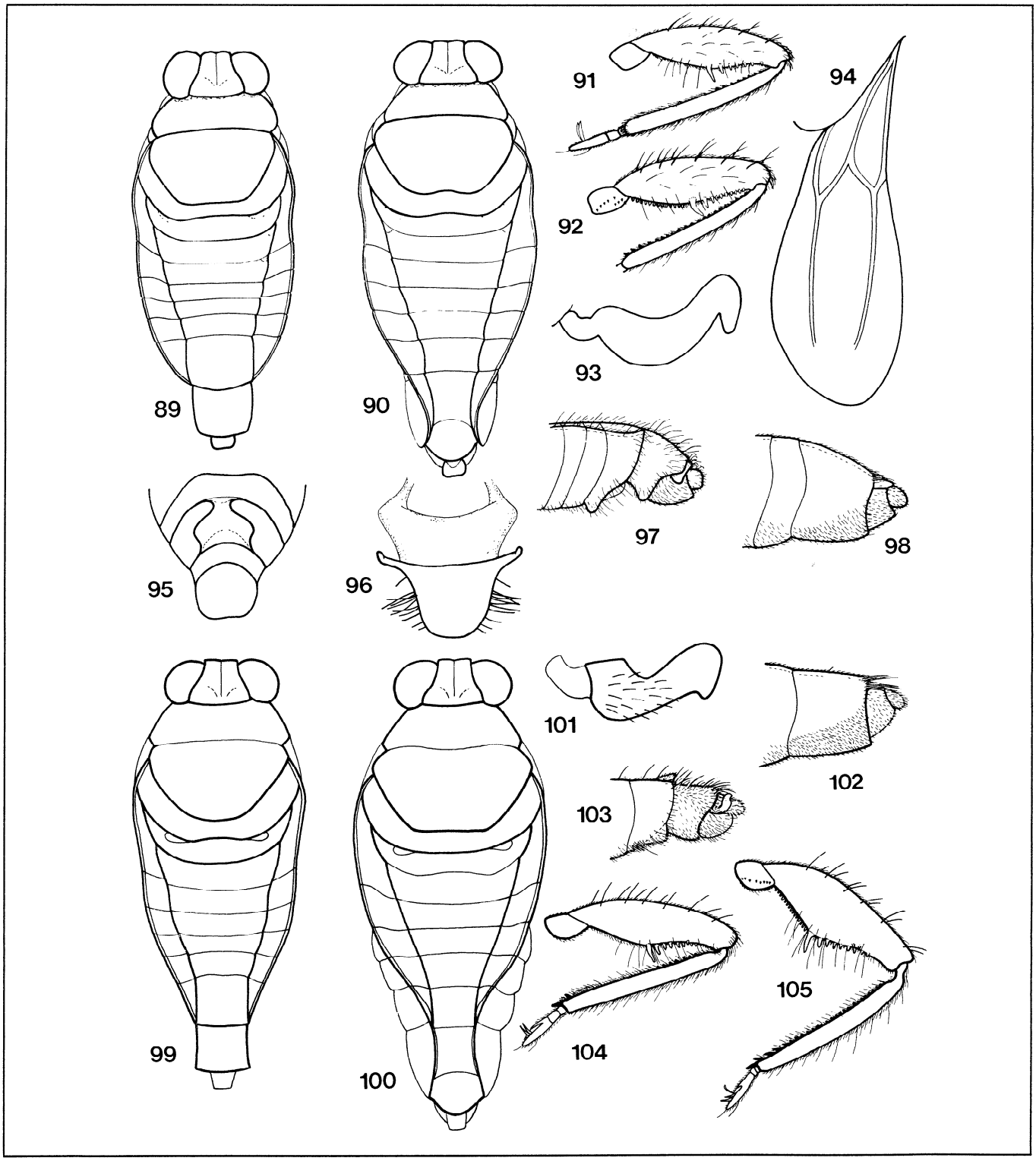
Figures 43-53. 43-45, *Rhagovelia unica* new species (Sabah, north Borneo). 43, dorsal view of female; 44, lateral view of female abdominal terminalia; 45, female posterior leg. 46-53, *Rhagovelia sabela* new species (Bacan, north Moluccas). 46, dorsal view of male; 47, dorsal view of female; 48, forewing; 49, male paramere or clasper; 50, lateral view of female abdominal terminalia; 51, lateral view of male abdominal terminalia; 52, female posterior leg; 53, male posterior leg.



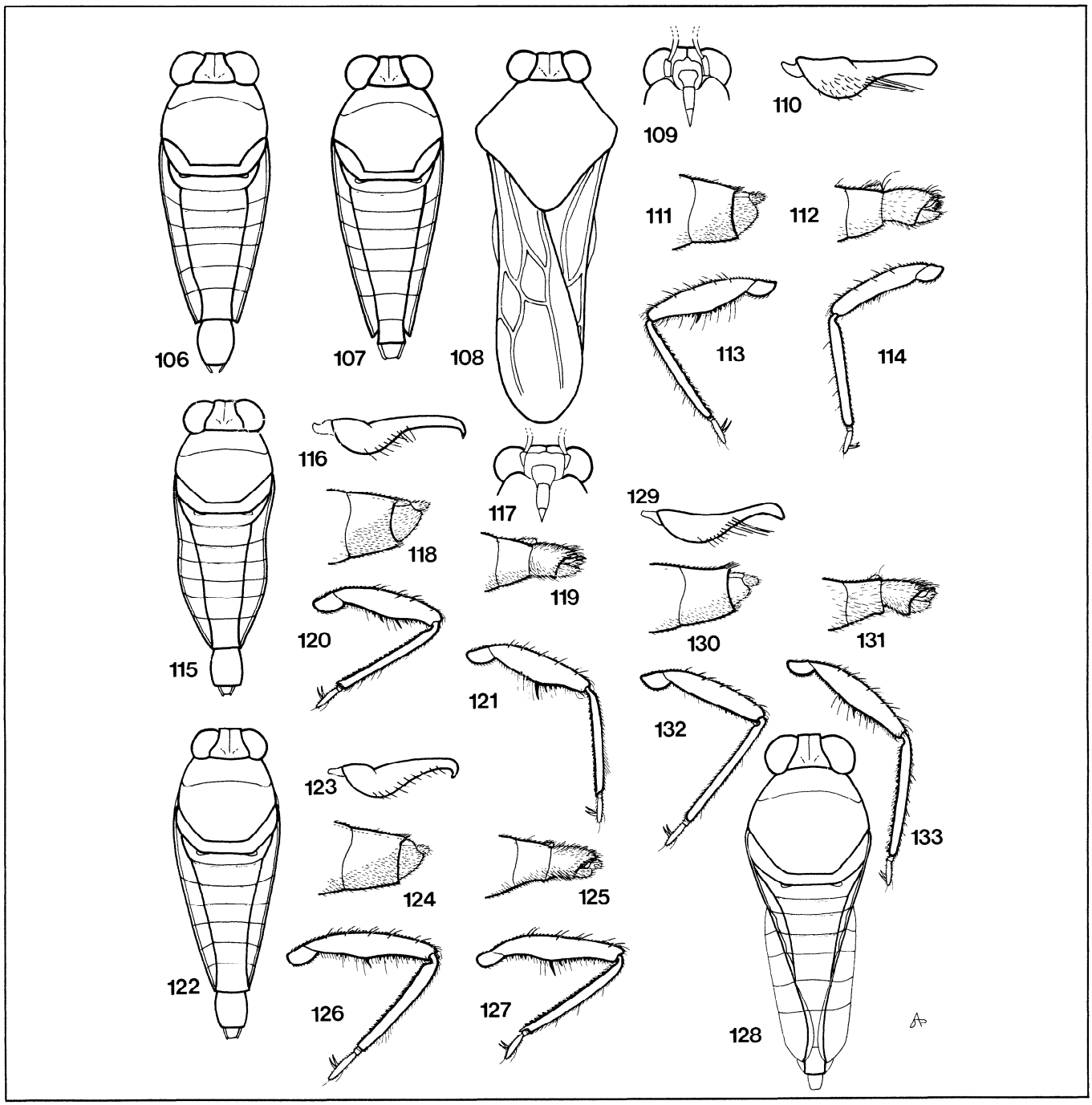
Figures 54-73. 54-60, *Rhagovelia incognita* new species (Sabah, north Borneo). 54, dorsal view of male; 55, dorsal view of female; 56, male paramere or clasper; 57, lateral view of male abdominal terminalia; 58, lateral view of female abdominal terminalia; 59, female posterior leg; 60, male posterior leg. 61-67, *Rhagovelia simulata* new species (Sabah, north Borneo). 61, dorsal view of male; 62, dorsal view of female; 63, male paramere or clasper; 64, lateral view of female abdominal terminalia; 65, female posterior leg; 66, lateral view of male abdominal terminalia; 67, male posterior leg. 68-73. *Rhagovelia ranau* new species (Sabah, north Borneo). 68, male paramere or clasper; 69, lateral view of male abdominal terminalia; 70, lateral view of female abdominal terminalia; 71, ventral view of male abdominal terminalia; 72, female posterior leg; 73, male posterior leg.



