

# BITING MIDGES (DIPTERA: CERATOPOGONIDAE) FROM BURMESE AMBER, MYANMAR

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**SYNOPSIS** Four new species in the extant genera *Austroconops* Wirth & Lee and *Leptoconops* Skuse are described from Burmese amber: *Austroconops asiaticus*, *Leptoconops burmiticus*, *L. myanmaricus* and *L. rossi*. *Johannsenomyia swinhoei* Cockerell is redescribed and assigned to the extinct genus *Atriculicoides* Remm, which is treated as an indicator group characteristic of the Cretaceous period.

**KEY WORDS** Ceratopogonidae, Myanmar, amber

## INTRODUCTION

The fossil record of biting midges (Family Ceratopogonidae) is one of the best known of all Diptera. There are currently 5748 named species with fossils representing almost 4.4% of these (A. Borkent, pers. comm.). The family is well documented from the Lower Cretaceous to the Tertiary (Evenhuis 1994; Szadziewski 1996; Borkent 2000) based on over 2700 specimens. The family has just two extant genera (*Austroconops* and *Leptoconops*) each with a long history reaching back to the Lower Cretaceous. Fossil biting midges preserved in amber shed new light on the phylogeny of the family, distribution of extant genera and evolution of feeding habits (Szadziewski 1996; Borkent 2000).

Cockerell (1919) briefly described, from Burmese amber, the well-preserved male of *Johannsenomyia swinhoei* and this holotype was photographed by Ross & York (2000). Until now the systematic position of the species was not clear (Szadziewski 1988).

Rasnitsyn & Ross (2000) reported 12 biting midges (Ceratopogonidae) among 1198 arthropods in 117 Burmese amber pieces preserved at The Natural History Museum, London. Through the courtesy of Dr Andrew J. Ross, I received all of these for detailed study and the results are presented below.

A new collection of inclusions in Burmese amber recently purchased by the American Museum of Natural History, New York, includes 204 biting midges among 3012 arthropods (Grimaldi *et al.* 2002). Specimens from this collection are to be studied by Dr A. Borkent from Canada.

## MATERIALS AND METHODS

Fourteen biting midges (1 *Austroconops*, 4 *Atriculicoides* and 9 *Leptoconops*) in six amber pieces from The Natural History Museum, London were examined. Large pieces of amber were separated into small pieces, polished and glued with Canada balsam to small microscope coverslips. The morphological terms and abbreviations used in this paper follow those explained by Szadziewski (1988). Burmese amber or Burmite from Myanmar (Burma) is considered to be

Lower Cretaceous (Upper Albian) in age, as demonstrated by Cruickshank & Ko (2003) for one amber locality.

While preparing one piece of amber (In. 20173) the distal half of the body of the holotype of *Myanmarella rossi* Sinitschenkova (Ephemeroptera) was damaged.

## SYSTEMATIC DESCRIPTIONS

Order **DIPTERA** Linnaeus, 1758

Family **CERATOPOGONIDAE** Newman, 1834

Subfamily **AUSTROCONOPINAE**  
Borkent *et al.*, 1987

Genus **AUSTROCONOPS** Wirth & Lee, 1958

**TYPE SPECIES.** By original designation *Austroconops mcmillani* Wirth & Lee, 1958.

**RANGE.** Lower Cretaceous to Recent.

**REMARKS.** *Austroconops* is an extant genus represented by one species living in Western Australia and six fossil species reported from Lower Cretaceous Lebanese amber (Szadziewski 1996; Borkent 2000), Lower Cretaceous Spanish amber (Szadziewski & Arillo 2003), Upper Cretaceous French amber (Szadziewski & Schlüter 1992) and Upper Cretaceous Siberian amber (Szadziewski 1996).

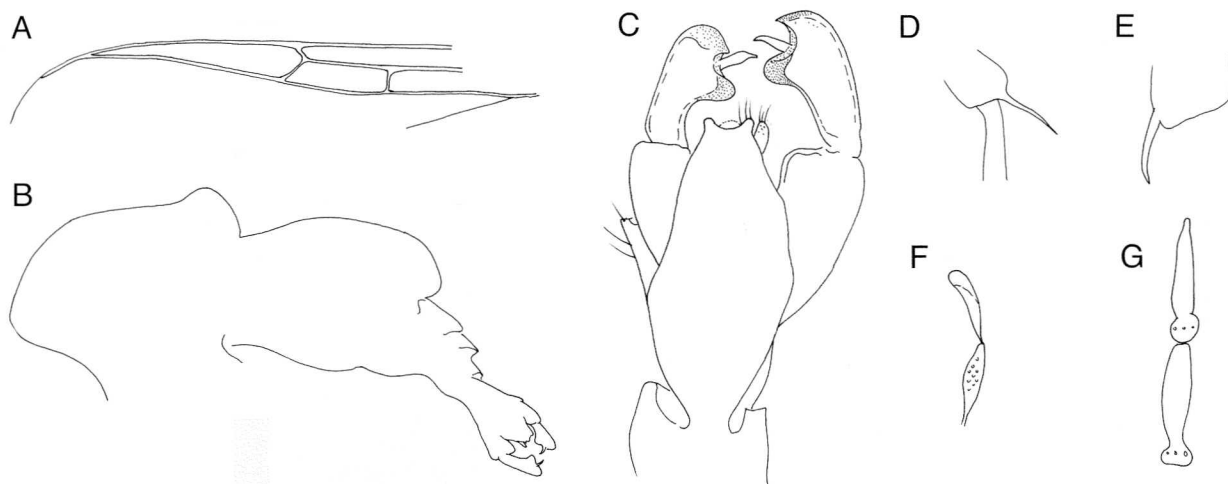
The genus in Burmese amber is represented by a single specimen, which is described below as a new species. This confirms that *Austroconops* was widely distributed in Europe and Asia during the Cretaceous.

***Austroconops asiaticus* sp. nov.** (Fig. 1; see Pl. 3, fig. 6)

**ETYMOLOGY.** The specific epithet refers to Asia, the continent of origin of the amber.

**DIAGNOSIS.** The only biting midge with male gonostylus armed with a very large apical tooth.

**HOLOTYPE.** BMNH In. 20173(4) male *Austroconops asiaticus* Szadziewski sp. nov.



**Figure 1** *Austroconops asiaticus* sp. nov., male, holotype, BMNH In. 20173(4). **A**, radial cells of wing; **B**, thorax and abdomen, lateral aspect; **C**, genitalia, dorsal aspect; **D**, tibial spur of fore leg; **E**, tibial spur of hind leg; **F**, distal palpal segments; **G**, terminal flagellomeres 12, 13.

