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Chetoneura shennonggongensis, a new species of cave–dwelling Keroplatini from China (Diptera: Keroplatidae), with a discussion of the position of *Chetoneura*

DALTON DE SOUZA AMORIM[1,4], Changying Niu[2,4], Xuezhen Li[2], Chaoliang Lei[2] & ARTHUR K. CLARKE[3]

[1] *Departamento de Biologia, Faculdade de Filosofia, Ciências e Letras de Ribeirão Preto, Universidade de São Paulo, Av. Bandeirantes 3900, 14040–901 Ribeirão Preto SP, BRAZIL. E-mail: dsamorim@usp.br.*
[2] *Institute of Insect Resources, Department of Plant Science & Technology, Huazhong Agricultural University, Wuhan, China. E-mail: niuchangying88@163.com*
[3] *Arthur K. Clarke, Honorary Research Associate, School of Zoology, University of Tasmania, Hobart, Tasmania, Australia. Email: Arthur.Clarke@utas.edu.au*
[4] *Corresponding authors*

Abstract

Chetoneura shennonggongensis Amorim & Niu, sp.n., inhabiting caves in East China, is described based on the adult male and female, plus larva. *Chetoneura* Colless, previously associated with *Orfelia* and known from a single species from caves in Malaysia, is formally transferred to the Keroplatini. This is the first description of the larva and of the general biology of the genus. The larva of this new species is suspended in a roughly horizontal hammock of silken threads amidst mucous coated snare threads from the roof of caves, but is not bioluminescent as some species of other genera in Keroplatidae (e.g., *Arachnocampa*, *Keroplatus*, and *Orfelia*). A key to separate both species of the genus is provided. The position of the genus within the Keroplatini is considered. *Chetoneura* is considered to be closely related to a clade containing *Heteropterna* and *Ctenoceridion*.

Key words: Diptera, Keroplatidae, Keroplatini, *Chetoneura*, cave fauna

Introduction

The family Keroplatidae includes over 950 species in about 87 genera, many of which have worldwide distribution (Matile 1990; Evenhuis 2006). The family is presently divided into the subfamilies Arachnocampinae, Macrocerinae, Keroplatinae, and Sciarokeroplatinae, if we accept subfamilial status of this taxon (see Papp & Ševčík 2005). The Keroplatinae are further divided into the tribes Keroplatini and Orfeliini.

An investigation of Chinese cave fauna by Clarke (2000, 2001a,b, 2002a,b, 2004a,b, 2006a), Li (unpublished) and Niu (unpublished) resulted in the discovery of the immature specimens (larvae) of a non–bioluminescent cave keroplatid. Some recently collected specimens from a cave in the northeast of Jiangxi Province, East China, were reared to adults and clearly belongs in the tribe Keroplatini. The species is described here based on males, females, and larvae, with some information on its biology. Suspended larvae of keroplatids have been found in several other caves in other karst regions of China, but adults had not been positively determined and no live larvae were collected, making rearing impossible, and therefore it remains unclear whether they belong to the same species or to different species of this genus, or perhaps another genus.

The new species described herein is congeneric with *Chetoneura cavernae* Colless (described from two specimens collected in the Batu Caves of Malaysia). In the original description of *Chetoneura*, Colless (1962)

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supposed the genus would be closer to *Orfelia* than to *Keroplatus*, and was not included by Matile (1990) in the Keroplatini. The position of *Chetoneura* among the Orfeliini was more recently maintained by Evenhuis (2006) in the catalogue of the world Keroplatidae. The position of the genus within the Keroplatinae is considered. Wing venation homology follows the interpretation by Amorim & Rindal (2007) for the Mycetophiliformia.

Chetoneura Colless

Chetoneura Colless 1962: 437. Type–species, *Chetoneura cavernae* Colless, by original designation.

Diagnosis. Adult mouthparts reduced, two ocelli, flagellum laterally compressed, mediotergite weakly sclerotized, with a group of setae medially. Wing vein R_4 absent; wing veins dark, membrane brownish, but without maculation. Gonostyle of male club–shaped, not bifid. Female terminalia with largely developed gonapophyses 8, entirely involving the distal part of the terminalia. Larva inhabiting caves.

Comments. Colless (1962) listed some features present in his new species *C. cavernae* as diagnostic of the genus *Chetoneura*. Among them are the flattened flagellomeres, the presence of only two ocelli, reduced mouthparts, presence of anepisternal setae, no postspiracular setae, laterotergite bare, regular rows of tibial setulae, and unbranched R_{4+5}. All these features are present in the species collected in Shennong Gong, herein described. The features that differ are the absence of "strong bristles dorsally" on the "metanotum", the short fusion of M_{1+2} with Rs, and the absence of a distal spine on the male gonostyle. However, there are additional features that suggested relationship between the two species, such as the general shape of the male terminalia, elongated anteriorly, the concentration of setae internally on the gonocoxites, the dorsal lobe of the gonocoxites, and the very unusual shape of the female sternite VIII. Even though the larval habitus of *Chetoneura cavernae* is not described, the fact that both species were collected in caves and other apomorphic morphological features suggest that the genus is monophyletic. Two other papers (McClure *et al.* 1967, Dittmar *et al.* 2005) have made reference to the Malaysian species of *Chetoneura*. In the original description, the position of the genus was not clear. Colless (1962) noted some features that are similar in *Chetoneura* and *Keroplatus*, such as the reduced palpus, but also listed a number of shared characteristics with *Orfelia*, and concluded that *Chetoneura* has a closer relationships to *Orfelia* than *Keroplatus*. This may have been the reason why Matile (1990) did not include the genus in the Keroplatini in his phylogenetic analysis of the tribe. The genus *Chetoneura* is herein formally transferred to the tribe Keroplatini.