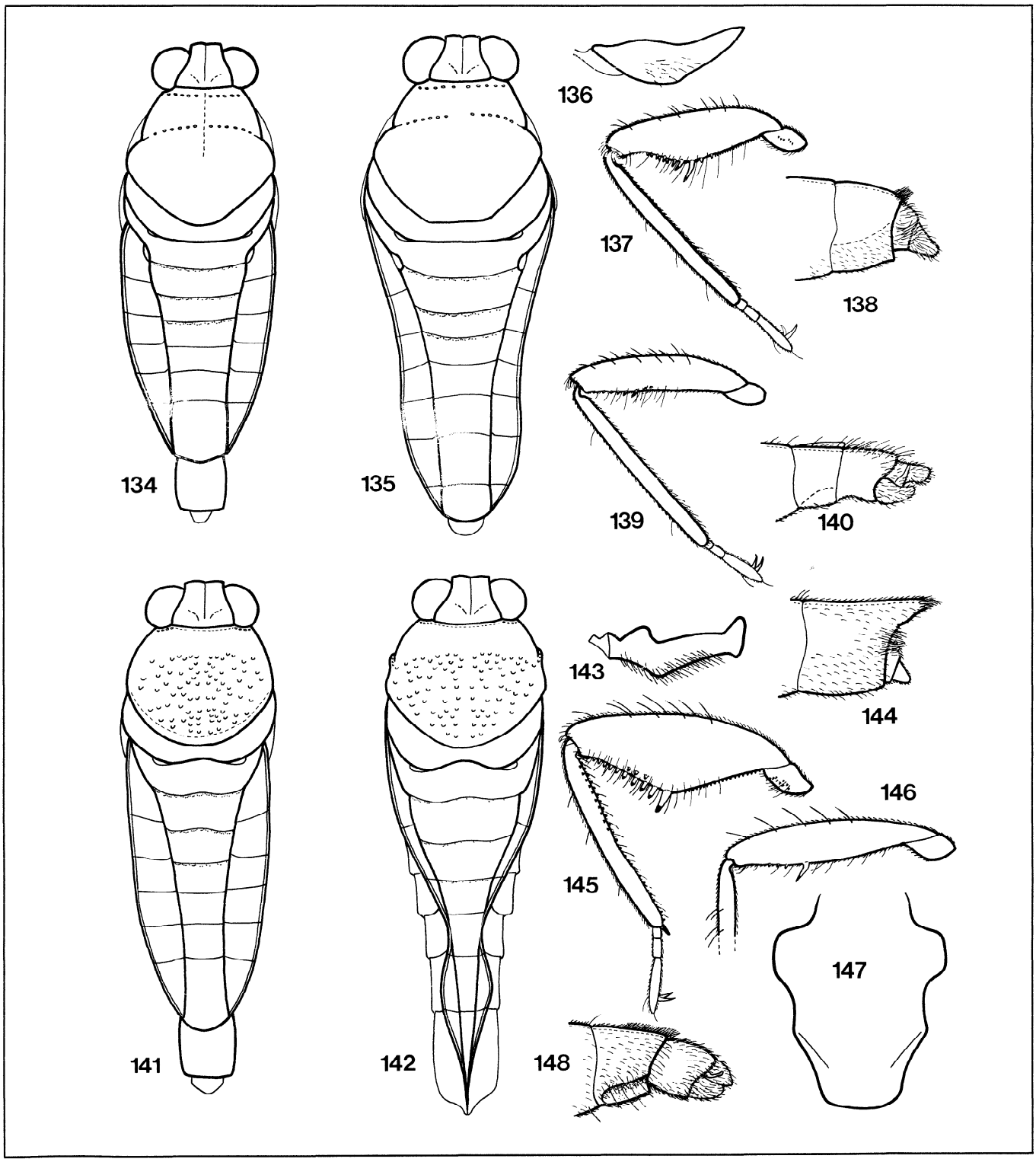
Figures 74-88. 74-80, *Rhagovelia kawakamii* (Matsumura) (Sabah, north Borneo). 74, dorsal view of male; 75, dorsal view of female; 76, male paramere or clasper; 77, lateral view of female abdominal terminalia; 78, lateral view of male abdominal terminalia; 79, female posterior leg; 80, male posterior leg. 81-88, *Rhagovelia melanopsis* new species (Sabah, north Borneo). 81, dorsal view of male; 82, dorsal view of female; 83, male paramere or clasper; 84, dorsal view of male proctiger; 85, lateral view of female abdominal terminalia; 86, lateral view of male abdominal terminalia; 87, female posterior leg; 88, male posterior leg.