ASSOCIATED FAUNA. BMNH In. 20173 *Myanmarella rossi* Sinitschenkova, holotype female (Ephemeroptera), Psocoptera 2, Psychodidae 1; In. 20173(1) *Leptoconops rossi* sp. nov. holotype male, Psychodidae 1 male; In. 20173(2) *Leptoconops rossi* Szadziewski sp. nov., 1 female paratype, Chironomidae 1 female; In. 20173(3) *Leptoconops rossi* sp. nov., paratype female. In other pieces: Chironomidae 1 female; Psychodidae 2 males 2 females; Brachycera indet. 1; Empididae 3; Coleoptera 2.

**DESCRIPTION.** Male. Body slender (Fig. 1B), total length about 1.3 mm. Antenna barely visible, with 13 flagellomeres, two terminal flagellomeres elongate, each with a subbasal constriction (Fig. 1G); plume well developed. Palpus 4-segmented, with terminal segment slender and long (Fig. 1F). Spur of fore tibia slender, straight (Fig. 1D), of hind tibia stout, curved (Fig. 1E). TR(I) 2.1, TR(II) 2.5, tarsomeres 2–5 of hind legs missing. Wing length 0.76 mm; membrane without macrotrichia; second radial cell two times longer than first one; costal vein prolonged beyond end of R3 (Fig. 1A). Distal half of abdomen slender (see Pl. 3, fig. 6). Genitalia rotated 90° (Fig. 1C). Sternite IX not visible. Tergite IX long; apicolateral processes small, rounded; cerci indistinct. Gonocoxite without special armature. Gonostyle with expanded, concave apex; armed with greatly enlarged apical tooth.

Female. Unknown.

**REMARKS.** Male gonostyli of biting midges armed with small apical spine or tooth are observed only in two plesiomorphic subfamilies, Leptoconopinae and Austroconopinae. The new species has unusual gonostyli armed with a greatly enlarged apical tooth, the largest within the family. Moreover, it seems they are articulated spines.

#### Subfamily **LEPTOCONOPINAE** Noé, 1907

##### Genus **LEPTOCONOPS** Skuse, 1889

**TYPE SPECIES.** By monotypy *Leptocops stygius* Skuse, 1889.

**RANGE.** Lower Cretaceous to Recent.

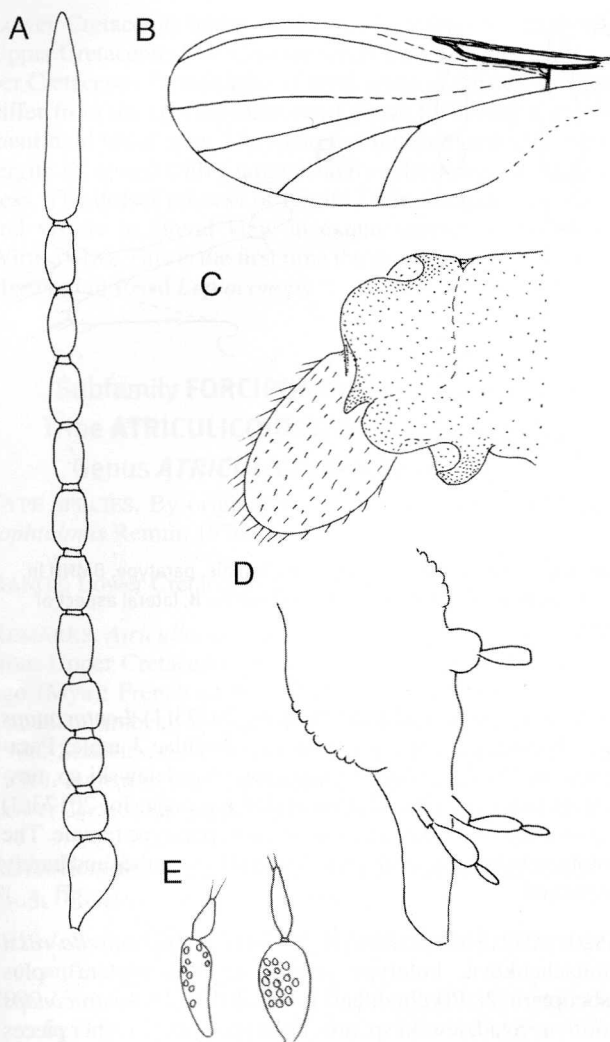
**REMARKS.** *Leptoconops* is a small genus including 134 extant and 10 named fossil species (Borkent 2001; Szadziewski & Arillo 2003). Larvae of extant species live in moist and usually saline soil in desert areas and in sand in coastal and inland beaches. They burrow in the soil or sand feeding on micro-organisms found there. Adults are diurnal and females feed on the blood of mammals, birds and reptiles. Most species of the genus are distributed in tropical and subtropical regions throughout the world. However, there are species described from as far north as the Moscow district in Europe and the Yukon Territory in Canada.

Extinct species have been described from Tertiary Baltic amber (*L. succineus* Szadziewski), Upper Cretaceous Siberian amber (*L. boreus* Kalugina, *L. sibiricus* Szadziewski), New Jersey amber (*L. curvachelus* Borkent, *L. copiosus* Borkent), Canadian amber (*L. primaevus* Borkent), Hungarian amber (*L. clava* Borkent), Lower Cretaceous Lebanese amber (*L. amplificatus* Borkent, *L. antiquus* Borkent) and Spanish amber (*L. zherikhini* Szadziewski & Arillo). Unnamed *Leptoconops* have also been recorded from Palaeocene amber from Sakhalin and Upper Cretaceous French amber (Szadziewski 1990; Szadziewski & Schlüter 1992).

Among the 14 biting midges available here, nine are of *Leptoconops*. They represent three species in the subgenus *Leptoconops s. str.* One barely visible female in a big piece of dark amber remains undetermined: *Leptoconops* sp. indet. BMNH In. 20172. Body length 0.8 mm. Other inclusions: Blattoptera 1, Lepidoptera 1, Thysanoptera 4 or more, Homoptera 1, Aranei 2, Psocoptera 1, Psychodidae 1 male, Cecidomyiidae 1.

