

The planthopper family Achilixiidae (Homoptera, Fulgoroidea): a synopsis with a revision of the genus *Achilixius*

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ABSTRACT. The planthopper family Achilixiidae (Homoptera, Auchenorrhyncha, Fulgoroidea) is reviewed and the Oriental genus *Achilixius* Muir revised. As here defined, the family consists of two genera: *Bebaiotes* Muir (*Muirilixius* Metcalf is here made a junior synonym, syn.n.) from the Neotropical region and *Achilixius* from the Oriental region. Sixteen *Achilixius* species are described or redescribed from Philippines, Sabah and Sulawesi. Females of undescribed species are also reported from the Solomon Islands and New Guinea. The following new species of *Achilixius* are described: *bakeri*, *irigae* and *mayoyae* from the Philippines; *fennahi* and *muri* from Sabah; *minahassae*, *danaumoati*, *torautensis*, *fasciata*, *kolintang*, *muajati* and *morowali* from Sulawesi. A key to males is given. The following new combinations are established: *Bebaiotes banksi* (Metcalf), *B. guianesus* (Fennah) and *B. nigrigaster* Muir restored to its original combination, comb.rev. The relationship of Achilixiidae to other fulgoroid families is discussed.

Introduction

The planthopper family Achilixiidae is one of the smallest of the twenty Fulgoroidea families currently recognized and perhaps one of the least well known and most enigmatic. The family contains only two genera *Achilixius* (sixteen species) from the Oriental region and *Bebaiotes* (eight species) from Central and South America. The family is characterized by the possession of one or two pairs of processes arising laterally from the abdomen (Figs 4–6), but rather similar processes are present in some Cixiidae and the relationship of Achilixiidae to other families is unclear. All species are known only from tropical lowland and medium altitude rain forest

where the adults probably feed on plant tissue. The nymphs may feed on roots or on rotten vegetation or fungus.

The objectives of this study have been to investigate characters of possible phylogenetic importance in Achilixiidae in order to improve our understanding of the position of the family in the Fulgoroidea, and to provide a revision of the type genus, *Achilixius*.

Material studied is deposited in the following collections denoted by the abbreviations given: BMNH: British Museum (Natural History), London, U.K.; BPBM: Bernice P. Bishop Museum, Honolulu, Hawaii, U.S.A.; MA: Manfred Asche collection, Marburg, West Germany; USNM: United States National Museum, Washington, U.S.A.; IRSNB: Institut Royal des Sciences Naturelles de Belgique, Brussels, Belgium.

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Achilixiidae

Small to medium sized fulgoroids, with one or two pairs of processes laterally on the abdomen between segments 3 and 5, forewings with costal margin concave at base in *Achilixius*, claval vein entering apex of clavus, rostrum with long apical segment. Male genitalia with base of aedeagus attached to a sclerotized bar across the pygofer.

Taxonomic history

The family was erected by Muir (1923a) for the genus *Achilixius* which contained *Syntames tubulifer* Melichar and three newly described species, *A. singularis* (type species), *A. davaoensis* and *A. sandakanensis*. Muir had earlier (1917) rejected *tubulifer* from the Derbidae and placed it tentatively in the Cixiidae, until his wider considerations on the classification of the Fulgoroidea (1923b) caused him to reconsider its placement. The Neotropical genus *Bebaiotes* Muir was described for two species *B. bucayensis* and *B. nigrigaster* with two further species *B. pallidinervis* and *B. pulla* being added later (Muir, 1924, 1934), all from Ecuador. *Muirilixius* was described by Metcalf (1938) for one species *M. banksi* from Panama. Fennah (1947) provided a synopsis of these latter two genera and described a further three species, *B. dorsivittata*, *B. nivosa* and *M. guianesus*.

Family relationships

The relationship of Achilixiidae to other families is not yet fully defined, although Fennah (1947, 1950) provided much useful information and discussion. Muir (1923a) considered the 'nature of the aedeagus [of Achilixiidae] places it in the Cixiine group . . . otherwise placed near Achilidae in the Meenopline group'. In 1930 Muir (1930a) confined himself to saying that the family has 'a cixiid connection'. Metcalf (1945) suggested that the family was closest to the bennine Cixiidae based on the presence of abdominal processes in both groups. Fennah (1947) dismissed this shared character as of little phylogenetic significance since it has probably arisen through parallel evolution.

The twenty currently recognized families of Fulgoroidea may be divided into two groups based on the arrangement of the spines of the second segment of the posterior tarsus, follow-

ing the work of Muir (1930a), which has been almost universally followed. The first group, in which the second posterior-tarsal segment is almost as large as the first and armed with a row of spines at the apex (probably a plesiomorphic character) comprises nine families; Achilidae, Achilixiidae, Cixiidae, Delphacidae, Dictyopharidae, Fulgoridae, Kinnariidae, Meenoplidae and Derbidae. The remaining families have the second segment of the posterior tarsus much smaller than the first, either devoid of spines at the apex or with a single spine at each side.

Few families from either group have been characterized adequately from a phylogenetic standpoint with the notable exception of the Delphacidae (Asche, 1985), yet each family constitutes a more or less discrete and useful unit. Fennah (1950) placed the Achilixiidae in a group with three other families, Achilidae, Kinnariidae and Meenoplidae on the basis of what he described as 'fundamental characters'; simple egg, cryptic nymphal life, reduced or obsolete ovipositor, tubular phallobase and a greatly reduced or obsolete phallus, a long second posterior tarsal segment, a rostrum with a long apical segment and a primitive forewing venation. These and other characters are discussed below in relation to the Achilixiidae in comparison with other families.

Characters of possible phylogenetic importance

Long apical segment of rostrum. Plesiomorphic condition found in many of the families. The notable exception is that the majority of Derbidae have a very short almost globular apical rostrum but some genera, e.g. *Cedusa* have a long apical segment.

Sensory organs of antennae. The 'star-shaped' sensory organs on the antennae (Fig. 2) are also found throughout the Fulgoroidea (except for Tettigometridae; Bourgoin, 1985) but a thorough survey of these organs is necessary before any more definite statement can be made.

Female ovipositor. The 'reduced' female ovipositor found in the majority of Fulgoroidea is of considerable phylogenetic interest. The plesiomorphic piercing ovipositor is found only in the Delphacidae and Cixiidae. In other fulgoroid families the ovipositor is modified for raking up particles of soil and stirring them with sticky secretions from oviposition glands to coat eggs before they are attached to the substrate.

This 'raking-stirring' ovipositor is found in various forms among the fulgoroid families. According to Emeljanov (1984) the simplified ovipositor in Meenoplidae and Kinnariidae (regarded as sister-groups by Emeljanov) can only be derived from the form found in Achilidae, Achilixiidae and Derbidae. The form found in the Achilixiidae is very similar to that in Achilidae.

Abdominal wax glands. Large abdominal wax glands on the sixth, seventh and eighth tergites are found in female Meenoplidae and Kinnariidae but entirely absent from Achilidae and Achilixiidae.

Sternite suture. Muir (1930a) noted that the fourth to sixth sternites in the female are divided in the mid-line in Achilixiidae, a character not found in other families.

Claval veins of forewing. In Achilixiidae, Achilidae and some Fulgoridae the united claval vein enters the apex of the clavus ('open' clavus) (Figs 7, 10, 12). This is probably a plesiomorphic condition.

Male genitalia. The form of the aedeagus in Achilixiidae is much closer to that found in Meenoplidae than to that in Achilidae. The aedeagus in Achilixiidae and Meenoplidae consists of a tubular phallobase (periandrium) with the central phallus reduced or absent. In Achilixiidae the phallobase consists of two plates and with a transverse cross-bar in the pygofer at the base of the phallobase (Figs 18, 24), a character regarded as unique by Muir (1930a)

Abdominal processes. The structure of the abdominal processes of *Bebaiotes* and *Achilixius* is shown in Figs 4–6. The apex consists of a shallow depression across which a sensory hair or bristle arises from a marginal orifice. In *Bebaiotes* one pair of processes arising from the third segment is found with 3 depressions (Fig. 4), in *Achilixius* two pairs are present arising from the third and fifth segments with respectively 2 and 1 depressions (Figs 5, 6). These resemble the processes found in bennine Cixiidae (*Benna* and *Bennarella* (Muir, 1930b)) but since the cixiid male and female genitalia show considerable differences in structure compared with Achilixiidae it is considered that these similarities are based in parallel evolution. The form of the depression and the arrangement of the sensory bristle is very close to that of the 'sensory pits' present on the head, thorax and abdomen of all nymphal Fulgoroidea (except Tettigometridae). These pits are retained almost

unchanged on the forewing veins of some but not all Derbidae, and also Flatidae, and on the claval veins and the face of all Meenoplidae. Perhaps in a modified form they appear in the Achilixiidae and bennine cixiids.

Long second posterior tarsal segment. The significance of this character was not clearly stated by Fennah (1950). It is actually the first posterior tarsal segment tarsal that is long in Achilixiidae, Meenoplidae, Achilidae and Kinnariidae. It is possible that he was referring to the relative size with reference to the second group of fulgoroid families in which the second segment is markedly smaller than the first. In either case it appears to be a plesiomorphic condition.

Simple eggs. Cobben (1965) provided an excellent survey of the egg structure of some Auchenorrhyncha families in relation to their micropylar structure. Unfortunately the egg structure of Achilidae, Kinnariidae, Achilixiidae and Meenoplidae were not examined. A simple egg-type is found in the Cixiidae and Delphacidae. Other families have a complicated micropyle arrangement. The eggs of Achilixiidae have not been examined in this study.

'Cryptic' nymphal stage. It is not entirely clear what Fennah (1950) intends by the use of this term for the nymphs of most fulgoroids are cryptic if compared with the nymphs of other Auchenorrhyncha such as Cicadellidae and Membracidae.