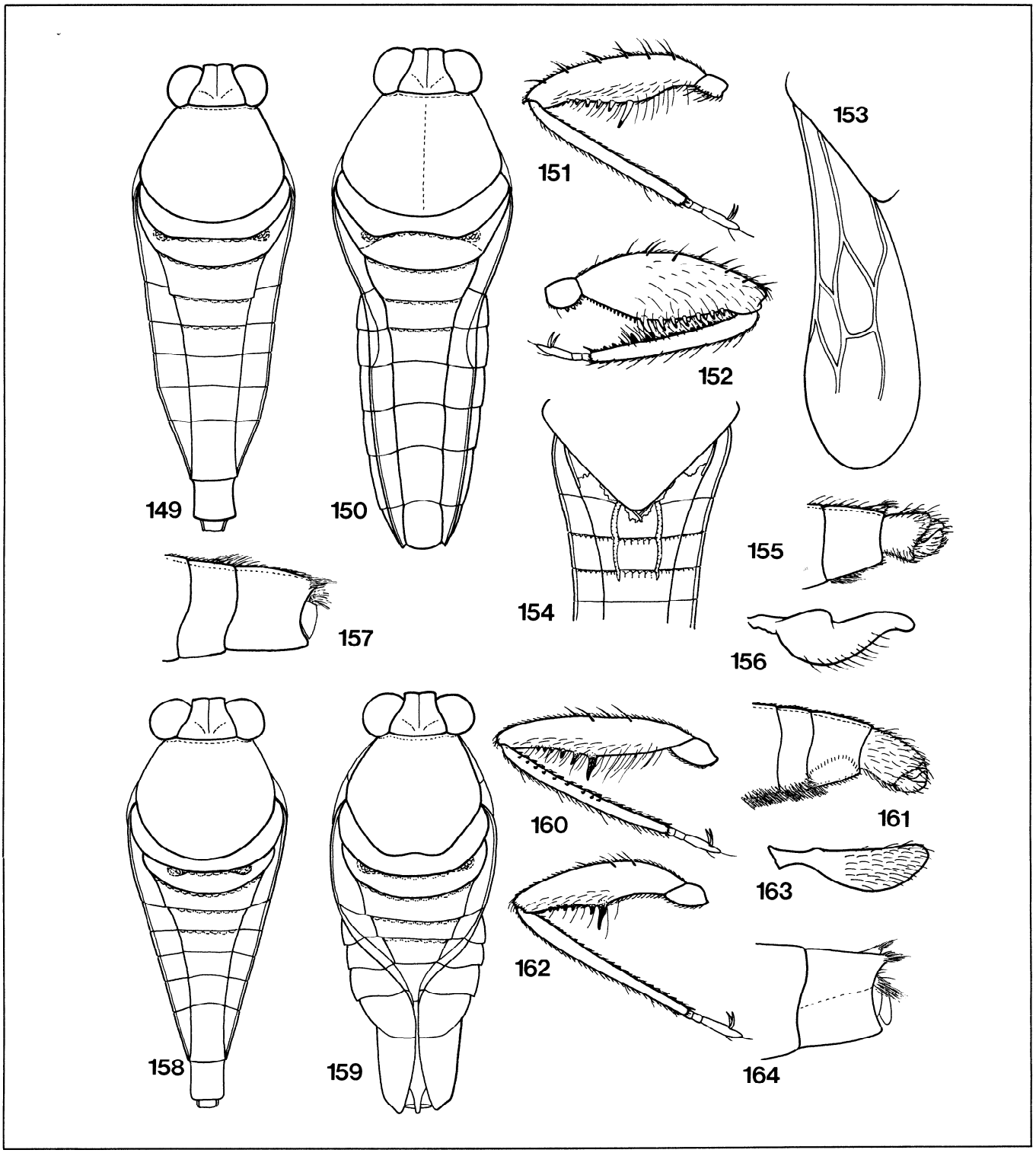
Figures 89-105. 89-98, *Rhagovelia borneensis* new species (Sabah, north Borneo). 89, dorsal view of male; 90, dorsal view of female; 91, female posterior leg; 92, male posterior leg; 93, male paramere or clasper; 94, forewing; 95, ventral view of male abdominal terminalia; 96, dorsal view of male proctiger; 97, lateral view of male abdominal terminalia; 98, lateral view of female abdominal terminalia. 99-105. *Rhagovelia silau* new species (Sabah, north Borneo). 99, dorsal view of male; 100, dorsal view of female; 101, male paramere or clasper; 102, lateral view of female abdominal terminalia; 103, lateral view of male abdominal terminalia; 104, female posterior leg; 105, male posterior leg.



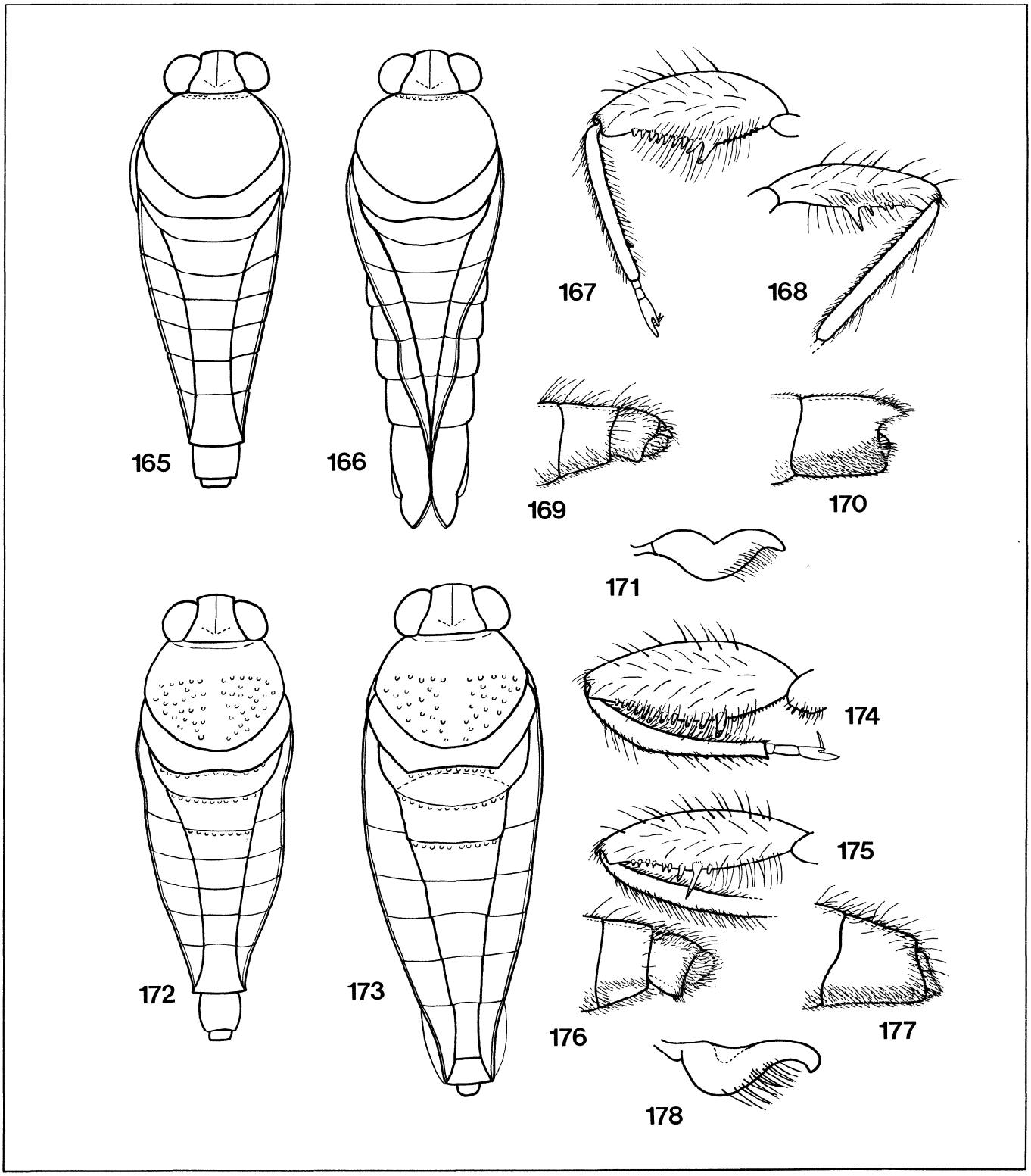
Figures 106-133. 106-114, *Rhagovelia sondaica* new species (Sarawak, west Borneo). 106, dorsal view of male; 107, dorsal view of female; 108, dorsal view of macropterous male from Templar Park, peninsular Malaysia; 109, ventral view of head showing narrow jugum; 110, male paramere or clasper; 111, lateral view of female abdominal terminalia; 112, lateral view of male abdominal terminalia; 113, male posterior leg; 114, female posterior leg. 115-121, *Rhagovelia samarinda* new species (Kalimantan Timur Prov., east Borneo). 115, dorsal view of male; 116, male paramere or clasper; 117, ventral view of head showing broad jugum; 118, lateral view of female abdominal terminalia; 119, lateral view of male abdominal terminalia; 120, female posterior leg; 121, male posterior leg. 122-127. *Rhagovelia tebakang* new species (Sarawak, west Borneo). 122, dorsal view of male; 123, male paramere or clasper; 124, lateral view of female abdominal terminalia; 125, lateral view of male abdominal terminalia; 126, female posterior leg; 127, male posterior leg. 128-133, *Rhagovelia sarawakensis* new species (Sarawak, west Borneo). 128, dorsal view of female; 129, male paramere or clasper; 130, lateral view of female abdominal terminalia; 131, lateral view of male abdominal terminalia; 132, female posterior leg; 133, male posterior leg.