#### **Leptoconops burmiticus** sp. nov. (Fig. 2; see Pl. 3, figs 2 & 3)

**ETYMOLOGY.** The species is named after the earlier name the country of origin of the amber (Burma).



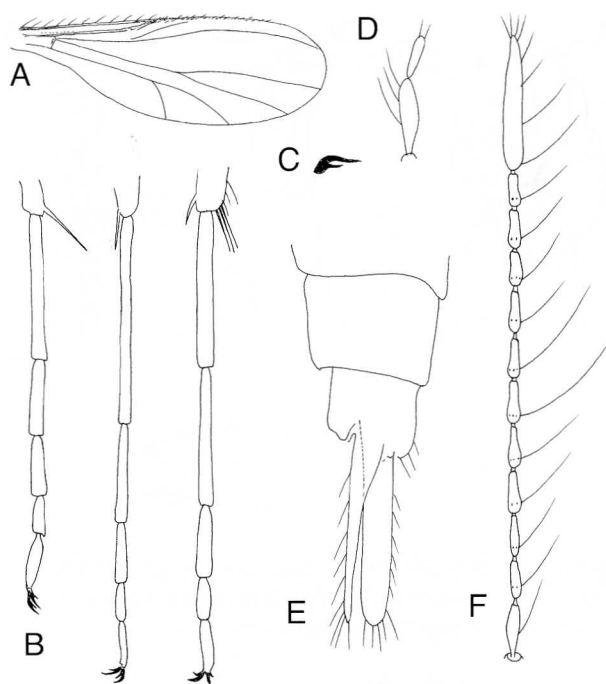
**Figure 2** *Leptoconops burmiticus* sp. nov., female, holotype, BMNH In. 20700. **A**, flagellum; **B**, wing; **C**, lateral aspect of cercus; **D**, lateral aspect of head; **E**, distal palpal segments.

**DIAGNOSIS.** The only fossil species of *Leptoconops* with females having very short cerci (1.4 times longer than high).

**HOLOTYPE.** BMNH In. 20700, female. Hukawng Valley, North of Burma.

**DESCRIPTION.** Female. Body length 0.9 mm. Antenna with 12 flagellomeres (Fig. 2A); total length 0.396 mm; flagellomeres 5–11 cylindrical; flagellomere 12 0.092 mm long, 4.2 times longer than flagellomere 11. Proboscis relatively long (Fig. 2D). Palp 4 segmented; palpal segment 3 stout, about 0.037 mm long; sensory organ surficial (Fig. 2E); terminal palpal segment slender. Eye separation not visible. Legs barely visible; tibia of fore and mid legs armed with spur, TR(II) 1.9; claws small, simple. Wing length 0.64 mm; veins R4+5 and M1+2 clearly visible (Fig. 2B); CR about 0.30, membrane covered with distinct microtrichia, macrotrichia absent. Abdomen slender. Tergite X with distinct caudo-medial excavation. Cerci relatively short (0.080 mm), only 1.4 times longer than high (Fig. 2C).

Male. Unknown.



**Figure 3** *Leptoconops myanmaricus* sp. nov., female, holotype, BMNH In. 20168(6). **A**, wing; **B**, tarsi of fore, middle and hind leg; **C**, tarsal claw; **D**, palpus; **E**, laterodorsal aspect of cerci; **F**, flagellum.

**DISCUSSION.** Short female cerci are known in only a few extant species of *Leptoconops* and these are included in the subgenus *Styloconops* Kieffer (shores adjacent to the Indian Ocean or western Pacific) and *Brachyconops* Wirth & Atchley (California and Argentina: Smee 1966; Wirth & Atchley 1973; Ronderos 1990). However, females of species included in *Styloconops* and *Brachyconops* have cerci higher than long, palpi with the sensory area confined to a pit, first tarsomeres armed with strong spines, and frons and vertex with numerous spines (*Styloconops*). *Leptoconops burmiticus* is assigned to the subgenus *Leptoconops* s. str. because the female has the cercus longer than high (1.4 times), it has no strong spines on the head or tarsi and the palpus has sensilla scattered over the mesal surface of the third segment.

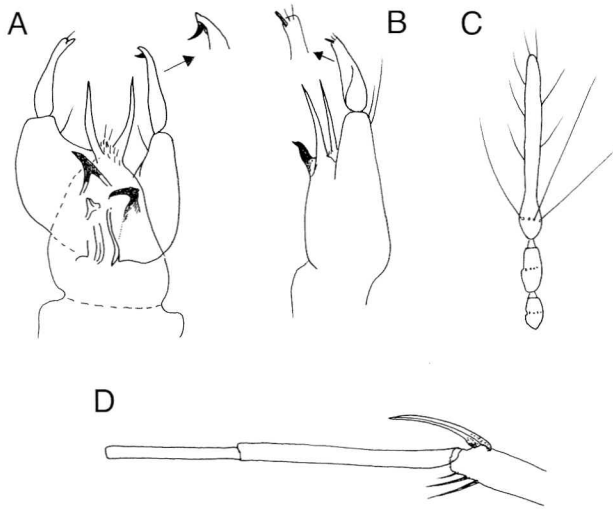
***Leptoconops myanmaricus* sp. nov.** (Fig. 3; see Pl. 3, fig. 1)

**ETYMOLOGY.** The specific epithet refers to Myanmar (Burma), the country of origin of the amber.

**DIAGNOSIS.** The only fossil species of *Leptoconops* with females with toothed claws and flagellomeres 2–11 cylindrical.

**TYPES.** Holotype female, BMNH In. 20168(6). Paratypes: In. 20168(7) *Leptoconops myanmaricus*, paratype female (+Cecidomyiinae, 1 female); In. 20168(8) *Leptoconops myanmaricus*, paratype female. In 20168 (9) *Leptoconops myanmaricus*, incomplete male, not included in the type series.

**ASSOCIATED FAUNA.** BMNH In. 20168 *Chaoburmus brevisculus* Lukashovich, holotype male (+Coleoptera 1); In. 20168(10) *Atriculicoides* sp. 1 female; In. 20168(11) *Atriculicoides swinhoei* (Cockerell), 1 male. Other syninclusions:



**Figure 4** *Leptoconops rossi* sp. nov., male, holotype, BMNH In. 20173(1). **A**, dorsolateral aspect of genitalia; **B**, lateral aspect of genitalia; **C**, distal flagellomeres; **D**, hind tibial spur.

Homoptera 1 specimen, Coccinea, 1 male; Thysanoptera 1; Diptera: Psychodidae, 1 female, Sciaridae 1; Hymenoptera parasitica, 1 specimen.

**DESCRIPTION.** Female. Antenna with 12 flagellomeres (Fig. 3A); flagellomeres 1–11 cylindrical. Palpus slender, 4 segmented; capitata sensilla not visible (Fig. 3D). Eye separation not visible. Tibiae of all legs with distinct apical spur (Fig. 3B), all tarsal claws armed with long basal tooth (Fig. 3C). TR(I) 1.8, TR(II) 2.0, TR(III) 1.1. Wing length 0.651 mm, CR 0.34. Costal vein disappearing gradually beyond vein R1 (Fig. 3A). Membrane without macrotrichia. Cerci slender, long (Fig. 3E).

Male. Unknown.