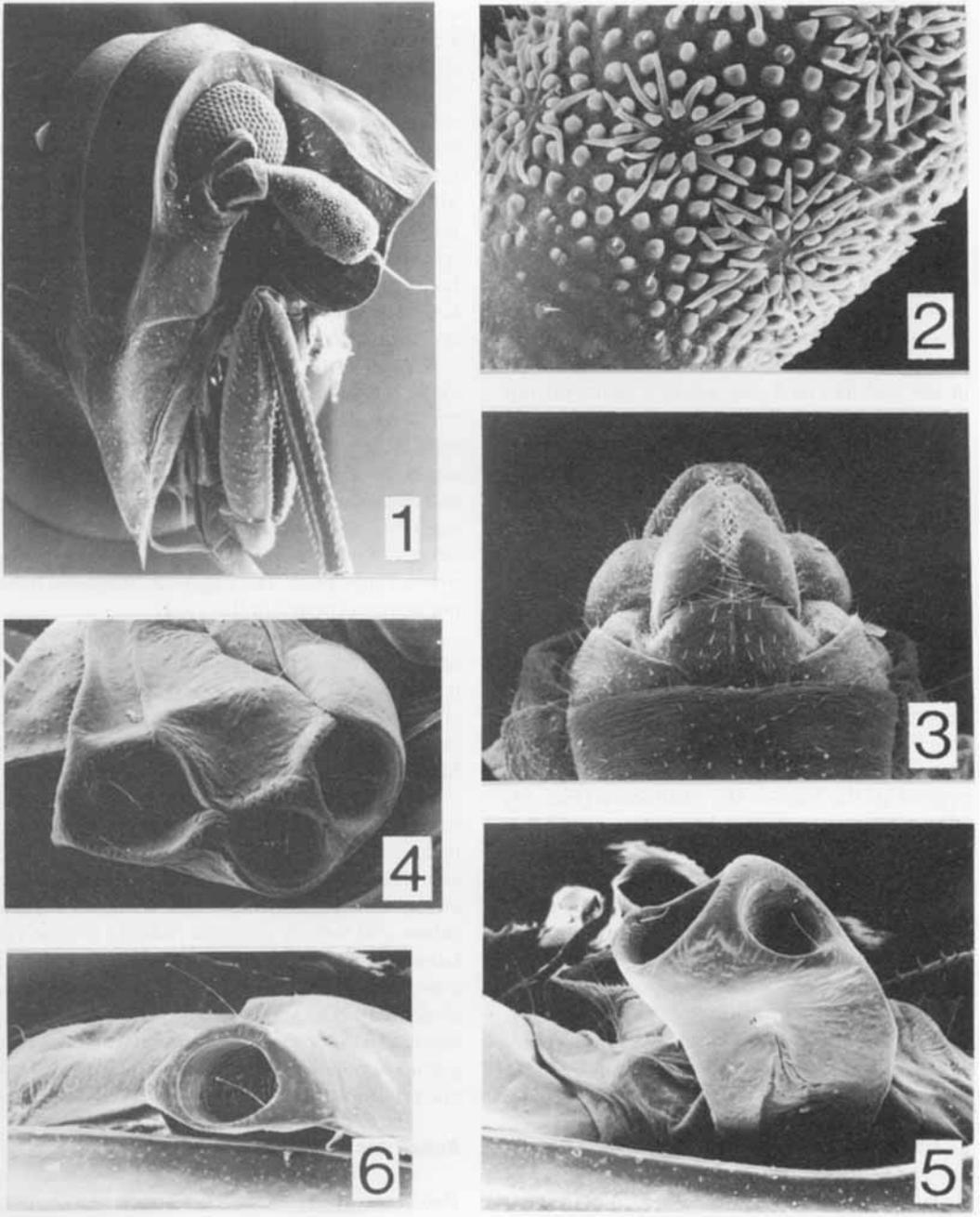
In summary, most of these characters appear to be plesiomorphic and cannot be used to investigate relationships between these taxa. The available evidence at present does not indicate any certain sister-group relationship. The open calvus and female genitalia indicate a close relationship of the Achilixiidae with the Achilidae; however, the male genitalia do not support this placement. Detailed comparative studies are needed to determine the monophyly of the Fulgoroid families and to determine their phylogenetic relationships.

***Bebaiotes* Muir**

Bebaiotes Muir, 1924: 33; Fennah, 1947: 188. Type-species *Bebaiotes bucaensis* Muir, 1924: 34

Muirilixius Metcalf, 1938: 333; Fennah, 1947: 186. Type-species *Muirilixius banksi* Metcalf, 1938: 333. **Syn.n.**

Diagnosis. Wings steeply tectiform. Vertex longer than wide, face narrow or very narrow, in



FIGS 1–6. SEM photographs of Achilixiidae. 1–3, 5, 6, *Achilixius* spp.; 1, lateral view of head; 2, portion of antenna showing 'star-shaped' sensory organs; 3, ventral view of ♀ genitalia; 4, *Bebaiotes* species, abdominal processes; 5, *Achilixius* spp. first abdominal processes; 6, *Achilixius* spp. second abdominal processes.

some lateral carinae almost touching, no median carina. Antennae with second segment about twice as long as first segment. Third abdominal segment formed into process bearing three cup-like depressions.

The nominal genera *Muirilixius* and *Bebaiotes* have been traditionally separated by the form of the lateral carinae of the head which are closer together in *Muirilixius* (e.g. Fig. 8) than they are in *Bebaiotes* (e.g. Fig. 10). In describing *Muirilixius*, Metcalf (1938) stated that the wing venation was fundamentally different between the two genera in addition to the difference in the carina of the head. The forewing and head of *B. bucayensis*, the type species of *Bebaiotes*, and of *M. banksi* the type species of *Muirilixius*, are shown in Figs 7–10. The forewings, contrary to Metcalf's comments, are very similar in venation. The head structure of the two species appears to be at opposite ends of a range of frons width. Fennah (1947) regarded the differences in the two genera as slight but in the absence of intermediate forms retained the two genera. Some undescribed species found recently from the Neotropical region are certainly intermediate in this head character. Lastly, the male genitalia in *Bebaiotes* species and *Muirilixius* species are very similar. There seems to be no justification in retaining *Muirilixius* as a separate genus and the synonymy is proposed here.

Although only eight species are currently described recent collecting in south and central America has shown achilixiids to be more common than earlier indicated, with additional undescribed species having been found (L. O'Brien, N. Penny and H. Wolda, pers. comm.). The following is a list of described species and their distributions:

B. banksi (Metcalf, 1938: 333, *Muirilixius*) comb.n. Panama.

B. bucayensis Muir, 1924: 34. Ecuador.

B. dorsivittata Fennah, 1947: 188. Ecuador.

B. guianesus (Fennah, 1947: 186, *Muirilixius*) comb.n. Guyana.

B. nigrigaster Muir, 1924: 34 (*Bebaiotes*, placed in *Muirilixius* by Fennah, 1947) comb.rev. Ecuador.

B. nivosa Fennah, 1947: 190. Guyana.

B. pallidinervis Muir, 1934: 132. Ecuador.

B. pulla Muir, 1934: 133. Ecuador.

Bebaiotes and *Achilixius* may be separated by the following key:

Two pairs of lateral abdominal processes (e.g. Fig. 15), median carina on face (Fig. 1), antennal segments short *Achilixius*
(Oriental region)

One pair of lateral abdominal processes, median carina on face absent, antennal segments long *Bebaiotes*
(Neotropical region)

Achilixius Muir

Achilixius Muir, 1923a: 483. Type-species *Achilixius singularis* Muir, 1923a: 484.

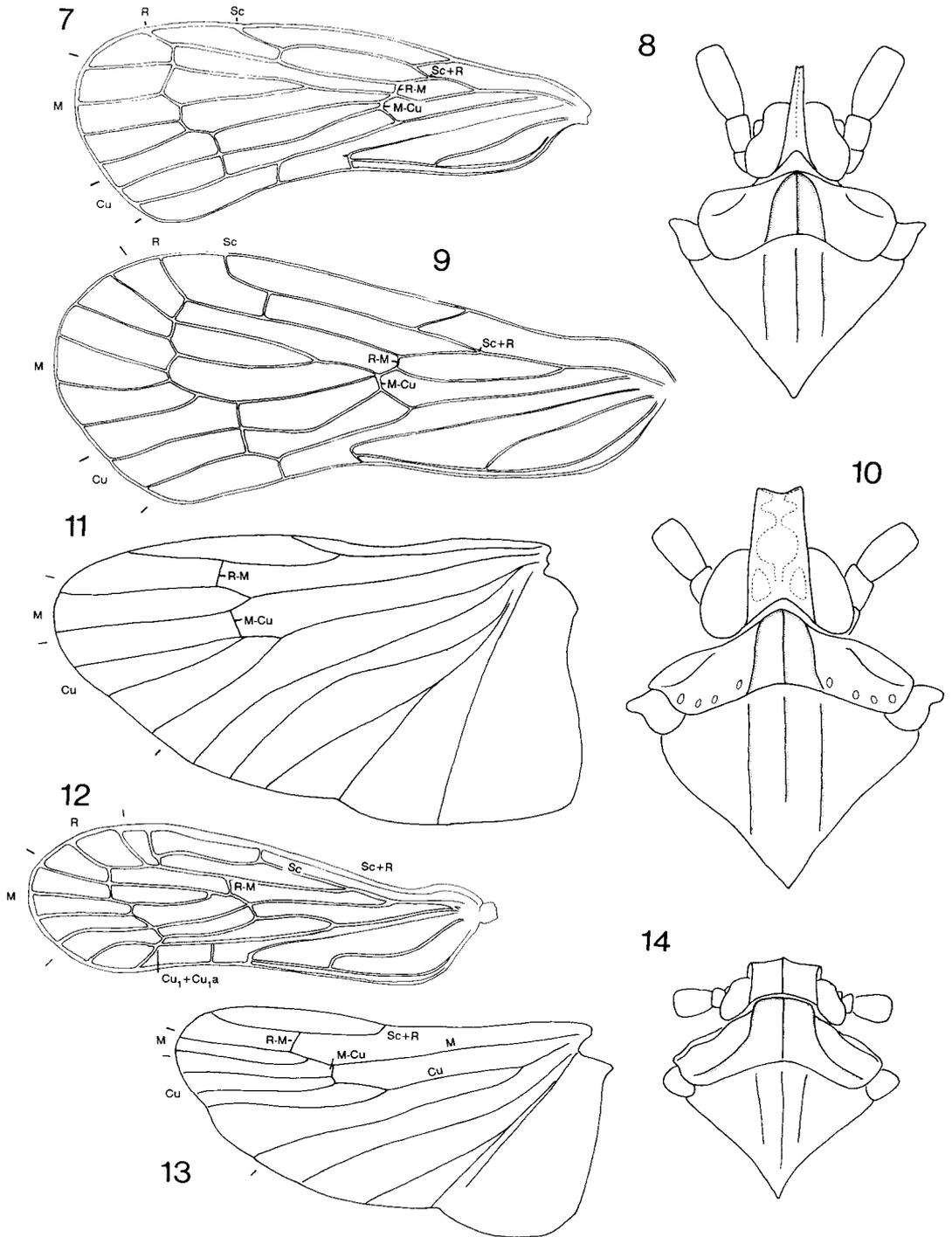
Diagnosis. *Achilixius* differs from *Bebaiotes* in having two rather than one pair of abdominal processes, shorter antennal segments, and a median carina on the face.