Key for the species of the genus

1 Male gonostyle with a strong apical spine; tergite 9 elongated..... *C. cavernae* Colless (Malaysia)

1' Male gonostyle densely covered with setae apically, but with no spine; tergite 9 wide anteriorly .... *C. shennonggongensis* Amorim & Niu, sp.n. (East China)

Chetoneura shennonggongensis, Amorim & Niu, sp.n.

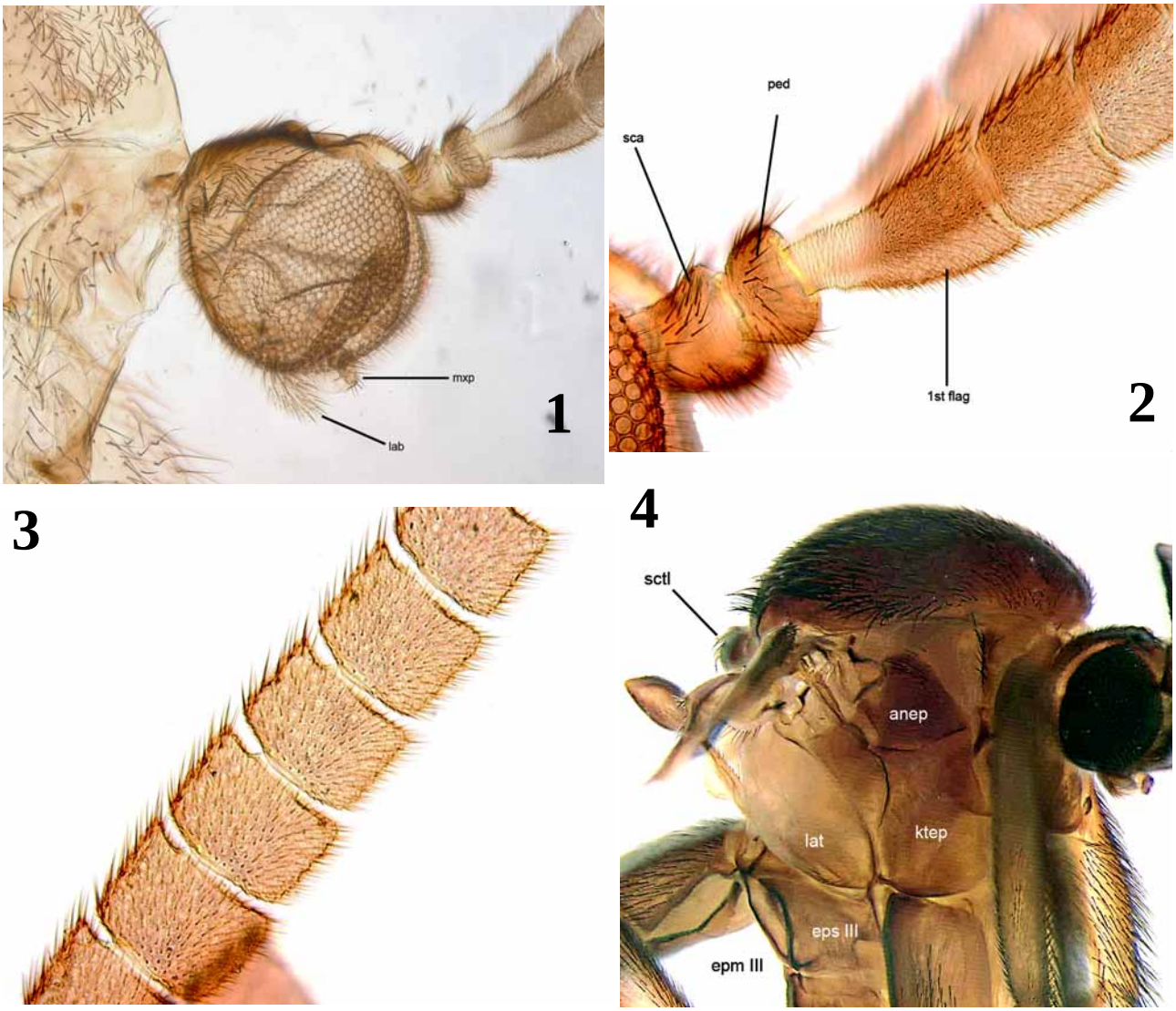
Diagnosis. Long fusion of M_1 to Rs. Male gonostyle only with setae distally, tergite 9 wide anteriorly.