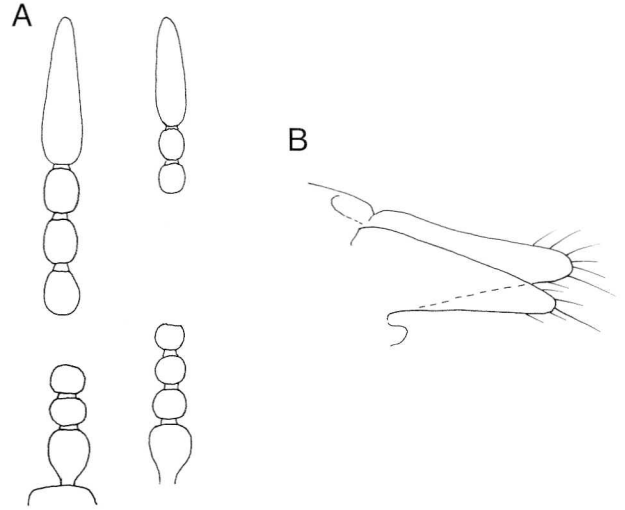
**DISCUSSION.** The hind leg tarsal ratio in the new species is 1.6–1.8 times lower than those of the fore and mid legs. This indicates that this character state is not limited to the Austroconopinae as suggested by Szadziewski (1996) but is present also in Cretaceous Leptoconopinae. This confirms the previous suggestion by Borkent (2000) that the lower ratio of hind leg is not diagnostic for the Austroconopinae.

Among fossil species of *Leptoconops* only females of *L. curvachelus* Borkent from New Jersey amber and *L. sibiricus* Szadziewski from Taimyr amber have similarly toothed claws as the new species, but they have more or less spherical flagellomeres 2–11 which in *L. myanmaricus* are cylindrical.

***Leptoconops rossi* sp. nov.** (Figs 4 & 5; see Pl. 3, fig. 5)

**ETYMOLOGY.** The species is named for Andrew Ross of The Natural History Museum, London, in recognition of his outstanding contributions to the study of fossil insects.

**DIAGNOSIS.** The only fossil species of *Leptoconops* with large tibial spurs in both sexes, female flagellomeres 2–11 almost spherical, tarsal claws simple and tergite IX of the male genitalia with very elongate apicolateral process.



**Figure 5** *Leptoconops rossi* sp. nov., female, paratype, BMNH In. 20173(2). **A**, proximal and distal flagellomeres; **B**, lateral aspect of cerci.

**TYPES.** Holotype male, BMNH In. 20173(1) *Leptoconops rossi* Szadziewski sp. nov. plus Psychodidae 1 male. Paratypes: In. 20173(2) *Leptoconops rossi* Szadziewski sp. nov. female paratype, plus Chironomidae 1 female; In. 20173(3) *Leptoconops rossi* Szadziewski sp. nov. paratype female. The holotype is heavily compressed laterally in amber and barely preserved.

**ASSOCIATED FAUNA.** BMNH In. 20173 *Myanmarella rossi* Sinitschenkova, holotype female (Ephemeroptera), plus Psocoptera 2, Psychodidae 1; In. 20173(4) *Austroconops asiaticus* Szadziewski sp. nov. holotype male; in other pieces Psychodidae 2 males 2 females, Chironomidae 1 female, Brachycera indet. 1, Empididae 3, Coleoptera 2.

**DESCRIPTION.** Male. Body length about 1.0 mm. Flagellum 0.333 mm long, distal flagellomeres as in Fig. 4A. Spur of fore tibia slender, tibial spur of hind leg strong and long (Fig. 4D), TR(I) 1.9, TR(II) 1.8, TR(III) 1.7. Wing length 0.82 mm, CR 0.27, microtrichia on membrane distinct, macrotrichia absent. Genitalia as in Figs 4A, B. Sternite IX barely visible. Tergite IX with two long apicolateral processes and one short, stout apicomedian projection or dorsal process. Apicolateral processes broadly separated at bases, long and pointed. Dorsal process heavily sclerotised, directed dorsally. Gonostylus without special armature, subapical tooth clearly visible. Paramere (one visible) scythe-like.

Female. Body length about 1.0 mm. Antenna with 12 flagellomeres. Flagellomeres 2–11 more or less spherical (Fig. 5A). Proboscis long. Palpus 4 segmented. Tibial spurs on fore, middle legs clearly visible, long; hind tibial spur large. TR(I) 1.8–1.9, TR(II) 1.7–1.9, TR(III) 1.3–1.7. Claws strongly bent at base, simple (without distinct tooth). Cercus long, slightly triangular (Fig. 5B). Wings barely preserved, wing venation not visible.

**DISCUSSION.** This species belongs to a group of Cretaceous species of *Leptoconops* subg. *Leptoconops* in which females have simple claws, more or less spherical flagellomeres 2–11, and long cerci (*L. zherikhini* Szadziewski & Arillo,

Lower Cretaceous amber of Alava, *L. primaevus* Borkent, Upper Cretaceous Canadian amber, *L. boreus* Kalugina, Upper Cretaceous Taimyr amber). Both sexes of the new species differ from the species mentioned above by having a prominent hind tibial spur. The male has unusual genitalia, with tergite IX armed with a large, heavily sclerotised dorsal process. The dorsal process of tergite IX in the genus is small and visible in lateral view in extant species (Clastrier & Wirth 1978). This is the first time the dorsal process has been observed in fossil *Leptoconops*.

Subfamily **FORCIPOMYIINAE** Lenz, 1934

Tribe **ATRICULICOIDINI** Szadziewski, 1996

Genus **ATRICULICOIDES** Remm, 1976

TYPE SPECIES. By original designation *Atriculicoides macrophthalmus* Remm, 1976.

RANGE. Lower Cretaceous to Recent.

REMARKS. *Atriculicoides* is a fossil genus previously known from Upper Cretaceous ambers dating 78–96 million years ago (Mya): French amber (Szadziewski & Schlüter 1992), Canadian amber (Borkent 1995), Siberian amber (Remm 1976; Szadziewski 1996) and New Jersey amber (Borkent 1996). Burmese amber is slightly older as it comes from Lower Cretaceous (Upper Albian) deposits (about 100 Mya).

***Atriculicoides swinhoei*** (Cockerell, 1919) (Fig. 6; see Pl. 3, fig. 4)

1919 *Johannsenomyia swinhoei* Cockerell, 1919: 243 (male, amber, Burma).