Description of genus

Vertex: In dorsal view wider than long with three carinae present, the median one prominent and produced slightly more anteriorly than lateral ones. In lateral view face and frons curved gently with distinct but small break between face and frons. Lateral keels extend onto clypeus for short distance. Marked median keel on frons. Lateral ocelli adjacent to eye and antenna, no median ocellus. Rostrum long, extending beyond hind coxae with final segment considerably longer than wide. Antennae: scape about one-third length of pedicel, pedicel with distinct 'star-shaped' sensory organs (Fig. 2). Pronotum: three prominent keels on dorsal surface, median extends from anterior to posterior margins, lateral keels curve and reach lateral margins at tegulae. A further keel on shoulder between eye and tegulae.

Mesonotum: Three parallel keels on disc, median one extending towards apex posteriorly. Head and thorax with small depressions on surface, otherwise shiny in appearance.

Forewing: Tectiform, longer than abdomen. Costal margin concave at base (where it reaches first abdominal processes), *Sc*+*R* separate about one-third from base. *R* ends in 2 branches (not 4 as Muir (1923a) erroneously (?) states). *M* with 4 branches at apex. *Cul* and *Cula* touch for short distance before apex. Clavus closed with united claval vein entering apex of clavus. Macrotrichae and tubercles absent on forewing. Hindwing: As figured (Fig. 13).



FIGS 7-14. 7, Forewing of *Bebaiotes banksi* (Metcalf); 8, head and thorax, dorsal view, *B. banksi*; 9, forewing of *Bebaiotes bucaeyensis* Muir; 10, head and thorax, dorsal view, *B. bucaeyensis*; 11, hindwing, *B. nigrigaster* Muir; 12, forewing, *Achilixius* spp.; 13, hindwing, *Achilixius* spp.; 14, head and thorax, *Achilixius* spp.

Abdomen: Lateral margins with two pairs of processes (Figs 5, 6) from pleura between tergites and sternites, first pair longer than broad, narrowed at base, and slightly flattened, with two deep depressions at the apex. A sensory hair or bristle arising from the rim of each depression extends across the opening. Second pair of processes shorter, more extensions of the pleura than actual processes with one depression at apex, their sensory hairs similar to those of the first pair.

Legs: Hind tibia with 8 spines apically, plus 2 lateral spines, one two-thirds from the base the other close to base. First tarsal segment long, almost twice length of second and third together. First and second tarsal segments with 6 spines at apex.

Female genitalia: External genitalia consists of: First valvulae, in profile with apical margin toothed with smooth sclerotized processes directed posteriorly (Fig. 105). Ventral flange intertined with apical fringe of long thin setae. Second valvulae, tapering distally, curved ventrad at tip (Fig. 107). Third valvulae, meeting in mid line covering apical portions of first valvulae (Fig. 106), rounded in profile with fringe of stout hairs overlapping when valvulae meet in mid line (Fig. 3). Bursa copulatrix consists of simple sac, sclerotized rings absent.

Male genitalia: Pygofer compressed laterally, anal segment varies considerably in shape and length, from rounded to elongate. Transverse cross-bar in pygofer at base of aedeagus. The position of this cross-bar varies between species, in *A. singularis* and *A. mayoyae* it is across the middle of the pygofer while in all others it is much closer to the anal segment. Aedeagus consists of two plates (phallobase), flattened, rounded or cultrate in profile, orifice at margin. Parameres elongate or sometimes broad, usually swelling towards apex and with projections directed dorsally.

Coloration: Dark brown overall, lateral aspects of head, antennae and pronotum often lighter brown or pale yellow. Legs light brown. In most species forewings dark brown with veins same colour as membrane, apices of veins pale especially obvious at apex of *R*, *Sc*, *Cu* and *clavus*. In *fasciata* sp.n. a dark longitudinal stripe on pale yellow forewings. Hindwings light brown with darker veins. Abdominal sternites and tergites brown, membranes between yellow. Abdominal processes light brown or yellow.

Length: All species 4–5 mm.

Distribution. Previously known from Philippines and N. Borneo (now Sabah). Now also found from Sulawesi, Solomon Islands and Papua New Guinea.

Ecology. In Sulawesi, specimens were collected commonly by Malaise trap and also sweeping from ground vegetation in lowland Rain Forest (200–400 m alt.). The nymphs, in common with those of Derbidae and Achilidae, may feed on rotten or decaying vegetation. Adults may feed from plant tissue.

Phylogenetic relationships of *Achilixius* and *Bebaiotes*

Achilixius and *Bebaiotes* have been included in Achilixiidae in the basis of the possession of abdominal processes but it is unlikely that these structures are homologous in the two genera since they arise on different segments. Muir (1930b) considered the 'cross-bar' in the male pygofer to be unique but this occurs most clearly only in *Achilixius* and may be of a different form in *Bebaiotes*. Similarly, in the female genitalia the bursa copulatrix is simple in *Achilixius* while provided with spines in *Bebaiotes* species (Fennah, 1947). Further study is necessary to define the relationships of these two genera within the Achilixiidae.

List of species (alphabetical order) and distribution

- A. bakeri* sp.n., Philippines
- A. danaumoati* sp.n., Sulawesi
- A. davaoensis* Muir, Philippines, Sulawesi
- A. fasciata* sp.n., Sulawesi
- A. fennahi* sp.n., Sabah
- A. irigae* sp.n., Philippines
- A. kolintangi* sp.n., Sulawesi
- A. mayoyae* sp.n., Philippines
- A. minahassae* sp.n., Sulawesi
- A. morowali* sp.n., Sulawesi
- A. muajati* sp.n., Sulawesi
- A. muiri* sp.n., Sabah
- A. sandakanensis* Muir, Sabah
- A. singularis* Muir, Philippines (type species)
- A. torautensis* sp.n., Sulawesi
- A. tubulifer* (Melichar), Philippines

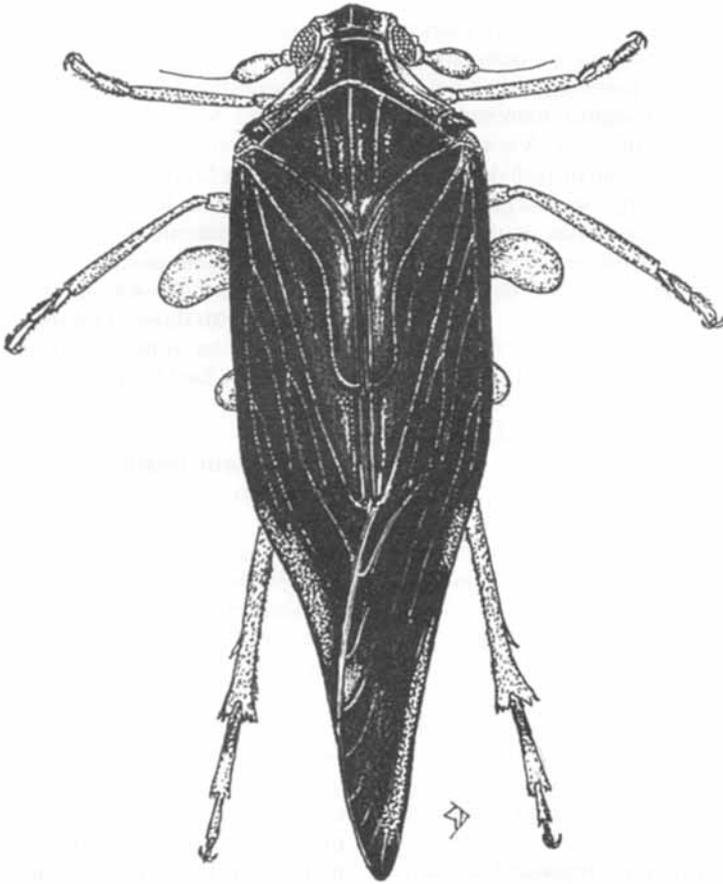


FIG. 15. Habitus of adult *Achilixius* spp.

Key to *Achilixius* species (males only)

Males and females resemble each other in coloration being uniformly dark brown/black in colour with the exception of *A. fasciata* sp.n. which has a distinct yellow costal margin to the forewing. All species differ in characters of the male genitalia which are used in the key for their separation. Many of the characters can be seen without dissection in well preserved specimens. No differences have been found between females (except for *A. fasciata*).