Material examined. Holotype male, limestone cave: Shennong Gong, near Pan Ling village, Huangtian Mountain, northeast Jiangxi (Province), Wannian Xian (County), East CHINA. GPS co–ordinates: 117° 15' 00.69" E, 28° 42' 45.17" N; elevation, approximately 370 m. Larvae reared in laboratory by Xuezhen Li; adult (holotype) male emerged July 20, 2006. Paratypes, same data: 2 males (emerged June 6, 2006), 2 females

(emerged August 1 and 23, 2006) and 4 larvae (fixed in 70% alcohol on June 6, 2006). Holotype and paratypes in the Museu de Zoologia da Universidade de São Paulo, Brazil.

Description.

Male. **Head**. Antenna brown, placed on a short protuberance (Figs. 1–3); 14 flagellomeres, first flagellomere about twice the second, flagellum fairly compressed, with microtrichia, small setae and scattered sensilla laterally and ventrally, longer setae dorsally; scape and pedicel shorter than flagellomeres. Two ocelli, medially on the vertex. Eyes normally developed, with ommatidia hairs. Frons and clypeus brown, setose, clypeus projected. Palpus reduced to single small palpifer and a rounded distal segment with a few setae. Occiput dark brown, yellow brown close to the eyes (Fig. 4).



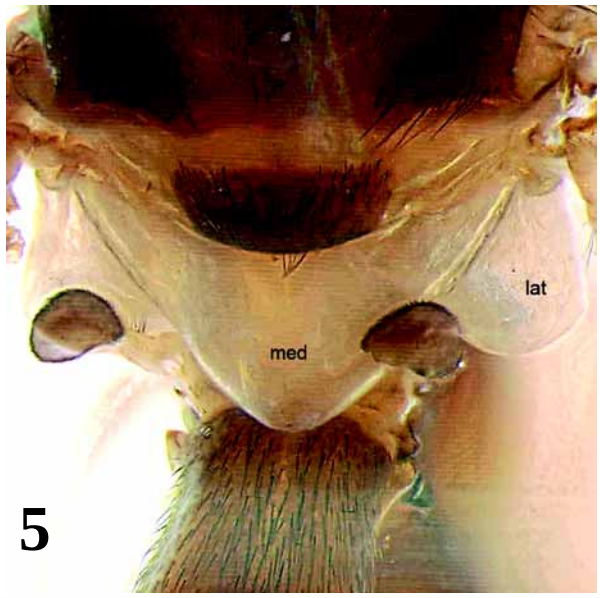
FIGURES 1–4. *Chetoneura shennonggongensis*, sp.n. 1. Head, with reduced mouthparts and palpus. 2. Base of antenna, with scape, pedicel, and elongated first flagellomere. 3. Laterally compressed flagellomeres. 4. Lateral view of thorax, with weakly sclerotized mediotergite with setae ventrally. Abbreviations: anep, anepisternum; epm III, metepimeron; eps III, metepisternum; flag, flagellomere; ktep, katepisternum; lab, labella; lat, laterotergite; mxp, maxillary palpus; ped, pedicel; sca, scape; sctl, scutellum. (Photos by D.S. Amorim).

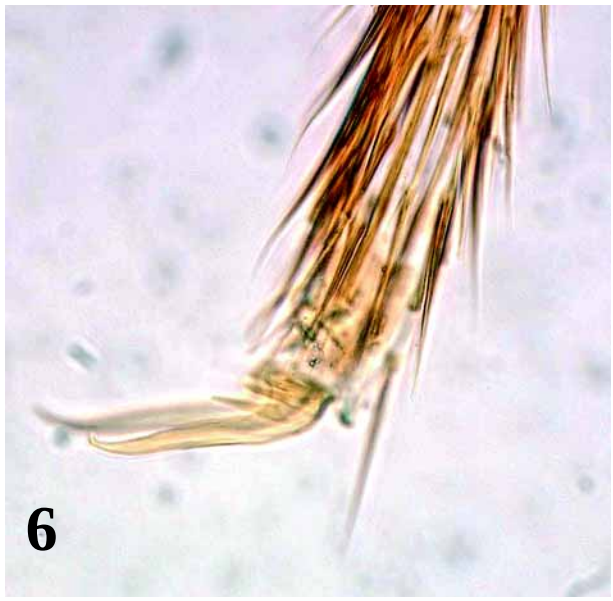
Thorax. Scutum brown, lighter at the borders, scutellum dark brown; scutum strongly arched posteriorly, uniformly setose (Fig. 4). Proepisternum and proepimeron brown, anepisternum brown, katepisternum, mesepimeron, and metepisternum light brown; laterotergite and mediotergite whitish, weakly sclerotized Anepisternum with about nine setae dorsally, laterotergite, katepisternum, and mesepimeron bare; no postspi-