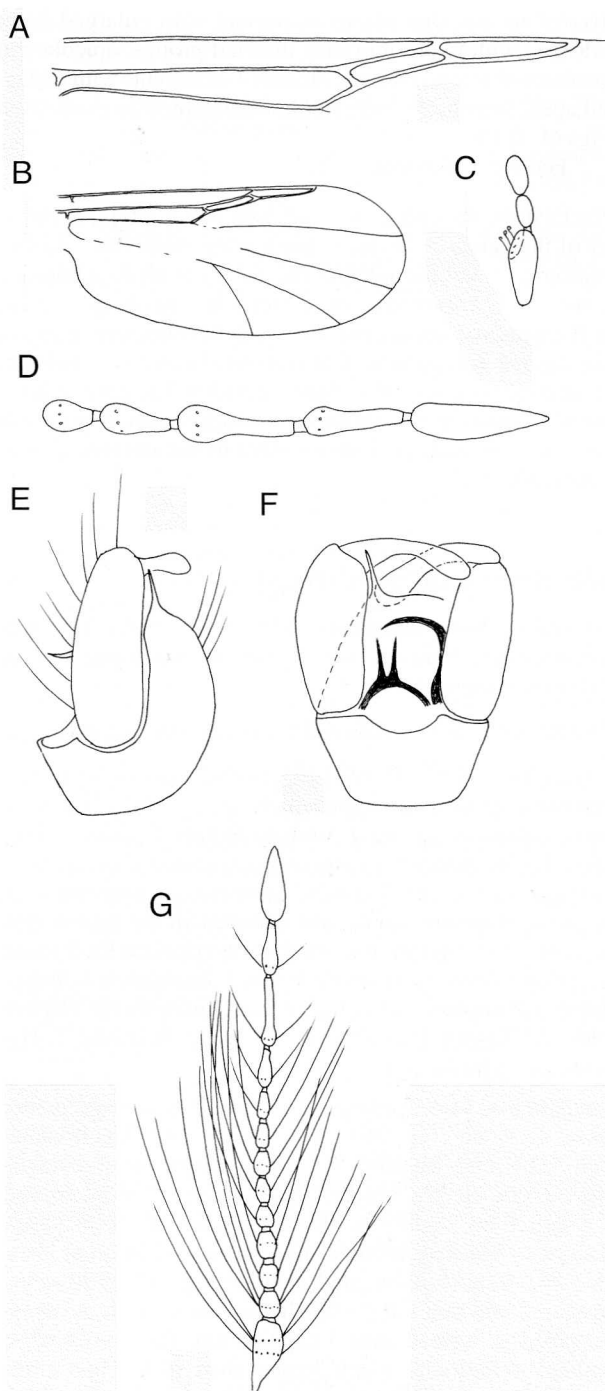
2000 *Johannsenomyia swinhoei* Cockerell; Ross & York: 13, fig. 13.

DIAGNOSIS. The only species of *Atriculicoides* with wing membrane devoid of macrotrichia, and flagellomere 10 only slightly elongate. Fifth palpal segment longer than fourth one.

HOLOTYPE. BMNH In. 19133. Holotype male in a large piece of amber. In the same amber piece is the holotype of *Aleurodiscus burmiticus* Cockerell (Homoptera).

ADDITIONAL MATERIAL. BMNH In. 20168(11) 1 male; In. 20190, 1 male, Pros. R.C.J. Swinhoe 3 July 1920, Brit. Mus. Geol. Dep. (syninclusions: Hymenoptera 2; Coleoptera 1, incomplete).

DESCRIPTION. Male. Holotype. Total length about 1.2 mm. Antenna with flagellum 0.57 mm long, with 13 flagellomeres (Fig. 6G). First flagellomere with two rings of long setae. Distal flagellomeres 11–13 elongate, 10 slightly elongate (Fig. 6D). Palpus 5-segmented. Third palpal segment about 0.038 mm long, with broad, open sensory pit at apex; palpal segment 5 longer than segment 4 (Fig. 6C). Legs slender, unarmed, fourth tarsomeres cylindrical. First tarsomere of hind leg somewhat stouter, with numerous strong setae on ventral surface. TR(I) 1.9, TR(II) 1.9, TR(III) 1.7. Wing length 0.73 mm. Both radial cells relatively long (Fig. 6A). CR 0.75. Wing membrane with distinct microtrichia; macrotrichia not visible in holotype (Fig. 6B). Genitalia barely visible. Gonostylus slender, slightly arched. Tergite IX with



**Figure 6** *Atriculicoides swinhoei* (Cockerell), male. **A–D, G**, BMNH In. 19133: **A**, radial cells; **B**, wing; **C**, distal palpal segments; **D**, distal flagellomeres 9–13; **G**, flagellum. **E & F**, BMNH In. 20168: **E**, lateral aspect of genitalia; **F**, ventral aspect of genitalia.

long, pointed apicolateral process. Aedeagus low. Paramere single, long, with pointed curved apex. Other males. Body length 1.02 mm. Proboscis not elongated. Palpal segment 5 longer than segment 4. Flagellum barely visible. Wing length 0.59–0.61 mm, CR 0.70–0.75. Wing membrane with distinct microtrichia, macrotrichia absent. Scutellum with six marginal setae. TR(I) 2.4, TR(II) 2.1, TR(III) 1.6–1.7. Genitalia

inverted or not; one paramere present with enlarged base; aedeagus with two posteriorly directed prongs, apicolateral processes of tergite IX long, slender. Gonostylus with expanded apex. Sternite IX with shallow caudomedian excavation (Figs 6E & F).

Female. Unknown.

**DISCUSSION.** *Atriculicoides swinhoei* is not a typical member of the genus as the male has a wing membrane without macrotrichia and the antenna has a short tenth flagellomere. In previously known species macrotrichia are always present on the wing membrane and the tenth flagellomere in males is elongated. It is possible that macrotrichia are not visible in all specimens preserved in Burmese amber. The generic position was established on the basis that males in small pieces of amber have a single paramere similar to that in other species of *Atriculicoides*.

### *Atriculicoides* sp. indet. (Fig. 7)

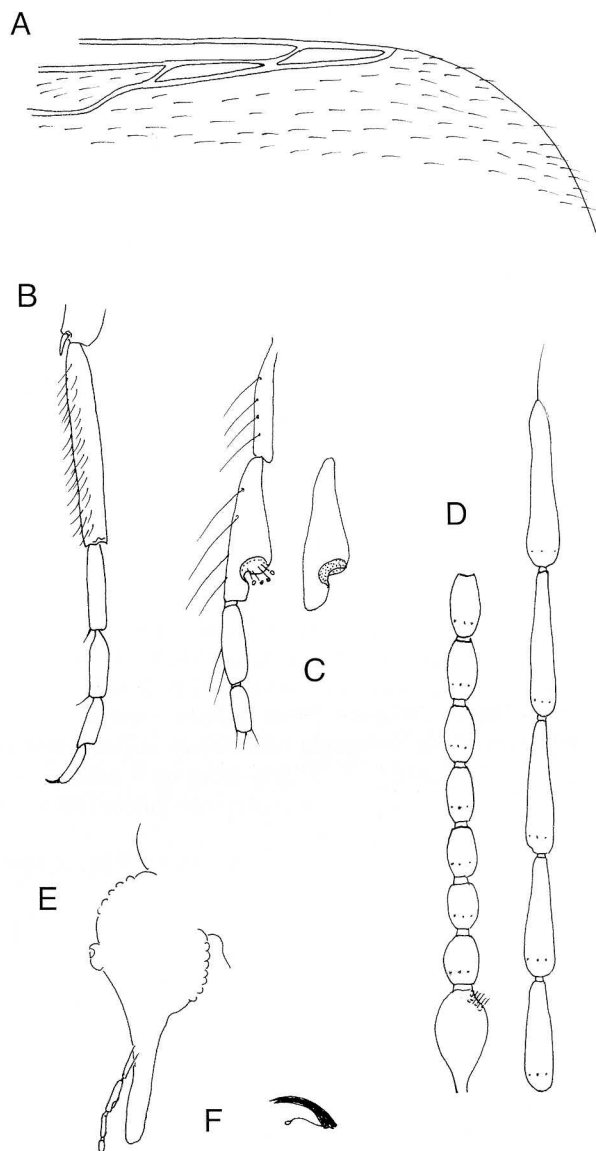
**DIAGNOSIS.** Wing membrane with macrotrichia. The fifth palpal segment is much shorter than the fourth one and the proboscis is elongate.