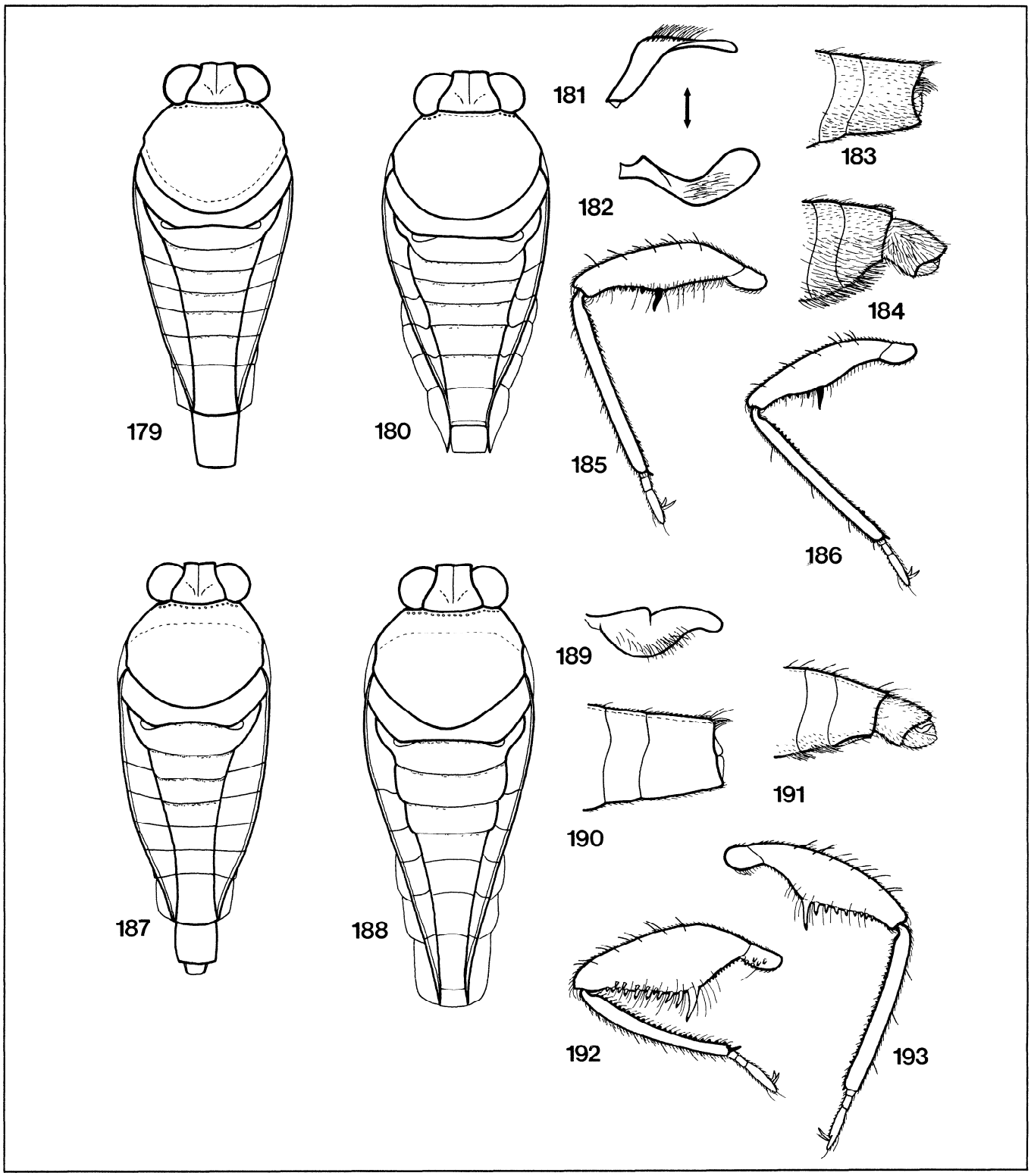
Figures 134-148. 134-140, *Rhagovelia hamdjahi* new species (central Celebes). 134, dorsal view of male; 135, dorsal view of female; 136, male paramere or clasper; 137, male posterior leg; 138, lateral view of female abdominal terminalia; 139, female posterior leg; 140, lateral view of male abdominal terminalia. 141-148, *Rhagovelia lorelinduana* new species (central Celebes). 141, dorsal view of male; 142, dorsal view of female; 143, male paramere or clasper; 144, lateral view of female abdominal terminalia; 145, male posterior leg; 146, female posterior leg; 147, dorsal view of male proctiger; 148, lateral view of male abdominal terminalia.