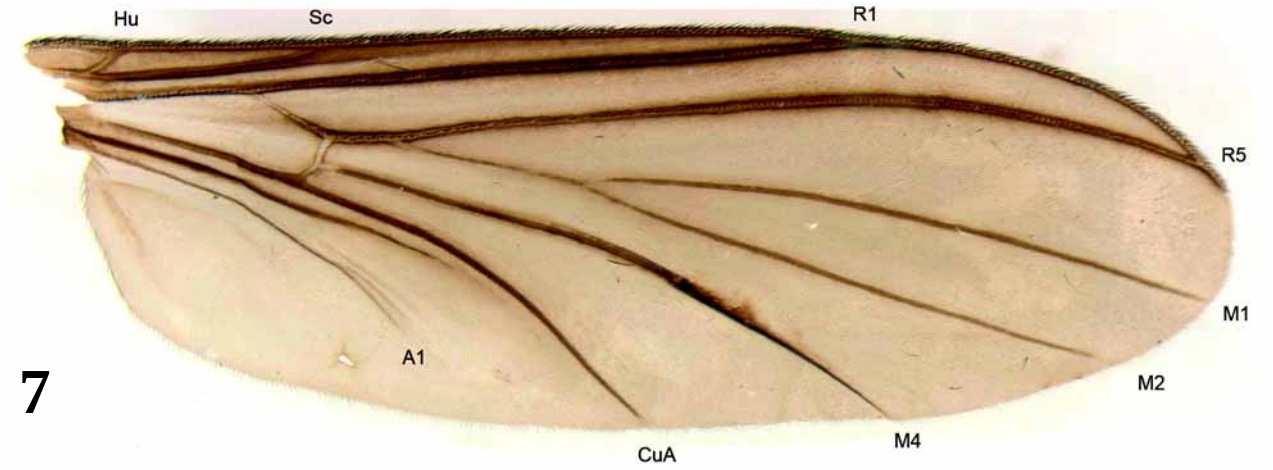
racular setae; laterotergito and mediotergite rather weakly sclerotized, mediotergite with a group of about 20 setae medially, the triangular subscutellar membranous area well developed (Fig. 5). Haltere with brown knob and yellow–brown pedicel, with a row of setae beginning from the base of the pedicel, quite abundant at the knob.

Legs. Legs elongate, brown, setae arranged in regular rows along tibiae and tarsi. All tibiae with a single apical spur, front spur very short, mid spur three times tibia width, hind spur more four times tibia width. Apex of hind tibia with a regular row of longer setae along distal margin. Tibiae and tarsi with setae arranged in regular rows. Tarsal claw with three basal teeth (Fig. 6)

Wing. Wing membrane smoky brown, veins darker (Fig. 7). C extending to just beyond R_5. Sc complete, reaching C beyond origin of Rs. Rs originating basally; R_4 absent; R_5 reaching C before wing apex; R_1 long, reaching C beyond medial fork. Medial fork long, more than twice the free length of M_{1+2}, M_2 ending slightly before wing margin; no bM fold; A_1 sclerotized, incomplete. Microtrichia densely covering wing membrane; macrotrichia present on R_1, R_5, and at base of CuA, absent on medial veins and on A_1.

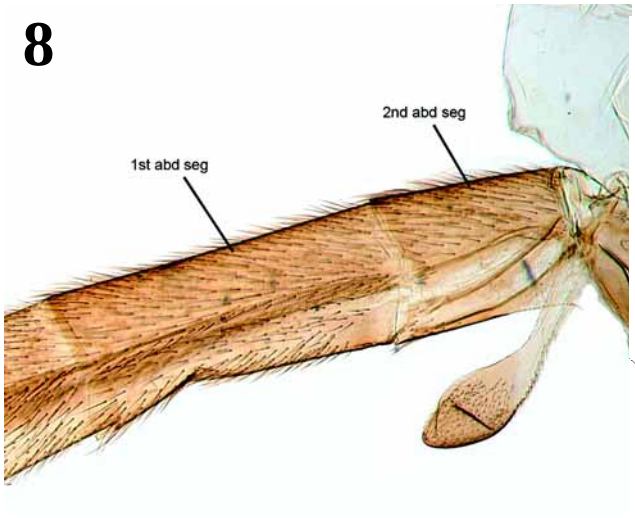


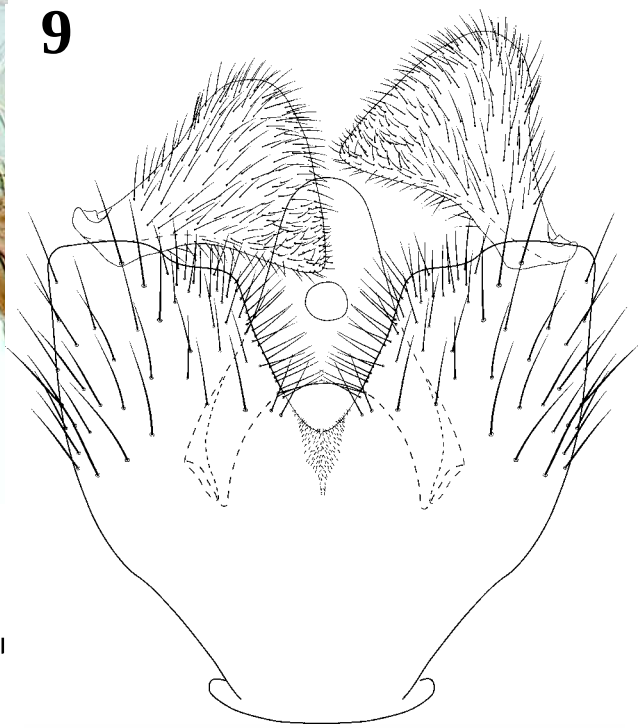




FIGURES 5–7. *Chetoneura shennonggongensis*, sp.n. 5. Dorsal view of posterior part of thorax. 6. Hind leg toothed tarsal claw. 7. Wing. (Photos by D.S. Amorim).