**MATERIAL EXAMINED.** BMNH In. 20168(10) 1 female.

**ASSOCIATED FAUNA.** BMNH In. 20168(6) *Leptoconops myanmaricus* sp. nov., holotype female. In. 20168(7) *Leptoconops myanmaricus* sp. nov., paratype female, Cecidomyiinae, 1 female. In. 20168(8) *Leptoconops myanmaricus*, sp. nov., paratype female. In. 20168(9). *Leptoconops myanmaricus*, sp. nov., incomplete male, not included in the type series. In. 20168(11) *Atriculicoides swinhoei* (Cockerell), 1 male. In. 20168 *Chaoburmus brevisculus* Lukaszewicz, holotype male (+ Coleoptera 1). In other pieces Homoptera 2, Thysanoptera 1, Diptera: Psychodidae, 1 female, Sciaridae 1, Hymenoptera parasitica, 1 specimen.

**DESCRIPTION.** Male. Unknown. Female. Well preserved. Proboscis elongate (Fig. 7E). Antenna with 13 flagellomeres (Fig. 7D); total length 0.564 mm; sensilla on first flagellomeres not clearly visible; flagellomeres 2–8 increasing in length from slightly to clearly cylindrical; distal flagellomeres cylindrical; terminal flagellomere with blunt apex; AR 1.35. Palpus 5-segmented, slender (Fig. 7C); third palpal segment 0.068 mm long, with shallow sensory pit in subapical position, with at least 4 capitate sensilla; fourth palpal segment cylindrical, much longer than fifth. Hind tibial spur short, blunt. First tarsomere of hind leg slender, fourth tarsomere cylindrical (Fig. 7B). TR(III) 2.2. Tarsal claws weakly curved, apices forked, with long sinuous capitate seta at base (Fig. 7F). Wing length 0.75 mm, CR 0.67. Wing membrane, including basal radial cell, covered with large macrotrichia (Fig. 7A).

**DISCUSSION.** The female described here has a much longer fourth palpal segment than the fifth one and is therefore distinct from *A. swinhoei*. I do not propose a new name for it as, within the fossil genus *Atriculicoides*, males are more diagnostic and determinable; moreover, among eight known species females are known for only three of these. It is worth noting that claws with a long slightly sinuous seta at their base are also present in extant *Dasyhelea* Kieffer and *Culicoides* Latreille.



**Figure 7** *Atriculicoides* indet., female, BMNH In. 20168(10). **A**, wing radial cells; **B**, tarsus of hind leg; **C**, palpus; **D**, flagellum; **E**, lateral aspect of head; **F**, tarsal claw.

## GENERAL DISCUSSION

The biting midges studied here belong to six species in three genera: extant *Austroconops* (1 specimen, 1 species), extant *Leptoconops* (9 specimens, 3 species) and fossil *Atriculicoides* (4 specimens, 2 species). The fossil genus *Atriculicoides*, previously reported from the Upper Cretaceous (Siberian amber, French amber, Canadian amber, New Jersey amber), suggests that the age of Burmese amber is approximately the same.

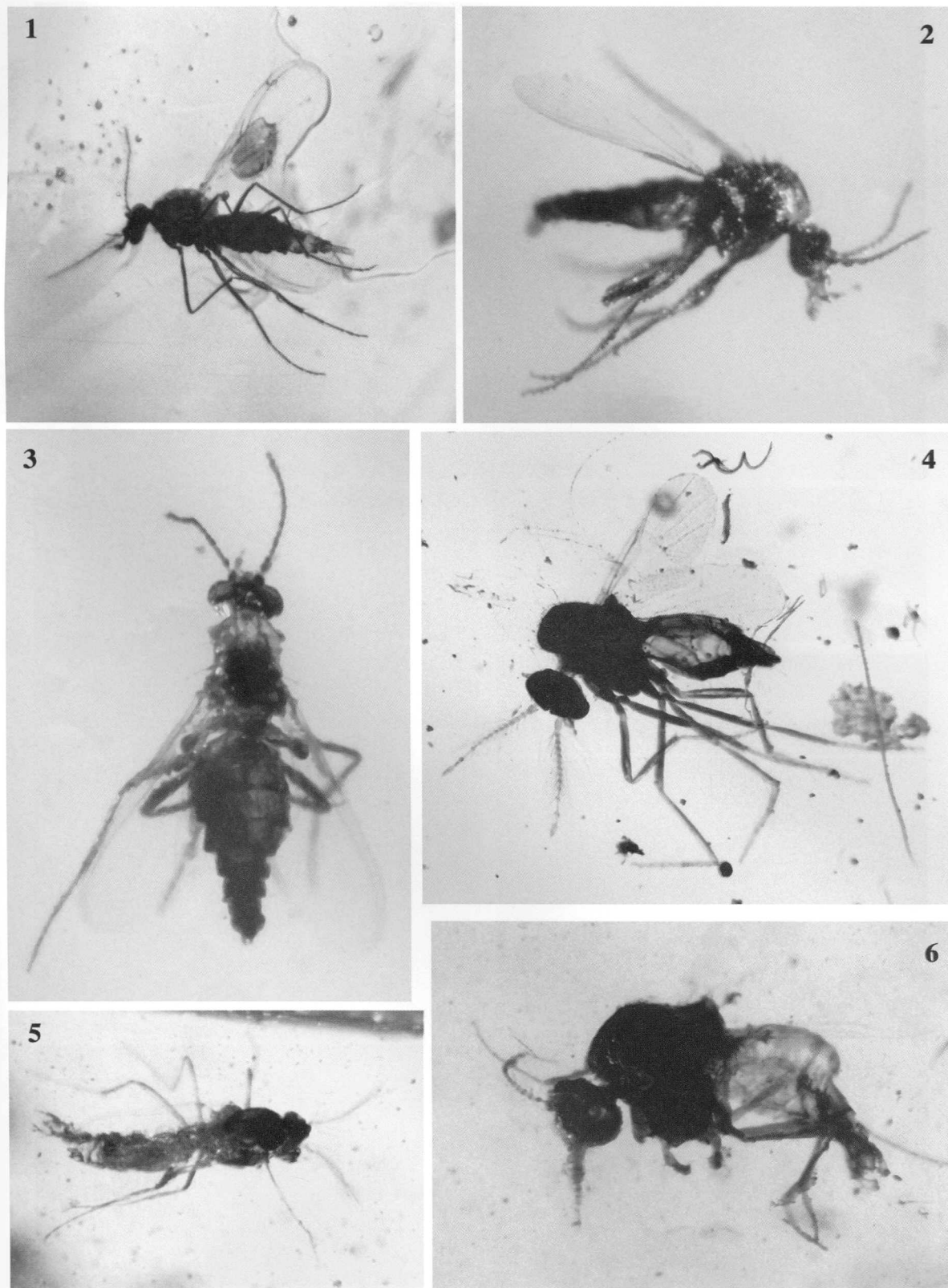
The predominance of *Leptoconops* in a small sample of biting midges may indicate that sea-shore habitats were near the amber producing forests. Biting midges in Burmese amber are poorly preserved and look as if they were quickly dried and subsequently entombed in resin. This may indicate that these inclusions were from dry and hot habitats.