- 1. Costal margin of forewing pale yellow. In male anal segment in lateral view with apical spines directed almost at right angles to remainder of segment. Aedeagus apically pointed .. *fasciata*
- Forewing entirely dark brown/black 2
- 2. Parameres long and thin in lateral view, with dorsal directed process in basal third (Fig. 89) *singularis*
- Parameres variously shaped with process in apical third (e.g. Figs 20, 27, 58) 3
- 3. Anal segment (in dorsal view with apical corners as distinct lobes or points (e.g. Figs 23, 65, 74, 95) 4
- Anal segment rounded or drawn into single large lobe or point (e.g. Figs 17, 40, 46, 54, 69, 80, 84, 97) 7
- 4. Anal segment drawn into two lateral apical short spines. Rounded mediodorsal lobe present on pygofer (Figs 23, 65) 6
- Anal segment with apex as two rounded lobes (Figs 74, 95) 5
- 5. Anal segment with two small apical lobes (Fig. 95) *torautensis*
- Anal segment with two large round apical lobes (Fig. 74) *muajati*
- 6. Anal segment in lateral view tapering to point (Fig. 62) *minahassae*

- Anal segment in lateral view widening then apically pointed (Fig. 22) *danaumoati*
- 7. Anal segment drawn into a narrow single apical lobe or narrow apical spine (Figs 50, 57, 80).. 8
- Anal segment rounded (Figs 17, 30) 10
- 8. Anal segment with narrow rounded apical lobe, parameres very broad in lateral view (Fig. 58) with prominent median projection (Fig. 60) *mayoyae*
- Anal segment with apical spine (Figs 54, 80), parameres less broad and without any median lobes 9
- 9. Aedeagus apically pointed in lateral view (Fig. 80) *muiiri*
- Aedeagus large and rounded in lateral view (Fig. 55) *kolintangii*
- 10. Anal segment short and rounded (Figs 30, 40, 84, 97) 11
- Anal segment longer with apex swollen (Figs 17, 46, 69) 14
- 11. Aedeagus rounded in profile (Fig. 31) *davaoensis*
- Aedeagus apically pointed (Figs 39, 85, 96) 12
- 12. Aedeagus with short tubercles (Fig. 85), styles almost rectangular apically in profile (Fig. 87) *sandakanensis*
- Aedeagus without tubercles 13
- 13. Parameres narrow, apically pointed, with small median lobe (Figs 96, 99) *tubulifer*
- Parameres wide, with two sub-apical dorsal processes (Figs 39, 43) *fennahi*
- 14. Aedeagus broad in profile (Fig. 68), anal segment curved of equal width in lateral view (Fig. 68), in dorsal view swollen apically (Fig. 69) *morowali*
- Aedeagus longer and thinner, rounded at apex, anal segment with sub-apical or lateral lobes (Figs 16, 45) 15
- 15. Aedeagus thin, long and slightly curved (Fig. 45), anal segment rounded with apical lobes visible in lateral view (Fig. 45) *irigae*
- Aedeagus broader, anal segment with lateral lobes extending ventrally (Fig. 16) *bakeri*

***Achilixius bakeri* sp.n.**

(Figs 16–21)

Diagnosis. Characterized by the male genitalia (Figs 16–21), with large anal segment

(Fig. 17), found in same localities and habitat as *A. tubulifer* (Mel.). First antennal segment light yellow brown in *A. bakeri* but darker in *A. tubulifer*.

Description. Antennae with first segment pale yellow. Legs with broad bands of darker coloration on tibia and tarsae.

Male genitalia (Figs 16–21): Anal segment large with lateral margins expanded and extend ventrad (Fig. 16) and rounded in profile (Fig. 17); parameres elongate, swelling towards apex which is rounded with dorsal margin pointed dorsally, a thin laterally directed process arises from dorsal margin near apex (Fig. 20). Aedeagus large, flattened, curved at base, dorsal margin more or less straight, ventral margin curved (Fig. 16).

Type material. Holotype, ♂, PHILIPPINES: Laguna Province, Mt Makiling, 4 km SE Los Baños (Wilson), 21.vi.1980 (BMNH).

Paratypes, PHILIPPINES: 2♂, 2♀ same data as holotype (BMNH); 1♂, Laguna Province, Liliw, Tuy Banaan (Wilson), vi–vii 1980 (BMNH); 1♂, 2♀, labelled ‘Mt Makiling, Luzon, Baker’ (USNM). 2♂ labelled, ‘Mt Maquiling Luzon PI, C F Baker collection’ (USNM).

Comments. Some of the above were found mixed with a series labelled as *A. tubulifer*. This species appears to be found in same localities in Luzon Island and in the same habitats (lowland rainforest sites).

***Achilixius danaumoati* sp.n.**

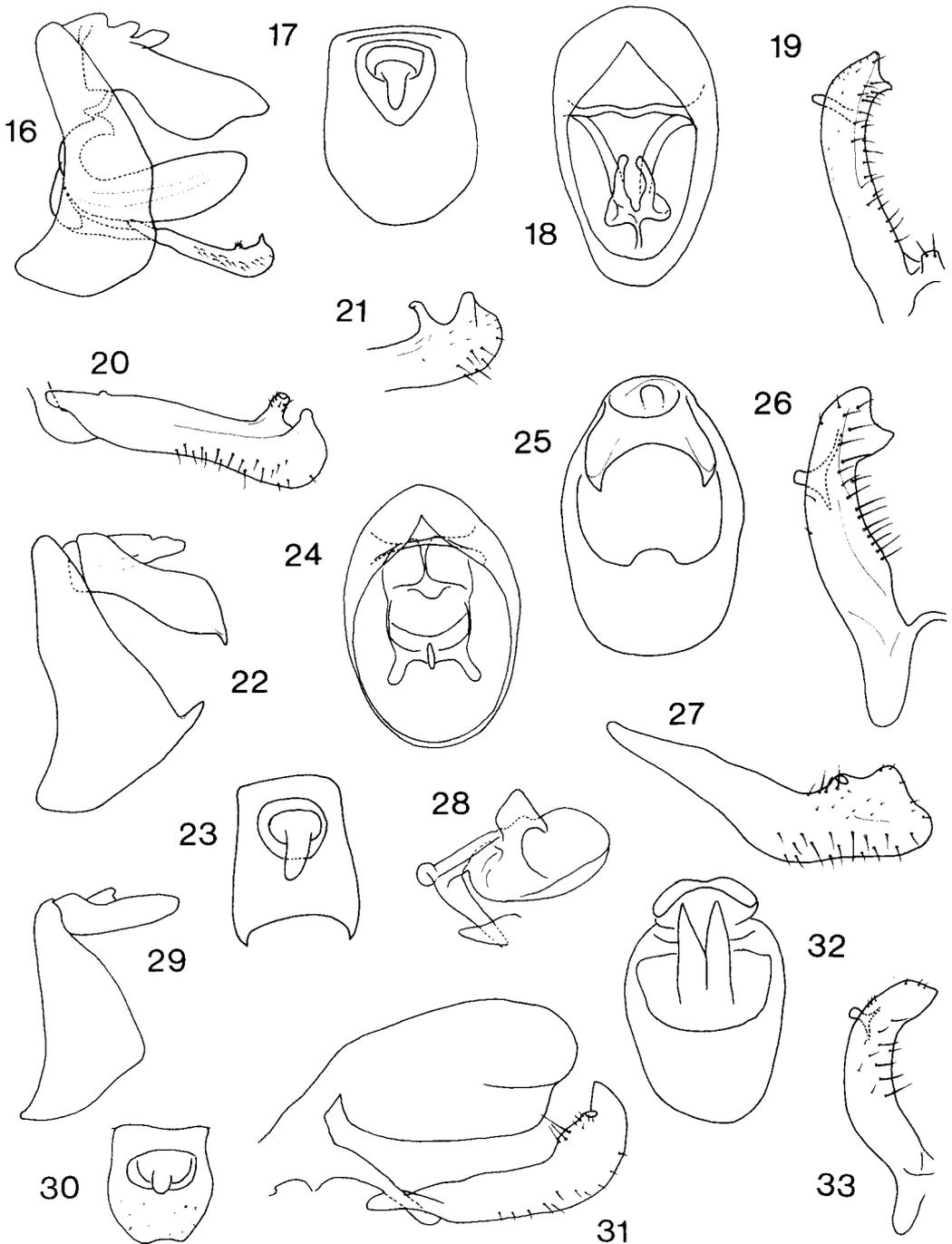
(Figs 22–28)

Diagnosis. The rounded medioventral lobe of the pygofer is diagnostic for *danaumoati* together with the shape of the anal segment. *A. minahassae* is very similar but differs in the tapering anal segment, swollen in *A. danaumoati*.

Description. Male genitalia (Figs 21–25): anal segment with apical corners pointed, segment swollen in lateral in lateral view (Fig. 22), in dorsal view concave at apex (Fig. 23); medioventral margin of pygofer with rounded lobe (Fig. 25); aedeagus, large rounded (Fig. 28).

Type material. Holotype, ♂, INDONESIA: N. Sulawesi, G. Muajat, Volcanic area, 1100 m alt. 19.xi.85 (Asche) (BMNH).

Paratypes, INDONESIA: 2♂ same data as holotype (BMNH, MA).



FIGS 16–33. ♂ genitalia *Achilixius* spp.: 16–21, *A. bakeri*, 16, pygofer, aedeagus, anal segment, parameres, lateral view; 17, anal segment, dorsal view; 18, pygofer, view from behind to show 'cross-bar'; 19, paramere, ventral view; 20, paramere, lateral view; 21, another view of apex of paramere. 22–28, *A. danaumoati*, 22, pygofer and anal segment, lateral view; 23, anal segment, dorsal view; 24, pygofer, view from behind; 25, pygofer and anal segment, ventrocaudal view; 26, paramere, ventral view; 27, paramere, lateral view; 28, aedeagus, lateral view. 29–33, *A. davaoensis*, 29, pygofer, anal segment lateral view; 30, anal segment, dorsal view; 31, aedeagus, parameres, lateral view; 32, pygofer and anal segment, ventrocaudal view; 33, paramere, ventral view.

***Achilixius davaoensis* Muir**

(Figs 29–33)

Achilixius davaoensis Muir, 1923a: 485.

Diagnosis. The rounded anal segment and large aedeagus serve to separate this species from others.

Description. Male genitalia (Figs 29–33): anal segment small, rounded in dorsal view (Fig. 30); aedeagus large, rounded (Fig. 31); parameres with rounded ventral margin (Fig. 31).