FIGURES 8–13. *Chetoneura shennonggongensis*, sp.n. 8. Base of abdomen, with elongated segment 2. 9. Male terminalia, ventral view. 10. Gonostyle, ventral view. 11. Female terminalia, ventral view. 12. Female terminalia dorsal view. 13. Female terminalia, dorsal view. Abbreviations: abd seg, abdominal segment; ae, aedeagus; ce gc, gonocoxite; ga VIII, gonapophysis of sternite 8; gs, gonostyle; S8, segment 8; S9, sternite 9; S10, sternite 10; T8, tergite 8, T9, tergite 9. (Photos by D.S. Amorim).


8
2nd abd seg
1st abd seg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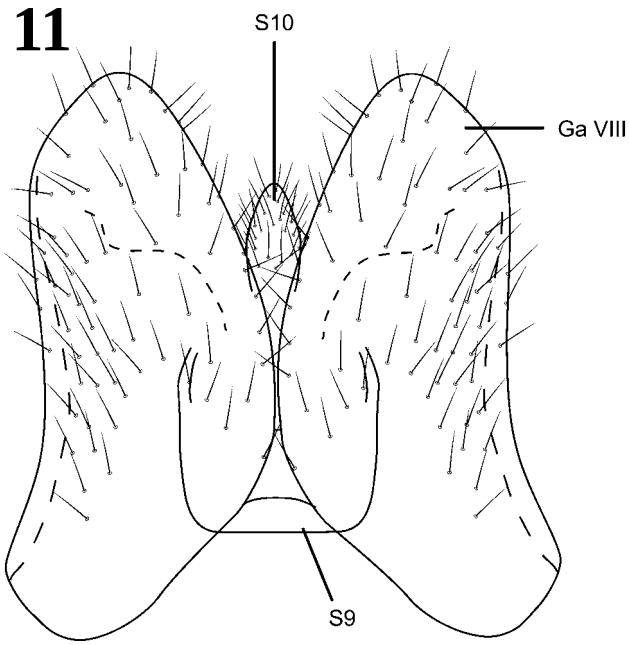
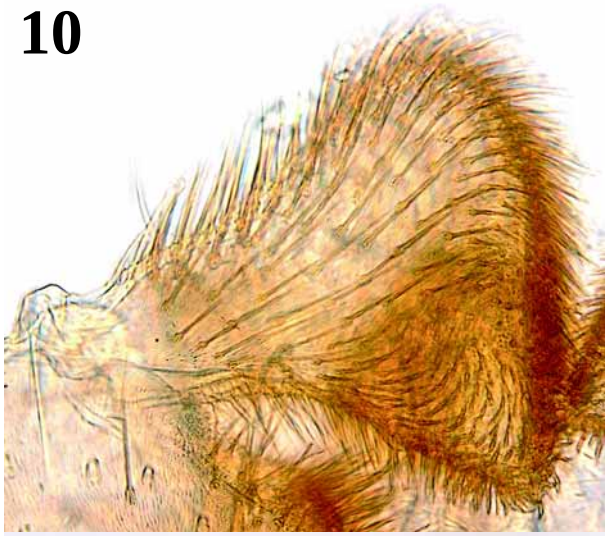