## ACKNOWLEDGEMENTS

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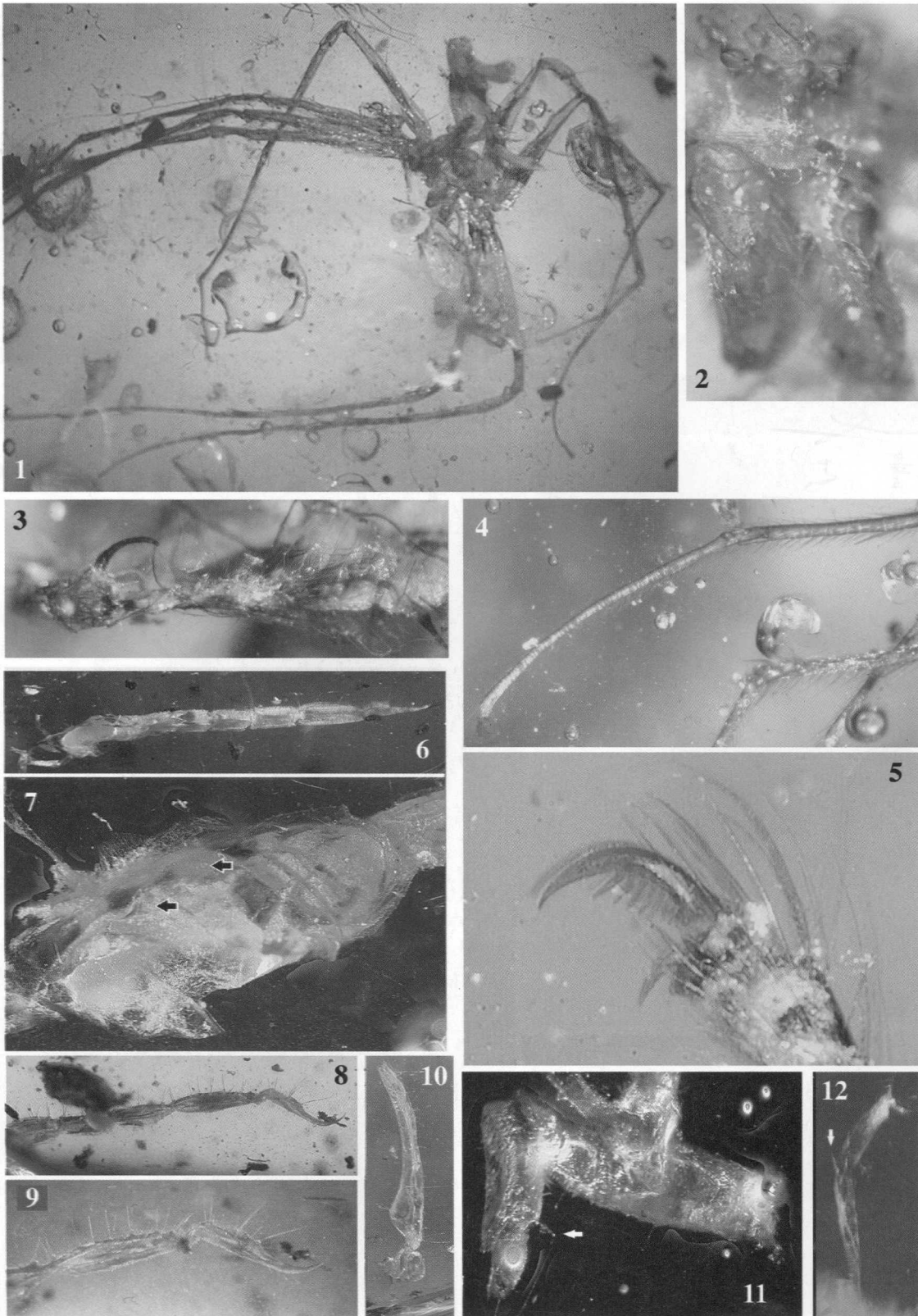
## REFERENCES