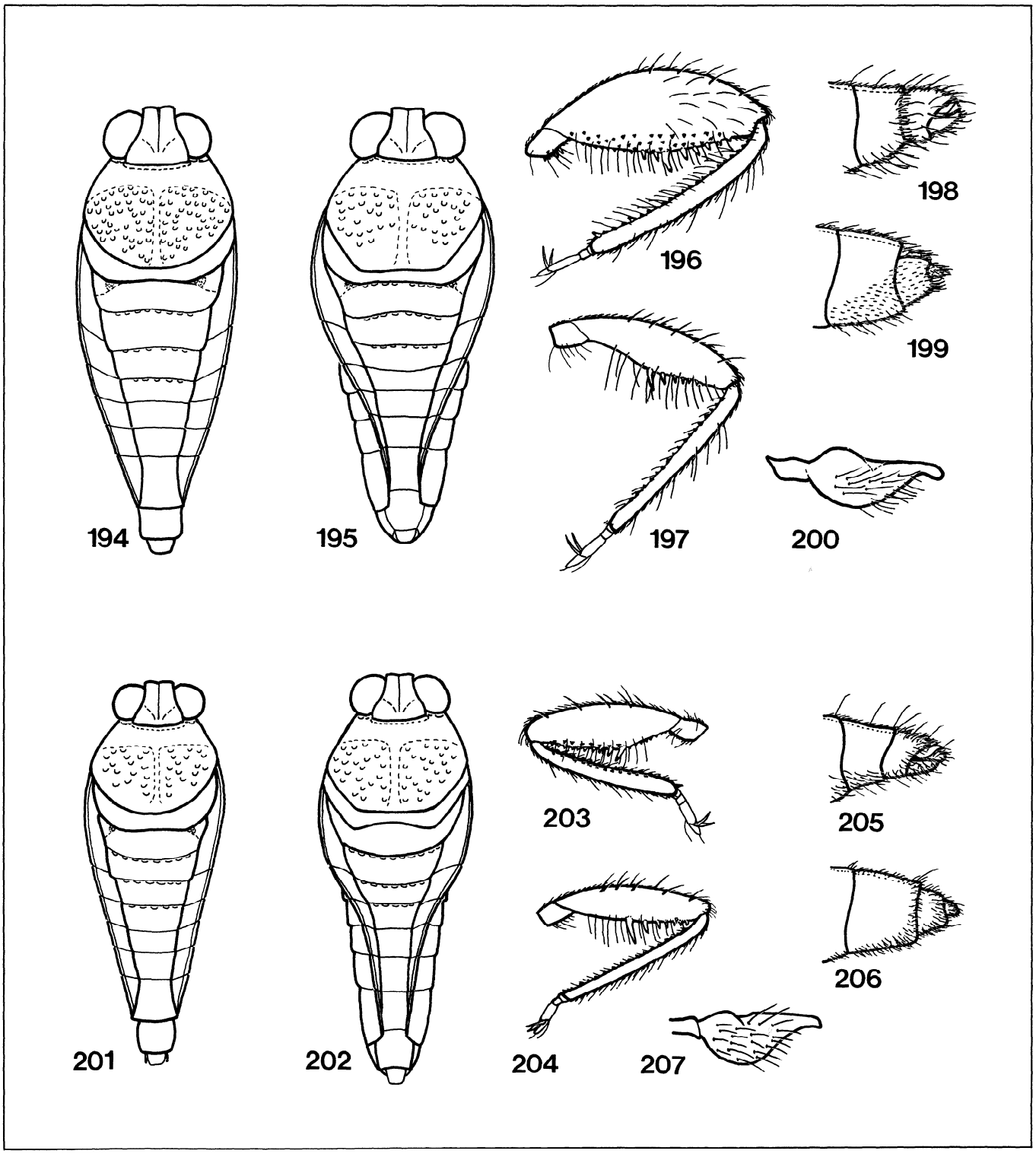
Figures 149-164. 149-157, *Rhagovelia pruinosa* new species (south Celebes). 149, dorsal view of male; 150, dorsal view of female; 151, female posterior leg; 152, male posterior leg; 153, forewing; 154, dorsal view of macropter showing abdominal carinae; 155, lateral view of male abdominal terminalia; 156, male paramere or clasper; 157, lateral view of female abdominal terminalia. 158-164. *Rhagovelia sulawesiana* new species (south Celebes). 158, dorsal view of male; 159, dorsal view of female; 160, male posterior leg; 161, lateral view of male abdominal terminalia; 162, female posterior leg; 163, male paramere or clasper; 164, lateral view of female abdominal terminalia.



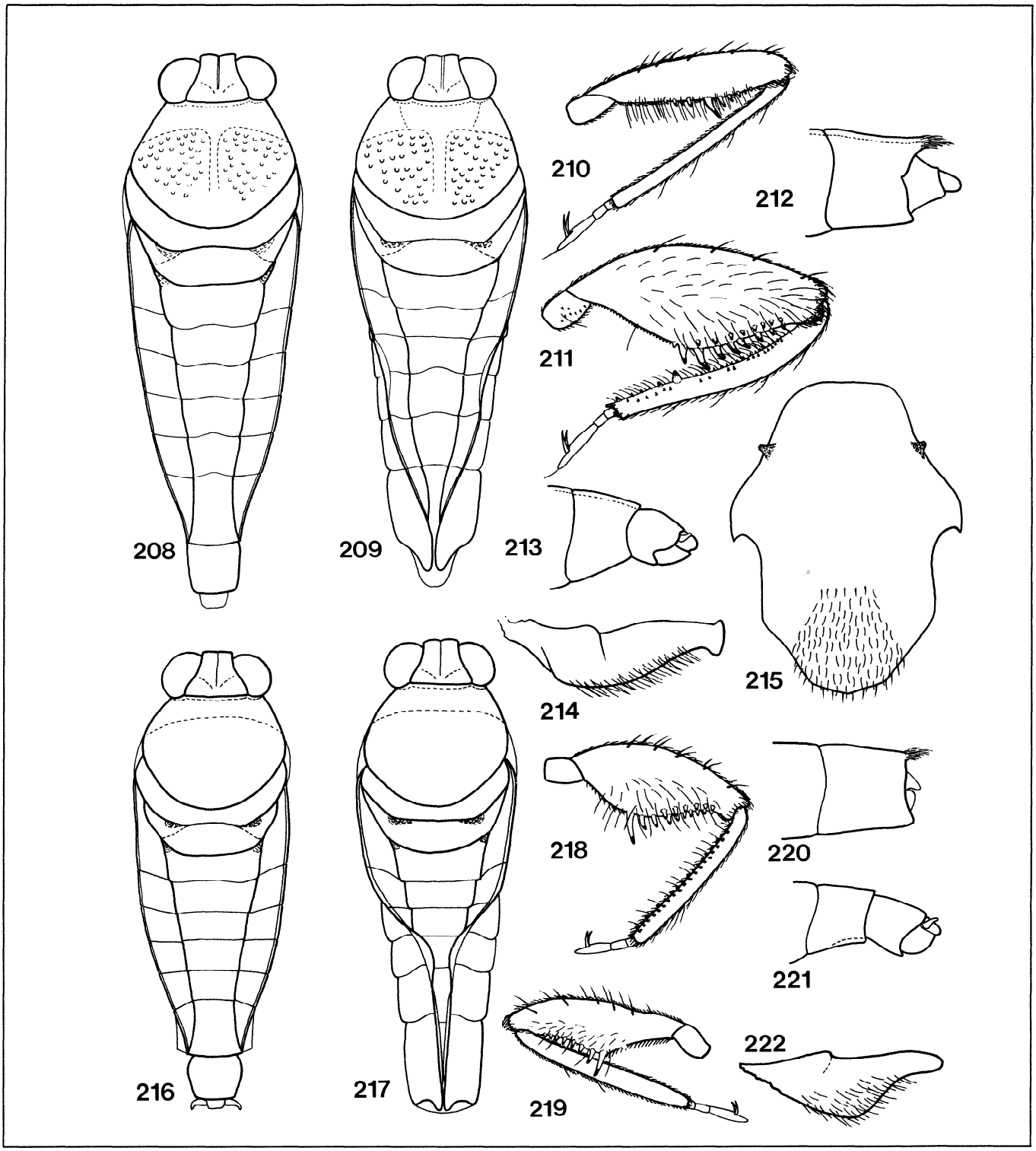
Figures 165-178. 165-171, *Rhagovelia ambonensis* Lundblad (Ambon). 165, dorsal view of male; 166, dorsal view of female; 167, male posterior leg; 168, female posterior leg; 169, lateral view of male abdominal terminalia; 170, lateral view of female abdominal terminalia; 171, male paramere or clasper. 172-178, *Rhagovelia meikdelyi* new species (Ambon). 172, dorsal view of male; 173, dorsal view of female; 174, male posterior leg; 175, female posterior leg; 176, lateral view of male abdominal terminalia; 177, lateral view of female abdominal terminalia; 178, male paramere or clasper.