11
S10
Ga VIII
S9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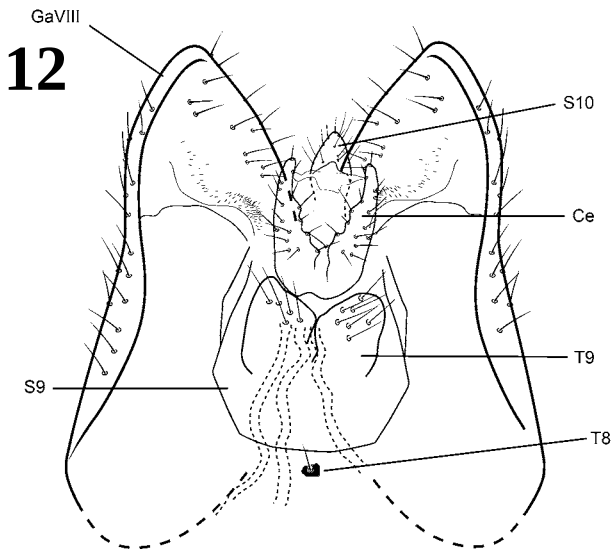
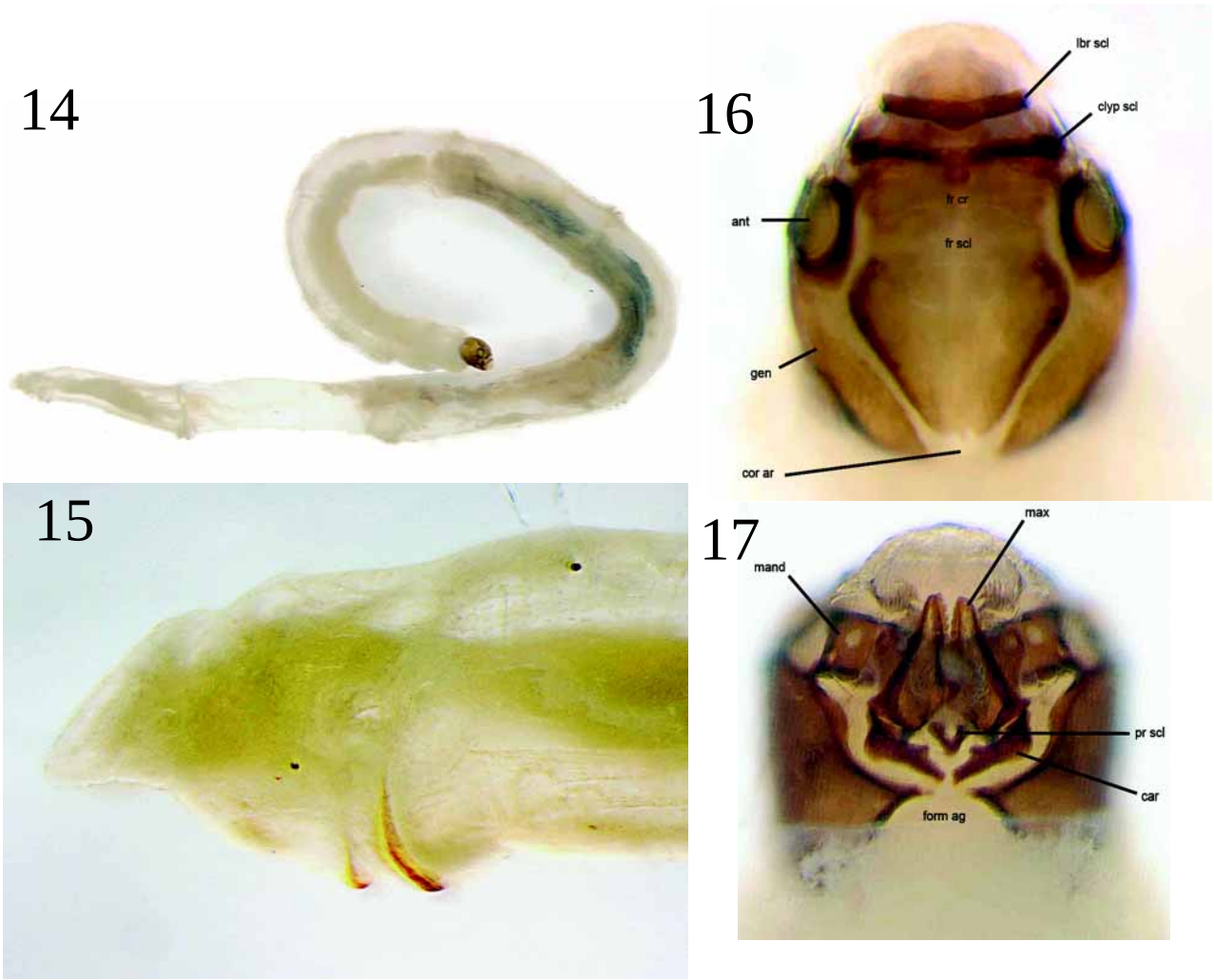

12
GaVIII
S10
Ce
T9
S9
T8


13

Abdomen. Tergites brown, sternites lighter. Terminalia brown. Segments 2 and 3 about twice length of segment 1 (Fig. 8).

Terminalia. Male terminalia elongated anteriorly (Fig. 9). Gonocoxites mesally fused at the anterior margin, with scattered setae laterally and densely pilose internally, gonostyles inserted apically; no mesal projection of syngonocoxite ("*intercoxalia*"). Gonostyle enlarged apically, densely covered with setae distally, no spines present (Fig. 10). Aedeagus elongated, anterior corners short, projected basally. Tergite 9 triangular, wide at base, slender toward apex.

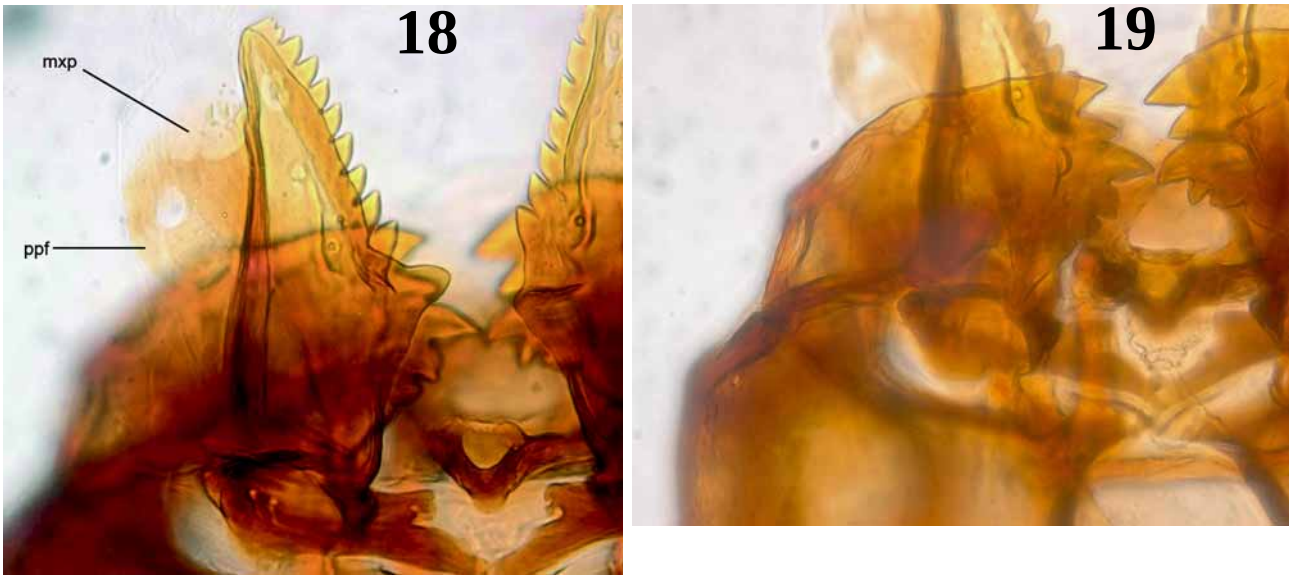
Female. As male in most features. Terminalia with S8 as a pair of largely developed gonapophyses, reaching more distally than the cerci and almost as wide as segment 7, involving the reduced, remaining of the terminalia. T8 nearly absent, visible only as a small plate around a single mesal setae anteriorly to T9. T9 present as a pair of more or less separated lobes with some few setae. T10 apparently absent, cerci unisegmented, postgenital plate (S10) elongated beyond distal end of cerci, ventrally to the anal membrane, with setae (Fig. 11–13).



