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Short communication

An enigmatic fossil hairy cicada (Hemiptera, Tettigarctidae) from mid-Cretaceous Burmese amber

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ABSTRACT

A new tettigarctid, *Hpanraais problematicus* gen. et sp. nov. is described based on a forewing from mid-Cretaceous Burmese amber. This new genus and species significantly differs from other fossil and extant tettigarctids in the details of tegmen venation. The fossil represents an enigmatic and very peculiar Tettigarctidae known from mid-Cretaceous Burmese amber from Kachin province, and it not only enriches the knowledge of the diversity of Mesozoic Tettigarctidae but also provides some key morphological details of the forewing in this family.

1. Introduction

Tettigarctidae, commonly known as hairy cicadas, is a relict group of cicadas consisting of only one extant genus *Tettigarcta* White, 1845 with two species: *T. tomentosa* White, 1845 and *T. crinita* Distant, 1883, inhabiting high altitude habitats in Tasmania and South-East Australia (Evans, 1941; Moulds, 1990). The fossil record of the family is relatively rich, and reaching terminal Triassic (Moulds, 2018; Szwedo, 2018); most recent commented list of fossil Tettigarctidae is provided by Moulds (2018), which includes described 22 extinct genera with 37 species (Moulds, 2018: table 1). The fossils of Tettigarctidae were earlier revised by Shcherbakov (2008). So far, all the fossil specimens of tettigarctids reported were found in sedimentary rocks as impression and compression fossils. In this paper, *Hpanraais problematicus* **gen. et sp. nov.** is described based on an isolated tegmen (forewing) from mid-Cretaceous Burmese amber. The discovery helps us observe more morphological details of the forewing of primitive Tettigarctidae, and adds new material for the further study of the evolutionary history of this insect group.

2. Material and methods

The amber specimen NIGP168934 described here originated from the Hukawng Valley in Tanaing Township, Myitkyina District of Kachin State, Myanmar (Kania et al., 2015: fig. 1). The age of this Burmese amber is 98.79 ± 0.62 Ma (Shi et al., 2012). The specimen is housed in the Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences (NIGPAS). Photographs were taken using a Zeiss Stereo Discovery V16 microscope system and Zen software, finished with CorelDraw 2018 and Adobe Photoshop CS6. All images are digitally stacked photomicrographic composites of approximately 40 individual focal planes obtained using the free software Combine ZP for a better illustration of the 3D

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structures. There is no agreement on the interpretation of vein nomenclature in Cicadomorpha. Here, the vein nomenclature of tettigarctids follows patterns and interpretations reported by Nel et al. (1998, 2012, 2013), Moulds (2005, 2018) and Wang et al. (2006). Venational abbreviations are as follows: ScP, subcosta posterior; RA, radius anterior; RP, radius posterior; M, media; CuA, cubitus anterior; CuP, cubitus posterior; Pcu, postcubital vein; A, anal vein.

3. Systematic palaeontology

Order Hemiptera Linnaeus, 1758
Suborder Cicadomorpha Evans, 1946
Superfamily Cicadoidea Latreille, 1802
Family Tettigarctidae Distant, 1905
1949 Tettigarctidae fam. n. [sic]: Becker-Migdisova, p. 20
1956 Cicadoprosbolidae Evans, p. 222
1982 Protabanidae Hong, p. 169

Hpanraais gen. nov.

Type species: *Hpanraais problematicus* sp. nov.; by present designation and monotypy.

Etymology. From the expression in te Kachin language, 'hpa n ra ai' meaning 'no problem'. Gender neuter 3rd declension.

Diagnosis. Tegmen elongate, nearly 3 times longer than wide, narrowed at base, piliferous and tuberculate on remigium. Nodal line distinct. Costal area wider than cubital cell. Vein RA with three terminals, forked beyond the nodal line. Vein M forked from ScP+R+M at about basal 0.25 wing length (4.29 mm from wing base). Vein M forked a little bit before R and branching into M_{1+2} and M_{3+4}. Veinlet *rp-*m_{1+2} and m_{1+2}-m_{3+4} (*im*) separating the areas between the first forking of stem R and M into two cells. The half of the latter cell as long as the former cell. The basal of CuA strongly curved anteriorly, and the most base of CuA fused with a vein. The vein forming an acute angle with the basal section of vein CuP, then fused with CuP as well as branching CuA.The distal section of CuA stronger than basal two-third of vein CuA. No obvious connection of vein between stem M and CuA. Nodal line veinlets *ra-rp* (*ir*), *rp-*m_{1+2}, m_{1+2}-m_{3+4} (*im*), m_{3+4}-*cua* distinct and parallel with the nodal line. Branch CuA forking into CuA_1 and CuA_2, the utmost apical portion of stem CuA form a short stalk running along the nodal line. Basal portion of terminal CuA_2 sinuous, parallel with the nodal line, strongly bent at about right angle and then parallel to tornus, apical of portion of CuA_2 curved towards the margin. Vein CuP nearly straight, ending at the nodal apex. Claval veins Pcu and A_1 simple, subparallel and curved.