Figures 179-193. 179-186, *Rhagovelia celebensis* new species (north Celebes). 179, dorsal view of male; 180, dorsal view of female; 181-182, male paramere or clasper, two views; 183, lateral view of female abdominal terminalia; 184, lateral view of male abdominal terminalia; 185, male posterior leg; 186, female posterior leg. 187-193, *Rhagovelia wallacei* new species (Celebes). 187, dorsal view of male; 188, dorsal view of female; 189, male paramere or clasper; 190, lateral view of female abdominal terminalia; 191, lateral view of male abdominal terminalia; 192, male posterior leg; 193, female posterior leg.



Figures 194-207. 194-200, *Rhagovelia samardaca* new species (Sabah, north Borneo). 194, dorsal view of male; 195, dorsal view of female; 196, male posterior leg; 197, female posterior leg; 198, lateral view of male abdominal terminalia; 199, lateral view of female abdominal terminalia; 200, male paramere or clasper. 201-207, *Rhagovelia christenseni* new species (Kalimantan Timur Prov., east Borneo). 201, dorsal view of male; 202, dorsal view of female; 203, male posterior leg; 204, female posterior leg; 205, lateral view of male abdominal terminalia; 206, lateral view of female abdominal terminalia; 207, male paramere or clasper.



Figures 208-222. 208-215, *Rhagovelia grayi* new species (north Celebes). 208, dorsal view of male; 209, dorsal view of female; 210, female posterior leg; 211, male posterior leg; 212, lateral view of female abdominal terminalia; 213, lateral view of male abdominal terminalia; 214, male paramere or clasper; 215, dorsal view of male proctiger. Figures 216-222, *Rhagovelia minahasa* new species (north Celebes). 216, dorsal view of male; 217, dorsal view of female; 218, male posterior leg; 219, female posterior leg; 220, lateral view of female abdominal terminalia; 221, lateral view of male abdominal terminalia; 222, male paramere or clasper.

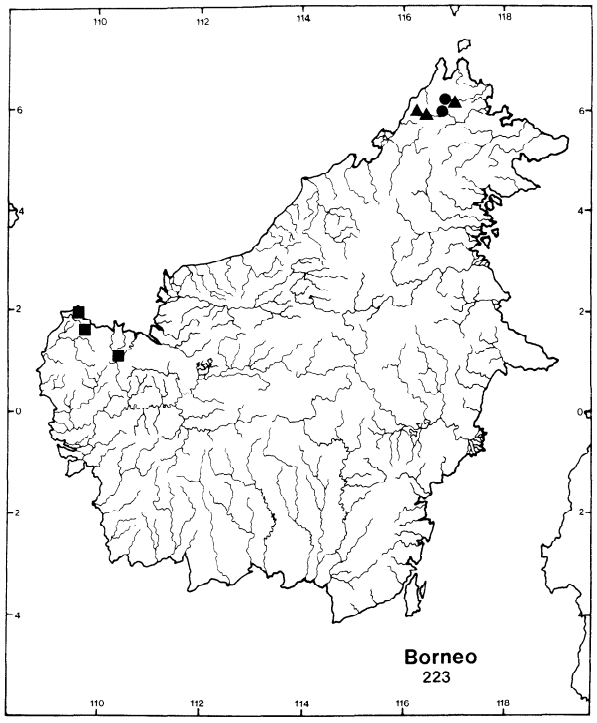


Fig. 223. Distribution of *Rhagovelia* species on Borneo: squares, *R. sarawakensis* new species; triangles, *R. simulata* new species; circles, *R. melanopsis* new species.

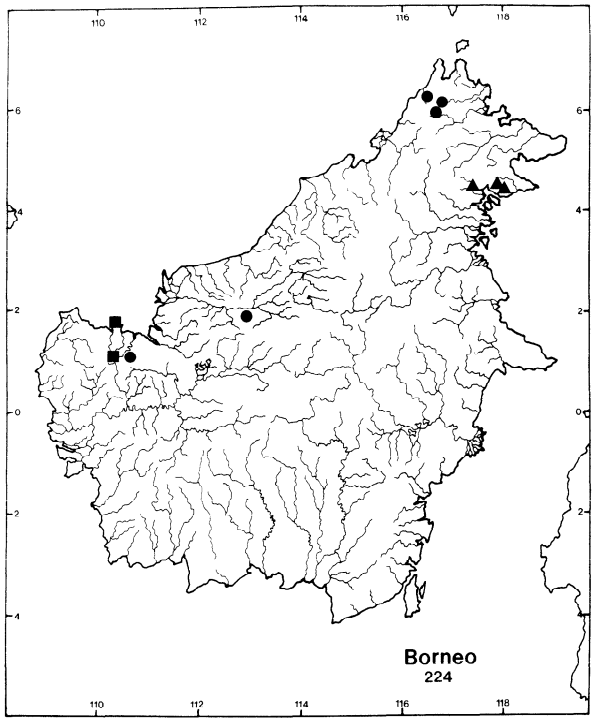


Fig. 224. Distribution of *Rhagovelia* species on Borneo: squares, *R. tebakang* new species; triangles, *R. tawau* new species; circles, *R. incognita* new species.