Material examined. Holotype, ♂, PHILIPPINES: labelled 'Davao, Mindanao, Baker, *Achilixius davaoensis* Muir ♂ 1047' (BPBM). Paratype ♂ and allotype ♀, same data as holotype (BPBM). Additional specimens, PHILIPPINES, 3♂, Mindanao+1♀ (? this species) (BPBM); INDONESIA: N. Sulawesi, Dumoga-Bone NP; 1♂, Hog's Back camp, 25.x.85 (*Asche*), 2♂, Toraut, 28.x.85 (*Asche*) (BMNH, MA), 1♂, Hog's Back camp, x.1985 (*Van Stalle & Bosmans*) (IRSNB). 1♂, Hog's Back camp, vii.1985, 1♂, Toraut, ii.1985, 1♂, Clarks camp, vi.1985 (BMNH).

Comments. This is the only species to have been found to have a wider distribution, being found in both the southern Philippines and N. Sulawesi.

***Achilixius fasciata* sp.n.**

(Figs 34–38)

Diagnosis. This is the most distinctive species of the genus due to the coloration of the forewing with the yellow costal margin.

Description. Body, legs, head and pronotum pale yellow (in some specimens some brown suffusion), mesonotum brown; forewings with costal margin and hind margin pale yellow with dark brown stripe along length of forewing, sometimes extending towards hind margin but costal margin always yellow.

Male genitalia (Figs 34–38): anal segment with lateral apical processes directed ventrad (Fig. 34); aedeagus apically pointed in lateral view (Fig. 34).

Type material. Holotype, ♂. INDONESIA: Sulawesi Utara, G. Magononipa summit, 1008 m (*Wilson*), 12.v.1985 (BMNH).

Paratypes. INDONESIA: Sulawesi Utara, Dumoga Bone National Park; 1♀, Edwards

Camp 664 m (*Asche*) 4.xii.1985 (MA); 1♂, 1♀ same data 7.v.1985 (*Wilson*); 2♂, 3♀, Edwards camp 664 m, malaise trap; 1♂, 2♀, Hog's Back camp, 3♀, Toraut, ii.1985 (BMNH, BPBM); 1♀, x.1985, station 049 (*Bosmans & Van Stalle*) (IRSNB); 2♀, Hog's Back camp, 492 m (*Wilson*); vi.1985 (1 sweeping, 1 Malaise trap), 2♂, same data except 25.x.1985 (*Asche*) (BMNH, MA); 1♀, Hog's Back, x.1985, station 051 (*Bosmans & Van Stalle*); 1♀, same data except 15.xi.1985, station 095 (IRSNB); 1♂, Toraut nr base camp, c. 200 m (*Asche*) 28.x.1985 (MA).

***Achilixius fennahi* sp.n.**

(Figs 39–44)

Diagnosis. The broad parameres (Fig. 43) and the shape of the aedeagus are diagnostic and resemble those of no other species.

Description. Male genitalia (Figs 36–41): anal segment disc shaped with rounded margin (Fig. 40). Parameres short and broad with round posterior-ventral margin (Fig. 43); two lobes towards tip directed dorsally and inwards (Fig. 43); aedeagus short, consisting of two flattened plates, two lobes directed ventrally, one conical lobe directed dorsad; posterior margin truncate (Fig. 39).

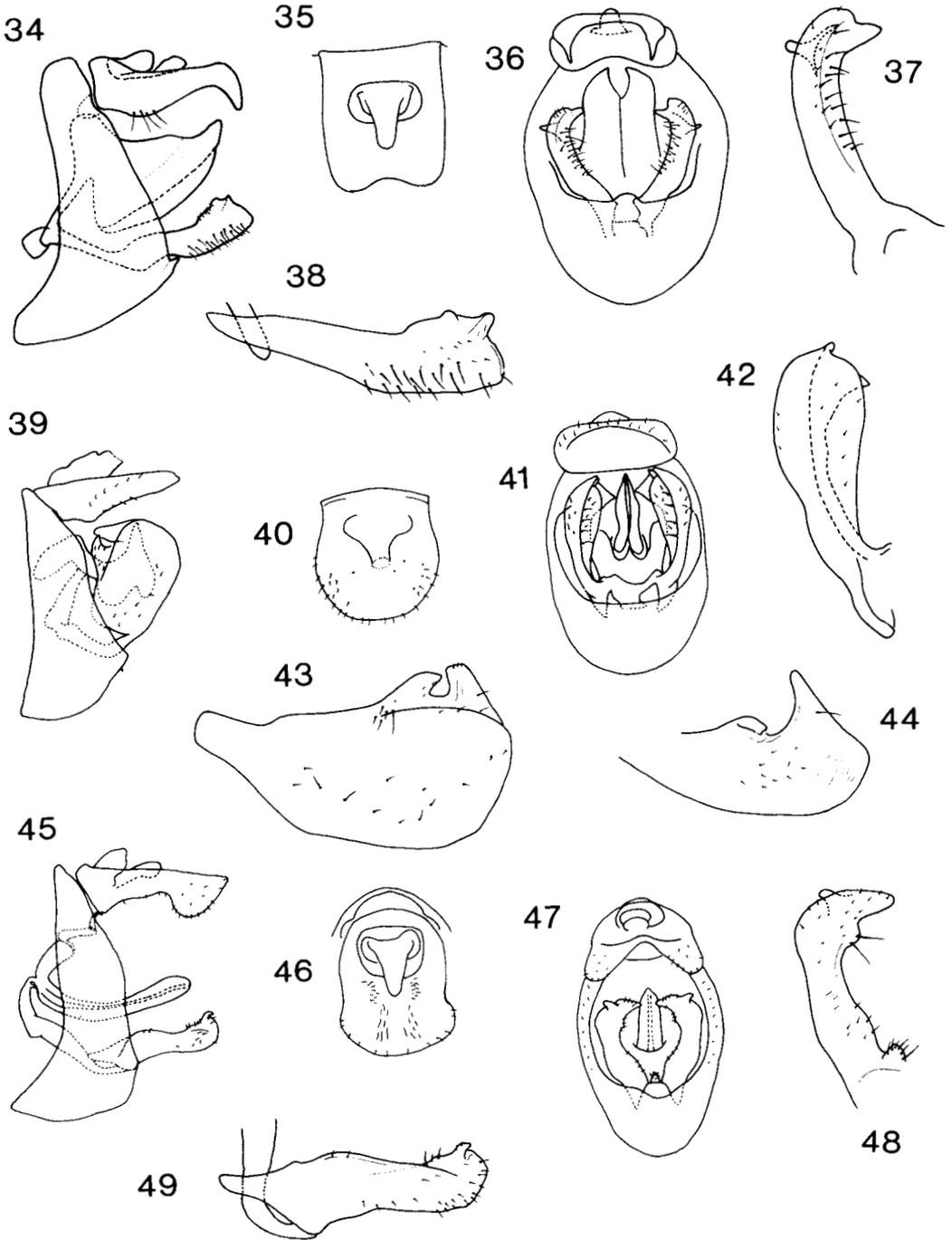
Type material. Holotype, ♂, SABAH: labelled, 'British N. Borneo, Sandakan. 20.xi.1958 (*Maa*)' (BPBM).

***Achilixius irigae* sp.n.**

(Figs 45–49)

Diagnosis. The male genitalia are distinct but the thin curved aedeagus resembles *A. mayoyae* sp.n. In the latter species the aedeagus is considerably more curved (Fig. 56) as well as possessing distinctly differently shaped parameres and anal segment.

Description. Male genitalia (Figs 45–49): anal segment large expanded laterally at apex with rounded margin (Fig. 46); in posterior view margins curve ventrally (Fig. 42); aedeagus thin, consisting of two adjacent plates, slightly curved, almost same width throughout (viewed laterally Fig. 45); orifice apical. Parameres thin, curving inwards at tip with laterally directed short processes before apex (Fig. 49), a small conical process joining parameres at base in the mid line (Fig. 47).



FIGS 34–49. ♂ genitalia *Achilixius* spp.; 34–38, *A. fasciata*. 34, pygofer, anal segment, paramere, aedeagus, lateral view; 35, anal segment, dorsal view; 36, pygofer, anal segment, ventrocaudal view; 37, paramere, ventral view; 38, paramere, lateral view. 39–44, *A. fennahi*. 39, pygofer, anal segment, paramere, aedeagus, lateral view; 40, anal segment, dorsal view; 41, pygofer, anal segment, ventrocaudal view; 42, paramere, ventral view; 43, paramere, lateral view; 44, apex of paramere, another view. 45–49, *A. irigae*. 45, pygofer, anal segment, aedeagus, paramere, lateral view; 46, anal segment, dorsal view; 47, pygofer, anal segment, parameres, ventrocaudal view; 48, paramere, ventral view; 49, paramere, lateral view.

Type material. Holotype, ♂, PHILIPPINES: Luzon I., Camarines Sur Province, Mt Iriga, 500–600 m, 9.iv.1962 (*Torrevillas*), light trap (BPBM).

Paratypes. PHILIPPINES: 1♂ same data as holotype but label does state if specimens caught by light trap. 3♀ with the same data have not been included in the type series (BPBM).

***Achilixius kolintang* sp.n.**

(Figs 50–55)

Diagnosis. The anal segment, in which the apex is drawn into a fine point, separates this species from others.

Description. Male genitalia (Figs 50–55): anal segment with apex drawn into fine point; medioventral process of pygofer present as small pointed triangular lobe (Fig. 51); parameres with dorsal margin rounded (Fig. 55); aedeagus, large rounded (Fig. 55).

Type material. Holotype, ♂, INDONESIA: Sulawesi, Dumoga-bone National Park, river Tumpah, x.1985, station 052. Project Wallace (*Bosmans & Van Stalle*) (IRSNB).

Paratypes. INDONESIA: 3♂, same data as holotype (BMNH, IRSNB).

***Achilixius mayoyae* sp.n.**

(Figs 56–61)

Diagnosis. The male genitalia are distinct with the strongly curved aedeagus and wide short parameres diagnostic. *A.fennahi* has similar shaped parameres but differs in the shape of the aedeagus and anal segment.