- Borkent, A.** 1995. *Biting Midges in the Cretaceous Amber of North America (Diptera: Ceratopogonidae)*. Backhuys Publishers, Leiden, 237 pp.
- 1996. Biting midges from Upper Cretaceous New Jersey amber (Ceratopogonidae: Diptera). *American Museum Novitates* **3159**: 1–29.
- 2000. Biting midges (Ceratopogonidae: Diptera) from Lower Cretaceous Lebanese amber with a discussion of the diversity and patterns found in other ambers. Pp. 355–451 in Grimaldi, D. (ed.). *Studies in Fossils in Amber, with Particular Reference to the Cretaceous of New Jersey*. Backhuys Publishers, Leiden.
- 2001. *Leptoconops* (Diptera: Ceratopogonidae), the earliest extant lineage of biting midge, discovered in 120–122 million-year-old Lebanese amber. *American Museum Novitates* **3328**: 1–11.
- , **Wirth, W. W. & Dyce, A. L.** 1987. The newly discovered male of *Austroconops* (Ceratopogonidae: Diptera) with a discussion of the phylogeny of the basal lineages of the Ceratopogonidae. *Proceedings of the Entomological Society of Washington* **89**: 587–606.
- Clastrier, J. & Wirth, W. W.** 1978. The *Leptoconops kerteszi* complex in North America (Diptera: Ceratopogonidae). *United States Department of Agriculture Technical Bulletin* **1573**: 1–58.
- Cockerell, T. D. A.** 1919. Insects in Burmese amber. *The Entomologist* **52**: 241–243.
- Cruickshank, R. D. & Ko, K.** 2003. Geology of an amber locality in the Hukawng Valley, northern Myanmar. *Journal of Asian Earth Sciences* **21**: 441–455.
- Evenhuis, N. L.** 1994. *Catalogue of the Fossil Flies of the World (Insecta: Diptera)*. Backhuys, Leiden.
- Grimaldi, D. A., Engel, M. S. & Nascimbene, P. C.** 2002. Fossiliferous Cretaceous amber from Myanmar (Burma): its rediscovery, biotic diversity, and paleontological significance. *American Museum Novitates* **3361**: 1–72.
- Lenz, F.** 1934. 13a. Heleidae (Ceratopogonidae). Pp. 95–133 in Lindner, E. (ed.) *Die Fliegen der palaearctischen Region* vol. **3** (Lfg. 78). Stuttgart.
- Linnaeus, C. von.** 1758. *Systema naturae per regna tria naturae, secundum classes, ordines, genera, species. Tom. I. Animalis*. Holmiae 823 pp.
- Newman, E.** 1834. Attempted division of British insects into natural orders. *Entomological Magazine* **2**: 379–431.
- Noé, G.** 1907. Due nuove specie di ditteri appartenenti ad un genere nuovo. *Archivio Zoologico Italiano: Pubblicato Sotto gli Auspicii Della Unione Zoologica* **3**: 101–164, 3 pls.
- Rasnitsyn, A. P. & Ross, A. J.** 2000. A preliminary list of arthropod families present in the Burmese amber collection at The Natural History Museum, London. *Bulletin of the Natural History Museum, Geology Series* **56**: 21–24.
- Remm, H.** 1976. [Midges (Diptera, Ceratopogonidae) from the Upper Cretaceous fossil resins of the Khatanga depression]. *Paleontologičeskij Zhurnal* **3**: 107–116. [in Russian].
- Ronderos, M. M.** 1990. A new species of *Leptoconops* (sic!) from Argentina (Diptera, Ceratopogonidae). *Revista Brasileira de Entomologia* **34**: 423–426.
- Ross, A. J. & York, P. V.** 2000. A list of type and figured specimens of insects and other inclusions in Burmese amber. *Bulletin of the Natural History Museum, Geology Series* **56**: 11–10.
- Skuse, F. A. A.** 1889. Diptera of Australia. Part VI. – The Chironomidae. *Proceedings of the Linnean Society of New South Wales* **4**: 215–311, pls 11–14.
- Snee, L.** 1966. A revision of the subfamily Leptoconopinae Noé (Diptera: Ceratopogonidae) in Australia. *Australian Journal of Zoology* **14**: 993–1025.
- Szadziewski, R.** 1988. Biting midges (Diptera, Ceratopogonidae) from Baltic amber. *Polskie Pismo Entomologiczne* **58**: 1–283.
- 1990. Biting midges (Insecta: Diptera: Ceratopogonidae) from Sakhalin amber. *Prace Muzeum Ziemi* **41**: 77–81.
- 1996. Biting midges from Lower Cretaceous amber of Lebanon and Upper Cretaceous Siberian amber of Taimyr (Diptera, Ceratopogonidae). *Studia Dipterologica* **3**: 23–86.
- & **Arillo, A.** 2003. The oldest fossil record of the extant subgenus *Leptoconops* (*Leptoconops*) (Diptera: Ceratopogonidae). *Acta Zoologica Cracoviensia* **46** (supp.-Fossil Insects): 271–275.
- & **Schlüter, T.** 1992. Biting midges (Diptera: Ceratopogonidae) from Upper Cretaceous (Cenomanian) amber of France. *Annales de la Société de Entomologie de France (N.S.)* **28**: 73–81.
- Wirth, W. W. & Atchley, W. R.** 1973. A review of the North American *Leptoconops* (Diptera: Ceratopogonidae). *Graduate Studies Texas Technical University* **5**: 1–57.
- & **Lee, D. J.** 1958. Australasian Ceratopogonidae (Diptera, Nematocera). Part VIII: A new genus from Western Australia attacking man. *Proceedings of the Linnean Society of New South Wales* **83**: 337–339.



**Plate 3** **Fig. 1.** *Leptoconops myanmaricus* sp. nov., Szadziewski. Holotype, BMNH In. 20168(6). (Diptera: Ceratopogonidae). **Figs 2–3.** *Leptoconops burmiticus* sp. nov., Szadziewski. Holotype, BMNH In. 20700. (Diptera: Ceratopogonidae). **2.** Lateral view. **3.** Dorsal view. **Fig. 4.** *Atriculicoides swinhoei* (Cockerell, 1919). Holotype BMNH In. 19133. (Diptera: Ceratopogonidae). **Fig. 5.** *Leptoconops rossi* sp. nov., Szadziewski. Holotype, BMNH In. 20173(1). (Diptera: Ceratopogonidae). **Fig. 6.** *Austroconops asiaticus* sp. nov., Szadziewski. Holotype, BMNH In. 20173(4). (Diptera: Ceratopogonidae). All from the Lower Cretaceous (Albian) Burmese amber of Myanmar. For measurements see the text. Photographs by P. York.





**Plate 4** Figs 1–5. *Palaeohydropoda myanmarensis* gen. et sp. nov., Penney. Holotype BMNH In. 19132(1). (Araneae: Pisauridae). 1. Dorsal view, whole specimen. 2. Anterior view; showing eyes, clypeus and chelicerae. 3. Pedipalp, showing diagnostic prolateral patellar clasp spur. 4. Metatarsus and tarsus showing curvature and apparent pseudosegmentation. 5. Superior and inferior tarsal claws. Figs 6–12. *Palaeoburmesebuthus grimaldii* Lourenço. BMNH In. 20174. (Scorpiones: incertae sedis). 6. Metasoma and telson. 7. Ventral aspect of mesosoma, showing sternite V, two pairs of carinae, sternite IV (almost complete) with two stigmata, and sternite III (in part) with one stigma. All stigmata are pointed to by arrows. 8. Metasoma and telson, right lateral aspect. 9. An enlargement of metasoma IV (distal end), metasoma V and the telson. 10. Right pedipalp chela, with visible trichobothria, dorsoexternal aspect. 11. Leg fragment, showing tibia with a possible tibial spur (arrow), and patella (partial and angled in view). 12. Leg showing epitarso, tarsus with two delicate rows of ventral spinules, pedal spur (arrow) and protarsus (partial). All from Lower Cretaceous (Albian) Burmese amber of Myanmar. For measurements see the text. Photographs of Figs 1–5 by D. Penney, photographs of Figs 6–12 by J. Santiago-Blay and P. Craig.