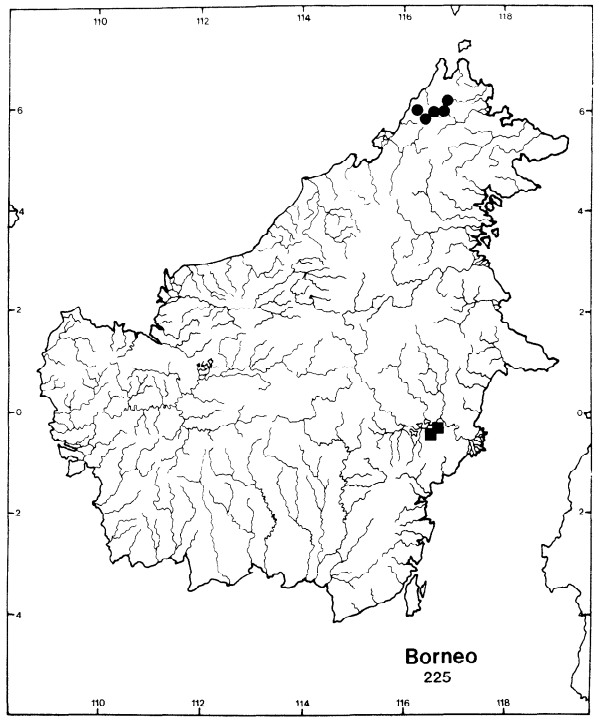


Fig. 225. Distribution of *Rhagovelia* species on Borneo: squares, *R. christenseni* new species; circles, *R. ranau* new species.

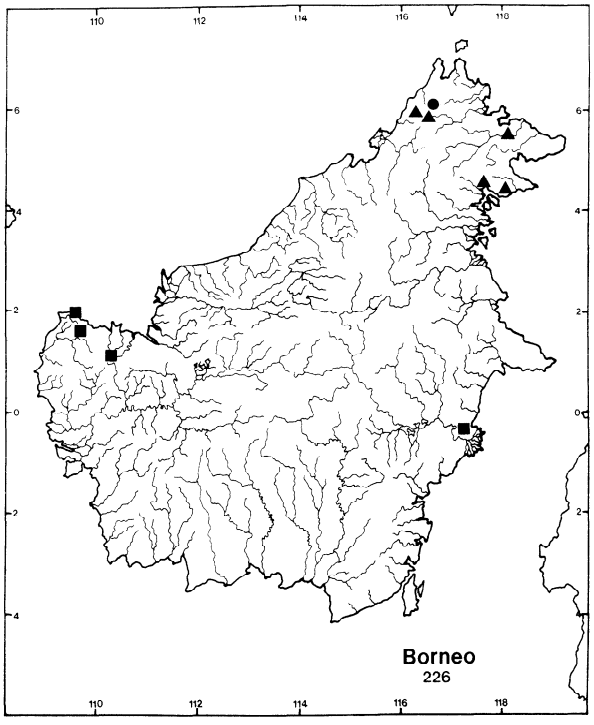


Fig. 226. Distribution of *Rhagovelia* species on Borneo: squares, *R. samarinda* new species; triangles, *R. samardaca* new species; circle, *R. borneensis* new species.

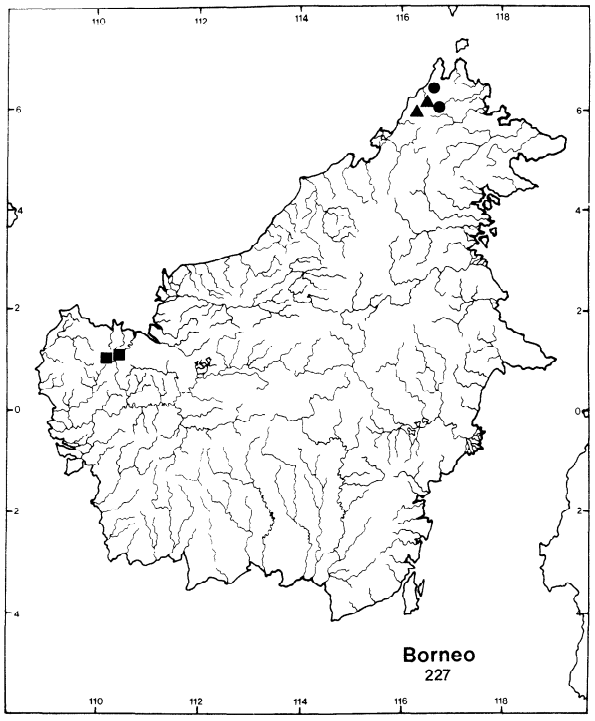


Fig. 227. Distribution of *Rhagovelia* species on Borneo: squares, *R. sondaica* new species; triangles, *R. silau* new species; circles, *R. kawakamii* (Matsumura).

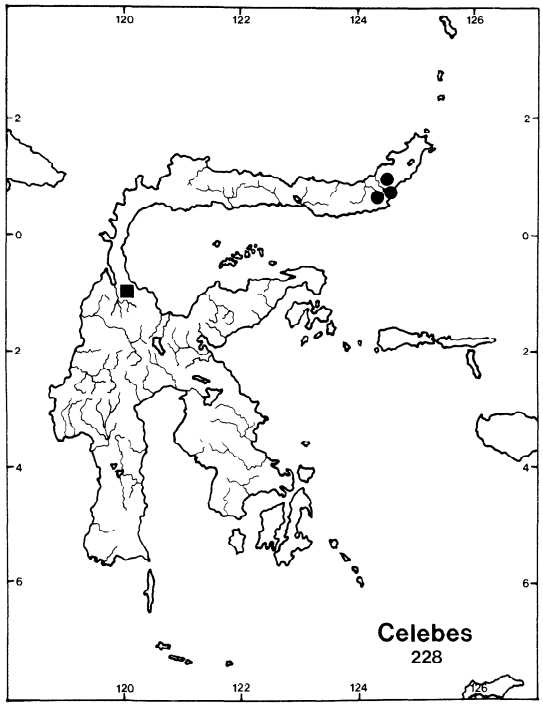


Fig. 228. Distribution of *Rhagovelia* species on Celebes: square, *R. lorelinduana* new species; circles, *R. minahasa* new species.