Description. Male genitalia (Figs 56–61): anal segment with median lobe, rounded at margin (Fig. 57); aedeagus strongly curved dorsad (Fig. 56), consisting of two plates joined at ventral margins and open at dorsal side to form a semi-circular structure; orifice presumably on inner portion of dorsal surface; parameres narrow at base widening markedly towards tip (Fig. 58); apex directed dorsally with two lobes (Fig. 59), the sub-apical lobe with process directed laterally, the narrow apical lobe curved inwards; parameres joined at base with prominent median conical process (Fig. 60).

Type material. Holotype, ♂, PHILIPPINES: Mt Province, Mayoyao, Ifugao, 1200–1500 m, 3.ix.1966 (*Torrevillas*) (BPBM).

***Achilixius minahassae* sp.n.**

(Figs 62–67)

Diagnosis. Closely resembles *A.danaumoati* but differs in shape of anal segment, which is tapered in *A.minahassae*.

Description. Male genitalia (Figs 62–67); anal segment gently curved ventrally, in dorsal view apical corners drawn into sharp points with concave margin between them, in lateral view anal segment tapers to point (Fig. 62); parameres short, apex almost rectangular in profile (Fig. 64); medioventral lobe of pygofer present (Fig. 66).

Type material. Holotype, ♂, INDONESIA: Sulawesi Utara; Dumoga-Bone NP, vi.1985, Hog's Back camp, 492 m (*Wilson*), Malaise trap (BMNH).

Paratypes. INDONESIA: 2♂, same data as holotype (BMNH); 24♂, Hog's Back camp, malaise trap, vii.1985, 3♂, Toraut forest, ii.1985 (BMNH, BPBM); 4♂, Molibagu Road, 18.xi.85 (*Asche*); 1♂, Tangkoko reserve nr Manado, 28.xi.1985 (*Asche*); 1♂, Dumoga-Bone NP, Tumpah path to 'beach', 28.x.85 (*Asche*). (BMNH, MA); 1♂, River Tumpah, x.1985 (*Bosmans & Van Stalle*), 1♂, Hog's Back sub-camp, 15.xi.1985 (*Bosmans & Van Stalle*) (IRSNB).

***Achilixius morowali* sp.n.**

(Figs 68–72)

Diagnosis. The large anal segment with expanded rounded apex is unlike that of any other species except *A.muajati*, but in the latter species the apical margin is strongly concave (Fig. 74).

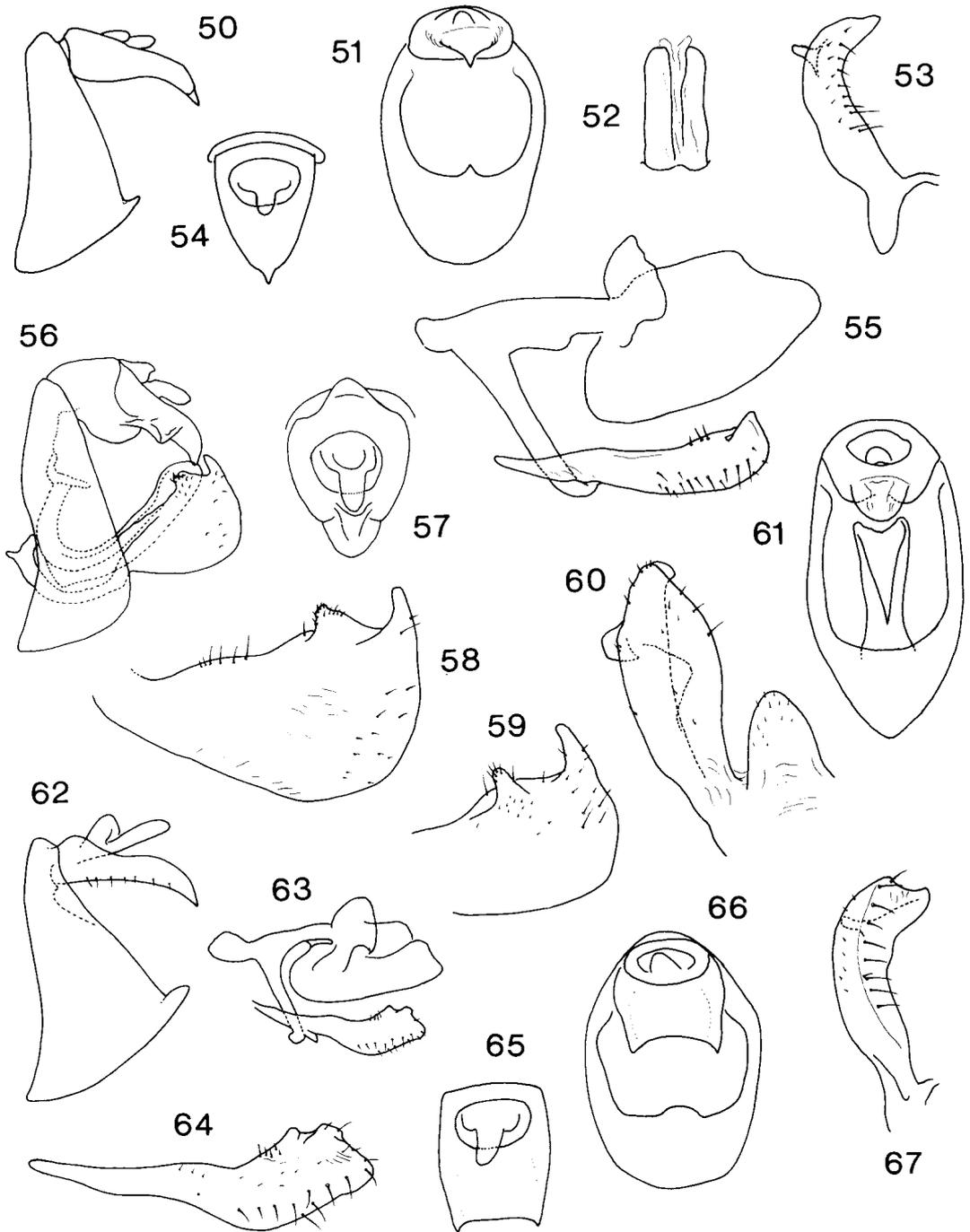
Description. Male genitalia (Figs 68–72): anal segment large, curved in lateral view (Fig. 68) apex rounded and expanded (Fig. 69); parameres with posterior margin apically rounded (Fig. 68); aedeagus broad, truncate (Fig. 68).

Type material. Holotype, ♂, INDONESIA: Sulawesi Tengah, nr Morowali, Ranu River Area, 27.–20.iv.1980, lowland rain forest (*Brendell*) (BM 1980-280) (BMNH).

***Achilixius muajati* sp.n.**

(Figs 73–77)

Diagnosis. The shape of the anal segment with



FIGS 50–67. ♂ genitalia *Achilixius* spp.: 50–55. *A. kolintangi*. 50, pygofer, anal segment, lateral view; 51, pygofer, anal segment, ventrocaudal view; 52, aedeagus, ventral view; 53, paramere, ventral view; 54, anal segment, dorsal view; 55, aedeagus, paramere, lateral view. 56–60. *A. mayoyae*. 56, pygofer, anal segment, paramere, aedeagus, lateral view; 57, anal segment, dorsal view; 58, paramere, lateral view; 59, paramere, apex, another view; 60, paramere, ventral view; 61, pygofer, anal segment, ventrocaudal view. 62–67. *A. minahassae*. 62, pygofer, anal segment, lateral view; 63, aedeagus, paramere lateral view; 64, paramere, lateral view; 65, anal segment, dorsal view; 66, pygofer, anal segment, ventrocaudal view; paramere, ventral view.

its concave apical margin and the shape of the aedeagus is diagnostic in this species.

Description. Male genitalia (Figs 73–77): anal segment long, in dorsal view lateral lobes extended, with concave margin (Fig. 74); parameres thin at base, expanding towards apex, apical margin truncate dorsad (Fig. 75), dorsal sub-apical process laterally directed; aedeagus broad, dorsal and ventral margin rounded (Fig. 73).

Type material. Holotype, ♂, INDONESIA: Sulawesi Utara, Gunung Muajat summit, 1780 m, 30.v.1985, light sheet (Wilson) (BMNH).

***Achilixius muiri* sp.n.**

(Figs 78–82)

Achilixius sandakanensis Muir, 1923a: 485 in part (description and figure).

Diagnosis. Male genitalia similar to *A. sandakanensis* but anal segment thin and pointed not rounded, aedeagus without tubercles.

Description. Male genitalia (Figs 78–82): anal segment tapering to sharp point (Fig. 80); parameres with dorsal margin almost at right angles at apex (Fig. 79); aedeagus tapering to narrow point apically (Fig. 81).

Type material. Holotype, ♂, SABAH: labelled, Borneo (Brit. N.), Sandakan 31.x.1957 (*Gressit*), light trap (BPBM).

Paratypes. SABAH: 1♂, same data as holotype; 4♂, Borneo, Sandakan: hotel, 50 m, 25.x.1957, light trap (*Gressit*) (BMNH, BPBM); 1♂, Sandakan, i.1927, B.N. Borneo (*Pember-ton*) (BPBM); 1♂, Sandakan Borneo Baker (BPBM specimen illustrated by Muir, 1923, as *sandakanensis*).

Comments. This species was described and illustrated by Muir (1923a) as *A. sandakanensis*. See also comments made under that species.

***Achilixius sandakanensis* Muir**

(Figs 83–88)

Achilixius sandakanensis Muir, 1923a: 485.

Diagnosis. The tuberculate aedeagus resembles that of no other species. The rounded anal segment resembles that of *A. fennahi* but that species differs markedly in the shape of the

paramere. The shape of the aedeagus in *A. muiri* is similar but lacks tubercles, and this species also has a pointed anal segment.

Description. Male genitalia (Figs 83–88): anal segment small, rounded (Fig. 84); parameres truncate, almost rectangular at apex (Fig. 87); aedeagus with distinct small tubercles present (Fig. 85).