FIGURES 14–17. *Chetoneura shennonggongensis*, sp. n., 14. Larva habitus. 15. Posterior end of larva. 16. Head capsule of larva, dorsal view. 17. Head capsule of larva, ventral view. Abbreviations: ant, antenna; car, cardo; clyp scl, clypeal sclerite; cor ar, coronal area; for mag, *foramen magnum*; fr cr, frontal crest; fr scl, frontal sclerite; gen, gena; lbr scl, labral sclerite; mand, mandible; max, maxilla; pr scl, prelabial sclerite. (Photos by D.S. Amorim).

Larva. In general terms similar to other Keroplatinae larvae. General color dark yellowish, head capsule brown (Fig. 12). No distinctive modification of the body cuticle, except for ventral pairs of transverse lines of

modified texture of the integument (Fig. 13). Cephalic capsule with well developed gena, frontal area unsclerotized posteriorly, not as large as in other genera (Fig. 14). Eye ventral to the antenna. Coronal area considerably developed, sagittal crest of frons evident, ventral part of *foramen magnum* longer than wide. Antenna placed more dorsally, considerably wide, flattened as in other members of the family, with an anterior pointed projection. Mandible well developed, with five stronger apical teeth; three sensorial depressions present as typically in other members of the family. Maxilla elongated, rather parallel distally, with eight teeth at the inner border, palpifer weakly sclerotized, wider distally than basally. Cardo slender, transverse, with two pairs of setae laterally (Fig. 15). Prelabial sclerite V–shaped, as in other genera. Thoracic segments short, abdominal segments long, except first and last (Fig. 16). Secondary annulation on abdominal segments. Posterior end with a pair of lobose triangular projections (Fig. 17).



FIGURES 18–19. *Chetoneura shennonggongensis*, gen.n., sp.n. 18. Detail of maxilla of the larva. 19. Detail of mandible of the larva. Abbreviations: mx p, maxillary palpus; ppf, palpifere. (Photos by D.S. Amorim).

FIGURE 20. *Chetoneura shennonggongensis*, sp.n. Live larva with suspended threads in Shennong Gong (photo by Arthur Clarke, 8th November, 2006).

Biology. The larvae of the Chinese Keroplatini species described here were first found in the Shennong Gong caves by Xuezhen Li and Changying Niu (Huazhong Agricultural University, China) in late December 2005. This discovery in Shennong Gong followed earlier reports by Arthur Clarke (University of Tasmania, Australia) from October 2000, with observations and collections of non-glowing keroplatid larvae from caves in several other provinces of China, including northwest Guangxi, northwest Zhejiang and eastern Yunnan, (Clarke 2000, 2001a,b, 2002a,b, 2004a,b, 2006a), plus the more recent observations and collections in caves of the elevated plateau karst region of Lichuan County, in western Hubei Province. They were later collected in Shennong Gong in early November 2006, when an abundant population of the larvae was located in a streamway chamber, quite close to an entrance (the tourist cave exit).

Shennong Gong is a stream cave, with a surveyed length of approximately five kilometers from the insurgence (stream entry) point near Pan Ling village to its known downstream resurgence; the first 450–500m of the cave has been recently developed as a tourist show cave. Beyond the main zigzag passage (tourist section), the underground stream extends several kilometers into the cave, creating a relatively constant year round temperature (18±2°C) and high humidity (98±2% rH) environment. The Keroplatini larvae are mainly distributed within a distance of up to 150–200 m from the entrance of the cave, where there is good ventilation and moist air flow following the course of inflowing stream water. The larvae are suspended from the moist roof of the cave above or adjacent to the streamway. Their numerous, long sticky silken ensnare threads coated with mucous droplets to enhance the capture of prey, chiefly flying insects, including the adult forms of the larvae.