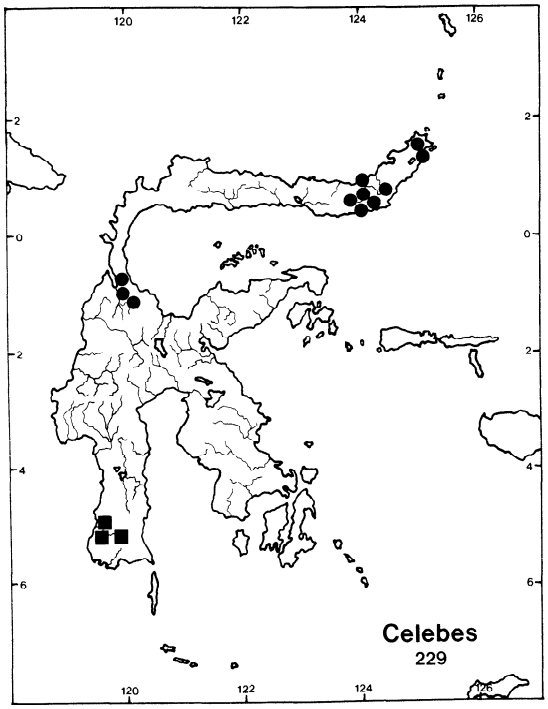


Fig. 229. Distribution of *Rhagovelia* species on Celebes: squares, *R. pruinosa* new species; circles, *R. celebensis* new species.

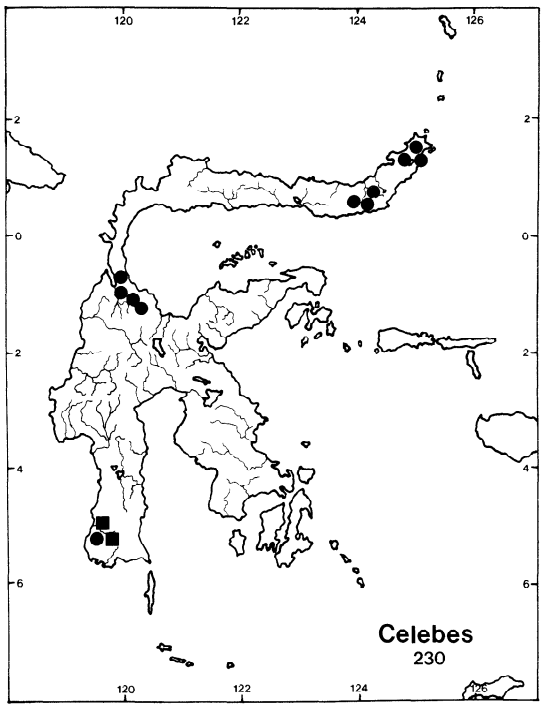


Fig. 230. Distribution of *Rhagovelia* species on Celebes: squares, *R. sulawesiana* new species; circles, *R. wallacei* new species.

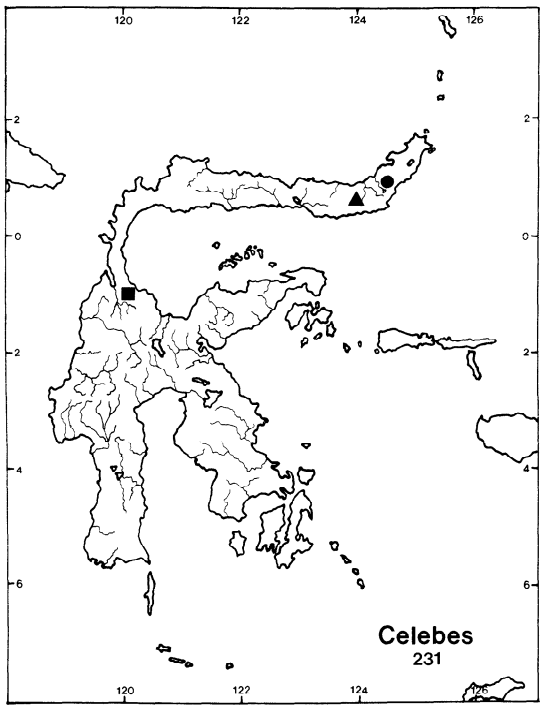


Fig. 231. Distribution of *Rhagovelia* species on Celebes: square, *R. hamdjahi* new species; triangle, *R. unica* new species; circle, *R. grayi* new species.

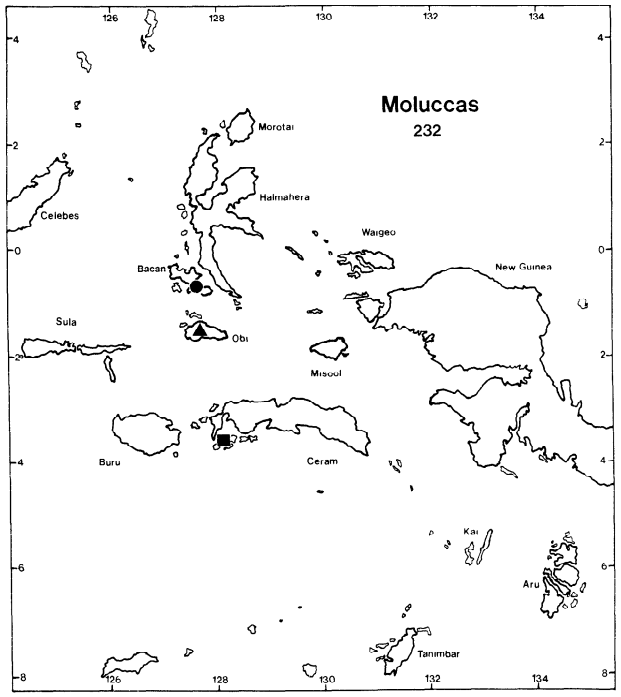


Fig. 232. Distribution of *Rhagovelia* species on the Moluccas: square, *R. meikdely* new species; triangle, *R. obi* new species; circle, *R. sabela* new species.

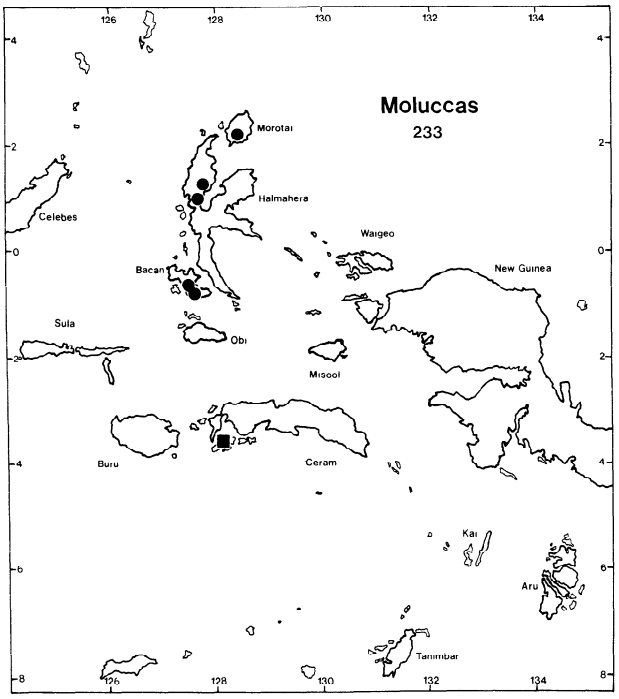


Fig. 233. Distribution of *Rhagovelia* species on the Moluccas: square, *R. ambonensis* Lundblad; circles, *R. bacanensis* new species.