Material examined. Holotype, ♂, SABAH: labelled 'Sandakan, Borneo, Baker/Achilixius sandakanensis Muir ♂, 1046' [handwritten] (BPBM). Allotype ♀, same data as ♂ 1046 (labelled) (BPBM). Additional material, 9♂, Sandakan, Borneo, Baker (USNM, BMNH). 2♀ probably this species with the same labels (USNM).

Comments. Muir (1923a) mentions 5 males and 2 females in the type series. Some of the above are probably part of this series but cannot be positively identified as such. The holotype male when dissected proved to be a different species from that described and figured by Muir and this has to bear the name *sandakanensis*. The remaining males, with the exception of the one that had been dissected and drawn by Muir, proved to be identical with the holotype. Muir's description and figure is referred to *A. muiri* sp.n. (see above). It appears that Muir studied a mixed series from Sandakan (which is a province not only a local area) and assumed the undissected holotype would be the same as the specimen illustrated.

***Achilixius singularis* Muir (type-species)**

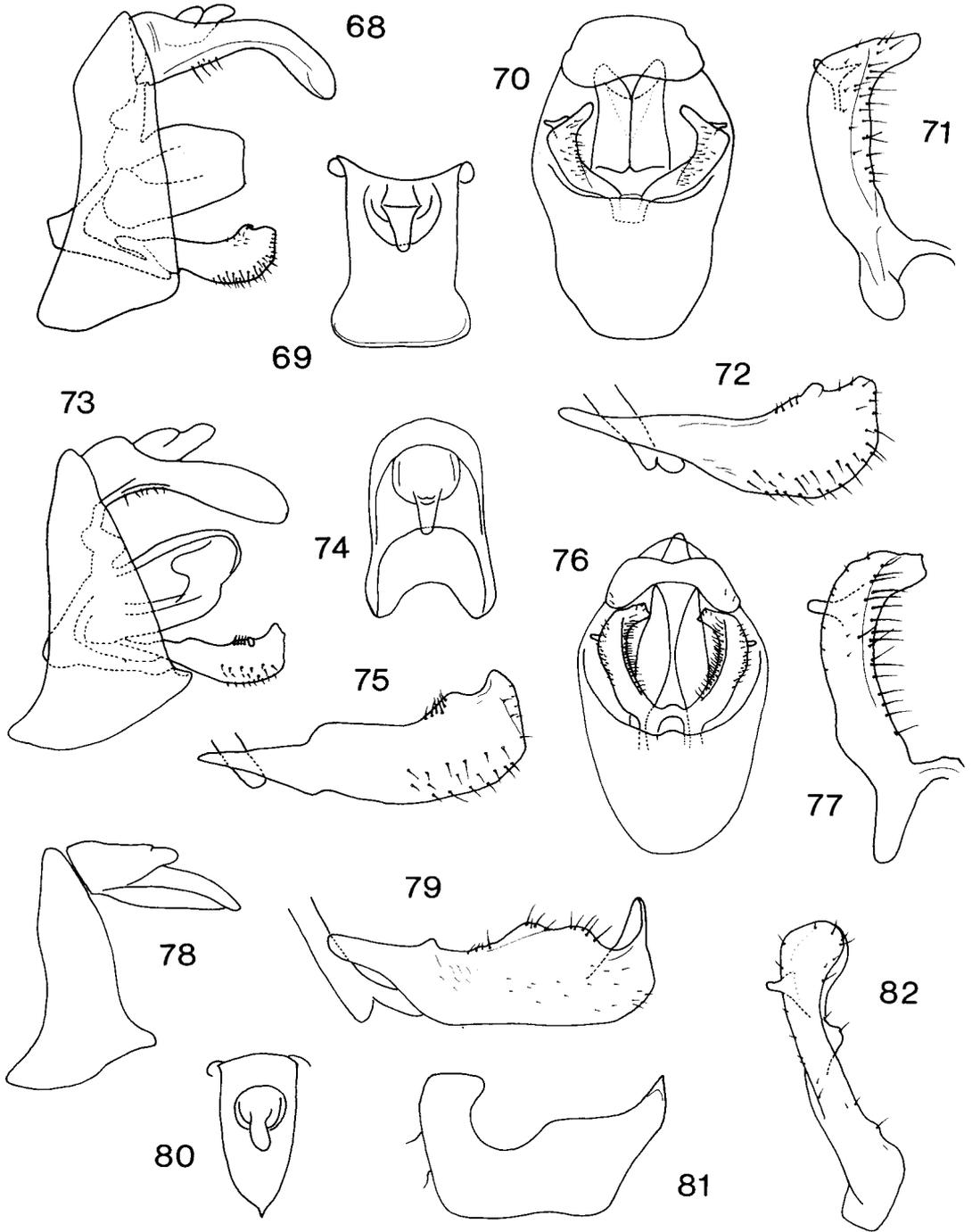
(Figs 89–90)

Achilixius singularis Muir, 1923a: 484.

Diagnosis. This species may be identified by the male genitalia (Fig. 89) which Muir (1923) fully described. The sclerotized cross-bar in the pygofer is figured here (Fig. 90) from an, apparently, unpublished sketch by Muir (F. A. G. Muir archive in BMNH Library).

Material examined. Holotype, ♂, PHILIPPINES: labelled 'Baguio, Benquet, Baker, Achilixius singularis Muir ♂ 1045' (genitalia slide mounted on same pin as specimen) (BPBM).

Comments. Known only from the holotype. This species has the most distinctive male genitalia and the largest genital capsule (although



FIGS 68–82. ♂ genitalia *Achilixius* spp.; 68–72, *A. morowali*. 68, pygofer, anal segment, aedeagus, paramere, lateral view; 69, anal segment, dorsal view; 70, pygofer, anal segment, parameres, ventrocaudal view; 71, paramere, ventral view; 72, paramere, lateral view. 73–77, *A. muajati*. 73, pygofer, anal segment, aedeagus, lateral view; 74, anal segment, dorsal view; 75, paramere, lateral view; 76, pygofer, anal segment, parameres, ventrocaudal view; 77, paramere, ventral view. 78–82, *A. muiri*. 78, pygofer, anal segment, lateral view; 79, paramere, lateral view; 80, anal segment, dorsal view; 81, aedeagus, lateral view; 82, paramere, ventral view.

the total body length is similar to other species) in the genus.

***Achilixius torautensis* sp.n.**
(Figs 91–95)

Diagnosis. The rounded anal segment with two lobes and concave apical margin, and the broad aedeagus serves to separate this species from the others of the genus.

Description. Male genitalia (Figs 91–95): anal segment with two rounded lobes at apex, margin between them concave; parameres truncate in dorsal view (Fig. 93); aedeagus broad with curved ventral margin (Fig. 94).

Type material. Holotype, ♂, INDONESIA: Sulawesi Utara, Dumoga-Bone NP, vi.1985, Toraut, nr base camp, 200 m (*Wilson*) (BMNH).

Paratypes. (BMNH, BPBM, USNM, IRSNB, MA) INDONESIA: Sulawesi: 1 ♂, same data as holotype, 3 ♂, same data except 20.x.1985 (*Asche*); 10 ♂, same data except Edwards camp, 664 m sweeping (*Wilson*), 2 ♂, Hog's Back camp, malaise trap, vi.1985, 1 ♂, Edwards camp, vi. 1985, 1 ♂, Toraut, v.1985, yellow pan trap (*Noyes*), 2 ♂, Toraut nr base camp, malaise trap, vii–viii.1985, 2 ♂, as above, except Hog's Back camp, 492 m, sweeping, 1 ♂, Hog's Back camp, 492 m, 25.x.1985 (*Asche*), 2 ♂, Sulawesi Utara, Dolodua to Molibagu Road, 18.xi.85 (*Asche*).

***Achilixius tubulifer* (Melichar)**
(Figs 96–108)

Syntames tubulifer Melichar, 1914: 269.

Achilixius tubulifer (Melichar) Muir, 1917: 59, Muir, 1923a: 485.

Diagnosis. *A. tubulifer* is distinguished from other species by the characters of the male genitalia (Figs 96–103). It may be easily separated from *A. bakeri*, also found on Mt Makiling, by the male genitalia, in which the anal segment is considerably smaller in *A. tubulifer*. Also the first antennal segment (both in males and females) in *A. tubulifer*, is dark, while in *A. bakeri* it is pale yellow. In addition *A. bakeri* has 'striped' legs with bands of darker coloration on