The species does not show any troglobiontic modifications. The colonies of larvae are found in the cave throughout the year. Similarly to what is seen in other Keroplatidae species, e.g., the Tasmanian glow–worms (Ferguson 1925, Clarke 2001c, 2006b), the larval stage may last 5–12 months, depending on the environmental conditions and prey availability. Large numbers of pupae are observed at the cave roof at the end of June, where they remain suspended horizontally from the silk threads. The pupal stage lasts 7–10 days in this cave. July is the peak time of adult emergence. Mating usually takes place immediately upon female emergence, if adult males are available. The adult life span is short. Females live 3–5 days and males 5–7 days. The eggs are black in color and round in shape. Egg development time is 12–30 days. The biology of the species will be explored in more detail elsewhere.

Etymology. The name of the species comes from the name of the cave, Shennong Gong, which means “Dragon Palace”.

Discussion

It is not the purpose of this paper to make a formal phylogenetic reanalysis of the Keroplatini. Nevertheless, Matile’s (1990) phylogenetic study of the family is of great help to place *Chetoneura* among the genera of Keroplatini. The fact that the genus extends north from Malaysia to reach East China is relevant in delimiting the extension of tropical elements in Asia, where there may be a possible overlap between Oriental and Palaearctic components.

The detailed examination of the adult and larval specimens of this species, in the light of the knowledge of the family accumulated in recent years, helped to place the genus in the Keroplatini, most clearly because of the reduction of the maxillary palpus and the labella. Within the tribe, it would not be a member of the Cerotelionina, but rather fits into the Keroplatina, because of the shape of the syngonocoxites distally. The shape of the distal palpomere, the reduction of the labella, and the bare laterotergite are shared features of Matile’s (1990) “sous–groupe *Platyroptilon*” that also includes *Chetoneura* . The large triangular membranous subscutellar area, the hind tibia enlarged to the apex and the weakly developed parameres are features shared in the tribe by the genera *Heteropterna* and *Ctenoceridion*. Indeed, among the diversity of genera of Keroplatini,

Chetoneura particularly resembles these two genera in some other features, such as the shape of the head anteriorly. It is particularly interesting to note that larval features of *Chetoneura* are also much more similar to those of *Heteropterna* than, e.g., to those of *Keroplatus*: the mandible has a few strong distal teeth (e.g., Matile 1990, fig. 563) and the maxilla also has fewer teeth along a straight line, with the palpifer wider distally (Matile 1990, fig. 564), instead of a larger group of small teeth in the mandible (Matile 1990, figs. 188–189) and the maxilla is wider and with more numerous teeth (Matile 1990, figs. 185–186). The large distal mandible teeth are also seen in *Arachnocampa,* indicating that this condition may be plesiomorphic in the family. The fact that *Chetoneura* is plesiomorphic for this feature excludes it anyway from the clade including *Keroplatus*, in which this feature is apomorphic.

The absence of R_4 is relatively rare in Keroplatidae (even though common in Mycetophilidae *s.s.*). Its modified condition in *Chetoneura* could merely correspond to an apomorphic condition within a subclade of clade *Heteropterna* or *Ctenoceridion*. In this case the generic status would not be justifiable. However, the gonostyle is simple in *Chetoneura*, plesiomorphic in relation to the distally split gonostyle seen in most species of *Heteropterna* and *Ctenoceridium*. *Heteropterna flavovittata* Matile, from Fiji, has two ocelli, but some other features, including the shape of the gonocoxites, points to independent origins of this condition. This indicates that *Chetoneura* would be possibly sister to a clade composed of both *Heteropterna* and *Ctenoceridium*. Some Australasian species of *Heteropterna* also have undivided gonostyle and the monophyly of *Heteropterna* has been questioned by Matile (1990). This would not interfere, anyway, in attributing generic status to this pair of species under *Chetoneura*. The female terminalia of *Chetoneura* is very unusual, with the largely developed gonapophyses of S8. This feature is not found either in *Heteropterna* or *Ctenoceridium* (and possibly not any other keroplatid genus). However, the weak sclerotization of T8 and the T9 divided mesally by a weakly sclerotized area are features shared with other Keroplatini genera.

To more fully understand the evolution of the biology of the larvae of keroplatids, a sound revision of the literature of immatures should be undertaken. Association with fungi is known to be plesiomorphic in the Mycetophiliformia , but larval predation was assumed by Matile (1997: 284) as the groundplan condition for the Keroplatidae. Probably many species live in shaded environments and it is not entirely surprising that different clades in the Keroplatidae live in caves, this most probably representing a homoplastic habitat shift in the group. As well, the evolution of bioluminescence is also clearly homoplastic within the family. The parts of the body in which luminescence is produced in different genera are not the same and even the structure of the luciferases in *Arachnocampa* and *Orfelia* is different (Viviani 2002, Viviani *et al.* 2002) corroborating the fact that this feature has evolved in different stems in the phylogeny of the Keroplatidae. More detailed biological information on more of the genera would help a better understanding of the changes of habitat and feeding behavior observed in the family. The presence of larvae of *Chetoneura* in caves of China and Malaysia suggests that this is an apomorphic condition shared by both species of the genus, but the acquisition of the cave habitus in *Chetoneura* must have been independent from other cases in the Keroplatini.

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from the type–species of the genus. Useful suggestions and corrections to the text were made by two anonymous referees.

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