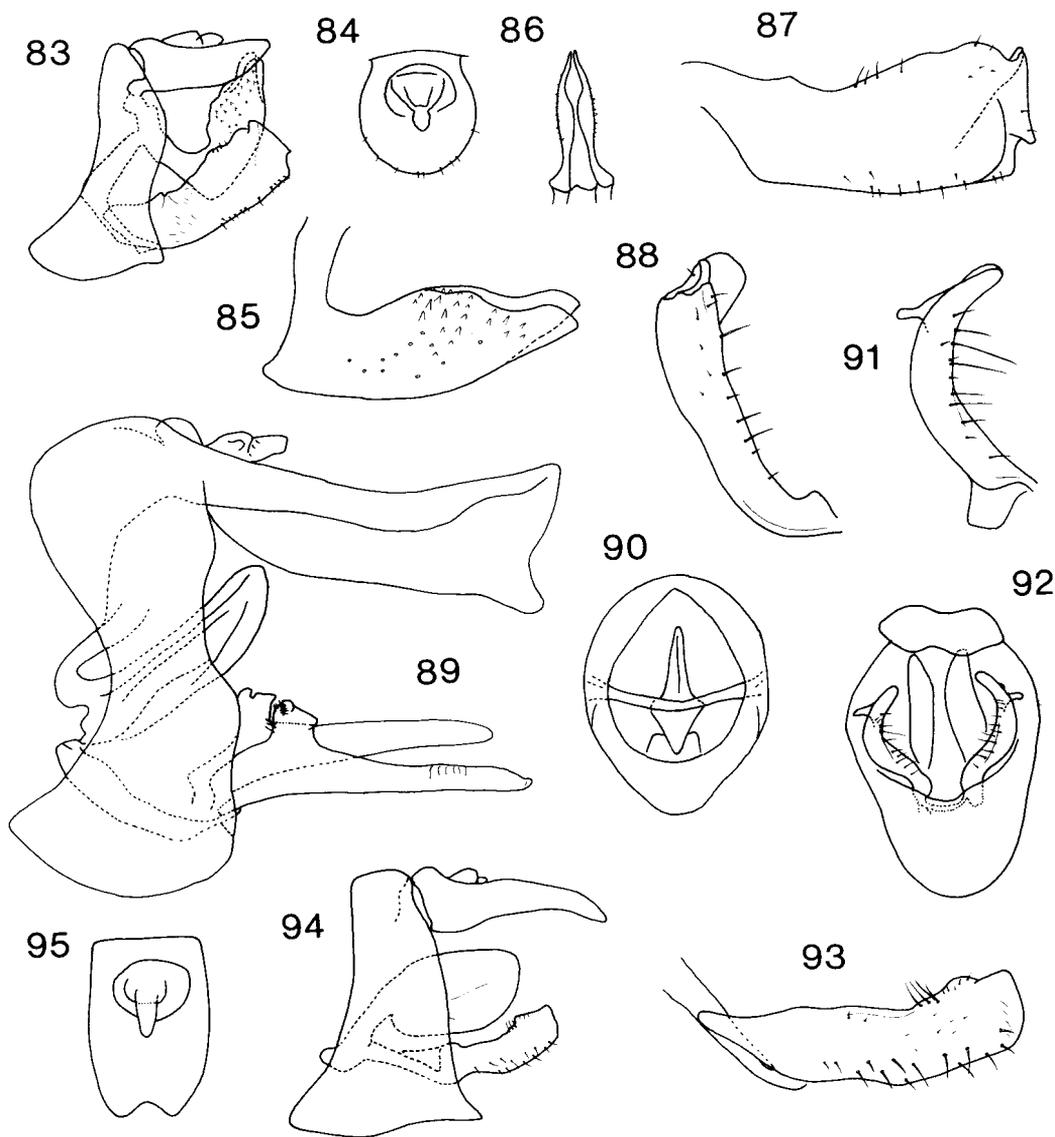
tibia and tarsal segments, while in *tubulifer* they are uniformly light brown.

Description. Male genitalia (Figs 96–103), Female genitalia (Figs 104–108). Melichar (1914) described the species and it was redescribed and figured by Muir (1923a). No further description is given here.

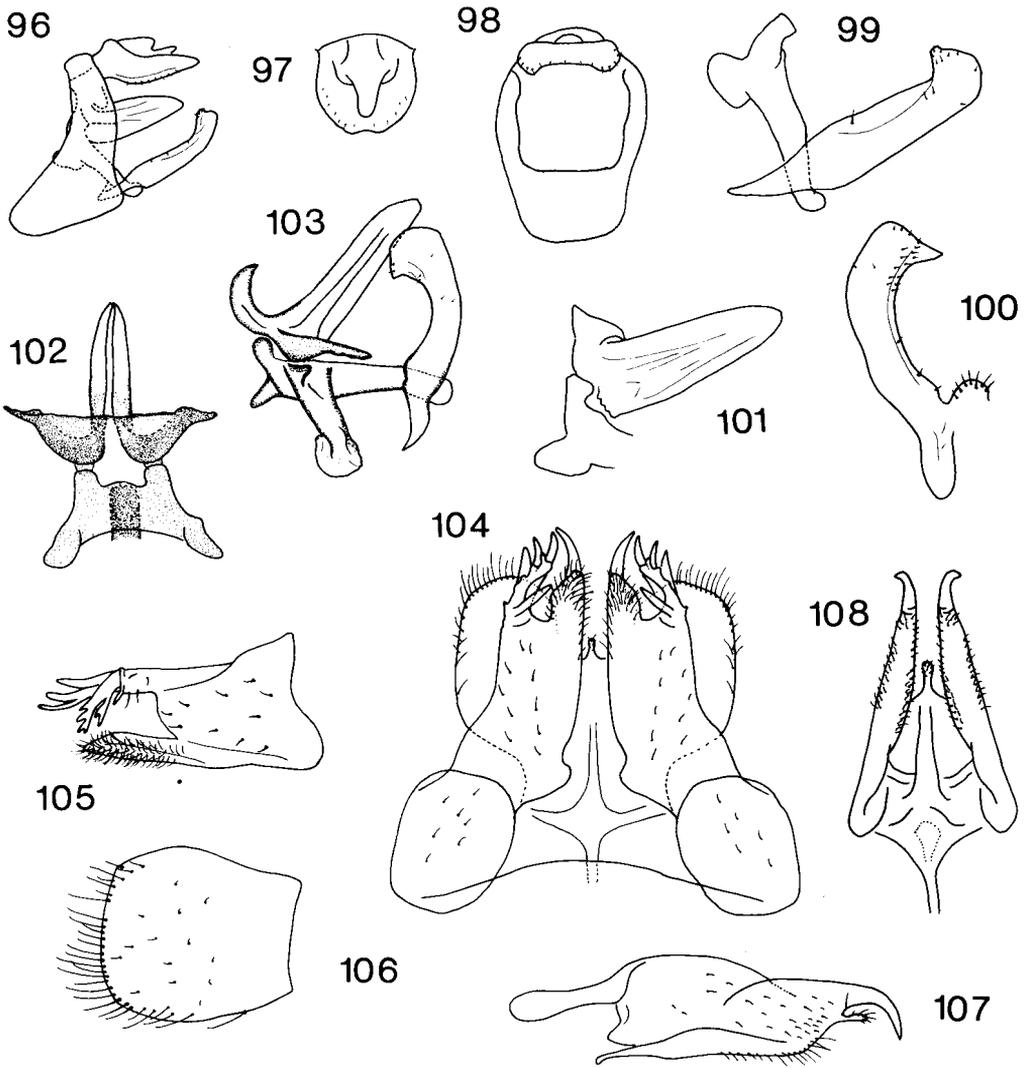
Material examined. Neotype, ♂ (here designated), PHILIPPINES: Luzon, Laguna Province. Mt Makiling, 4 km SE Los Baños, vi–vii.1980 (*Wilson*), labelled '*Achilixius tubulifer* (Melichar) designated M. R. Wilson 1989' (BMNH).

Additional material. PHILIPPINES: 1 ♀, Mt Makiling, Luzon, Baker (USNM); 1 ♂, Los Baños, P.I., ix.1914 (BPBM); 1 ♂, Mt Makiling, Luzon, Baker (BPBM); 1 ♂, 1 ♀, Mt Makiling Luzon Baker (USNM); 2 ♂, 1 ♀ (genitalia of one ♂ on slide attached to specimen, Los Baños, Philippine Is (*Muir*), x.[19]15 (BPBM); 1 ♂, Los Baños, Philippine Is (*Pemberton*), iii–vi.1925 (BPBM); 4 ♂, 12 ♀, Philippines, Laguna Province (Luzon Is), Liliw, Tuy Banaan (*Wilson*), vi–vii.1980, (BMNH); 1 ♂, 1 ♀, same data (USNM); 3 ♂, 4 ♀, Philippines, Laguna Province, Mt Makiling, 4 km S.E. Los Baños (*Wilson*), vi–vii.1980 (BMNH).

Comments. Melichar's type material appears to be lost. It is not present in Brno, Czechoslovakia (where much of his collection is housed) (P. Lauterer, pers. comm.) and no specimens of this species labelled by Melichar are present in the Baker collection at the USNM or at the BPBM. Muir (1923a) illustrated what he considered to be this species, and his interpretation has been followed here. It is possible that Muir examined specimens determined by Melichar. However, the position is complicated somewhat by the discovery of a second, distinct, although less common, species among specimens from the adjacent localities 'Los Baños' and 'Mount Makiling' both among Baker and Muir specimens and confirmed by recent collecting. Muir's concept of *A. tubulifer* has been accepted here and the other species is described as *A. bakeri* sp.n. (see above). A neotype of *A. tubulifer* has been selected from among topotypic specimens (Mount Makiling). The male genitalia of *A. tubulifer* actually illustrated by Muir (1923a) appear to be slide mounted on the same preparation as attached to the pin of *A. muiri* sp.n. in the Bishop Museum (illustrated by Muir as *A. sandakanensis*, see above).



FIGS 83–95. ♂ genitalia *Achilixius* spp.: 83–88, *A. sandakanensis*, 83, pygofer, anal segment, paramere, aedeagus, lateral view; 84, anal segment, dorsal view; 85, aedeagus, lateral view; 86, aedeagus, ventral view; 87, paramere, lateral view; 88, paramere, ventral view. 89–90, *A. singularis*, 89, pygofer, anal segment, aedeagus, parameres, lateral view; 90, pygofer, view from behind. 91–95, *A. torautensis*, 91, paramere, ventral view; 92, pygofer, anal segment, parameres, ventrocaudal view; 93, paramere, lateral view; 94, pygofer, anal segment, paramere, aedeagus, lateral view; 95, anal segment, dorsal view.



FIGS 96–108. *Achilixius tubulifer*; 96–103, ♂ genitalia; 96, pygofer, anal segment, aedeagus, paramere, lateral view; 97, anal segment, dorsal view; 98, pygofer, anal segment, ventrocaudal view; 99, paramere, connective, lateral view; 100, pygofer, ventral view; 101, aedeagus, lateral view; 102, aedeagus, and connective from behind; 103, aedeagus, parameres, lateral view. 104–108, ♀ genitalia, 104, ventral view; 105, first valvulae; 106, third valvulae, lateral view; 107, second valvulae, lateral view; 108, second valvulae, ventral view.

Undescribed species

Females from the following localities have been examined and probably represent new species that have not been described because males are not available; 2♀, Solomon Isles, Choiseul I. (BPBM), 1♀, New Guinea, Biak Island

(BPBM), 4♀, Brunei, 2♀ Sarawak (Mulu), 1♀, Philippines, Palawan Is (BMNH). The specimens from the Solomon Islands and from New Guinea are especially interesting since they considerably extend the known distribution of the genus.

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