Remark. The studied forewing resembles in general features of Tettigarctidae mainly based on its elongate shape and distinct nodal line, pattern of longitudinal veins forkings, simple veins CuP, Pcu and A_1. The new genus *Hpanraais* gen. nov. presents resemblance to some genera of Cicadoprosbolinae and Tettigarctinae in venation pattern: RA forked in three branches; vein M_{3+4} forked; CuA_2 very sinuous, the base of CuA_2 and the apical of CuA section running along nodal line; apical cell behind CuA different to next anterior cell; wing margin rounded beyond claval apex; costal area are wider than cubital cell. As noted by Shcherbakov (2008) and Moulds (2018), this group of genera include *Macrotettigarcta* Chen & Wang, 2016, *Maculaprosbole* Zheng et al. (2016), *Tianyuprosbole* Chen et al., 2014, *Shuraboprosbole* Becker-Migdisova, 1949, *Sanmai* Chen et al. (2016) and *Liassocicada* Brodie, 1953. However, the new genus shares characters with multiple other genera, but can be separated from them and extant species by the basal of CuA strongly curved anteriorly, and the most base of CuA fused with a vein, this vein forming an acute angle with the basal section of vein CuP then fused with CuP as well as branching CuA; the distal section of CuA stronger than basal two-third of vein CuA; no obvious vein connection between stem M and CuA; nodal line veinlets *ra-rp*, *rp-*m_{1+2}, m_{1+2}-m_{3+4}, m_{3+4}-*cua* distinct and parallel to nodal line strengthening. Apparently, the new genus shows a mixture of features present in different subfamilies and tribes of Tettigarctidae, but also has its own features. That is the reason of difficulties to place this new genus into any tribe or subfamily and it is ambiguous to erect a new tribe or even higher classification level merely by an incomplete forewing wing. Therefore, we temporary place the studied specimen into a new genus within the family Tettigarctidae, in hope to find more complete specimen(s) and resolve its taxonomic placement.

Hpanraais problematicus sp. nov.

Fig. 1A–K

Etymology. Specific epithet is derived from Ancient Greek próblēma (πρόβλημα) - meaning question propounded for a solution.

Type material. Holotype. NIGP 168934, incomplete tegmen (forewing) (Fig. 1A, 1B), with very base covered with debris and bubbles (Fig. 1C, 1D), apical portion missing; gender unknown; deposited in the Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, China.

Locality and horizon. Hukawng Valley, Kachin Province, Myanmar; lowermost Cenomanian, lowermost Upper Cretaceous.

Diagnosis. As for genus, by monotypy.

Description. Tegmen (Fig. 1A, 1B); piliferous and tuberculate. Length as preserved 14.35 mm, estimated complete length approximately 16.70 mm; maximum width 6.01 mm. Costal margin convex at basal 0.18 wing length (3.05 mm from wing base), costal area very long, the basal portion of costal area narrow, distinctly widened in the middle portion of costal area, basal portion of costal area narrow tapering to the apex. Nodal incision not distinct but visible at basal 0.67 wing length (11.18 mm from wing base) (Fig. 1E). Stem ScP+R+M slightly curved, vein ScP+R forked with vein M at basal 0.25 wing length (4.29 mm from wing base). Vein ScP separating from vein ScP+R at basal 0.59 wing length (9.84 mm from wing base) with the nodal line, terminating at the nodal incision. Stem R branching beyond nodal line veins RA and RP at basal 0.38 wing length (6.29 mm from wing base). Stem R length more than 2/3 length of stem ScP+ R+M. Branch RA curved posteriorly and branching into three terminals RA_1, RA_2 and RA_3. Branch RA_1 at basal 0.64 wing length (10.65 mm from wing base), RA_2 and RA_3 forked at basal 0.77 wing length (12.90 mm from wing base). Vein M curved posteriorly and branching into veins M_{1+2} and M_{3+4} at basal 0.39 wing length (6.50 mm from wing base). Vein M_{3+4} connected with vein CuA_1 by m_4-cua_1 crossvein at basal 0.76 wing length (12.67 mm from wing base). Veinlets *ra-rp*, *rp-*m_{1+2}, m_{1+2}-m_{3+4}, m_{3+4}-*cua* distinct and parallel with the nodal line (Fig. 1F). The basal of stem CuA strongly curved anteriorly (Fig. G), and the most base of CuA fused with a vein. This vein forming an acute angle with the basal section of vein CuP then fused with CuP as well as branching CuA (Fig. G, H, I). No obvious connection of vein between stem M and CuA (Fig. G, H). The distal section of CuA stronger than basal two-third of vein CuA, stem CuA running along the nodal line with a short bent section at the nodal line, then branching into two terminals CuA_1 and CuA_2 at basal 0.58 wing length (9.67 mm from wing base). Vein CuA_2 very sinuous, parallel with a nodal line, bent at an about right angle and parallel to the tornus (Fig. 1J), then curved and shifted to the margin slightly based of apical m_4-cua_1 veinlet, at basal 0.70 wing length (11.73 mm from wing base). Vein CuP almost straight, ending at the nodal incision. Vein Pcu curved apically towards posterior claval margin. Vein A_1 short and curved anteriorly. Nodal line traceable as strengthening parallel to terminal ScP, veinlets linking RA and RP (*ir*), RP and M_{1+2} (*rp-m*),

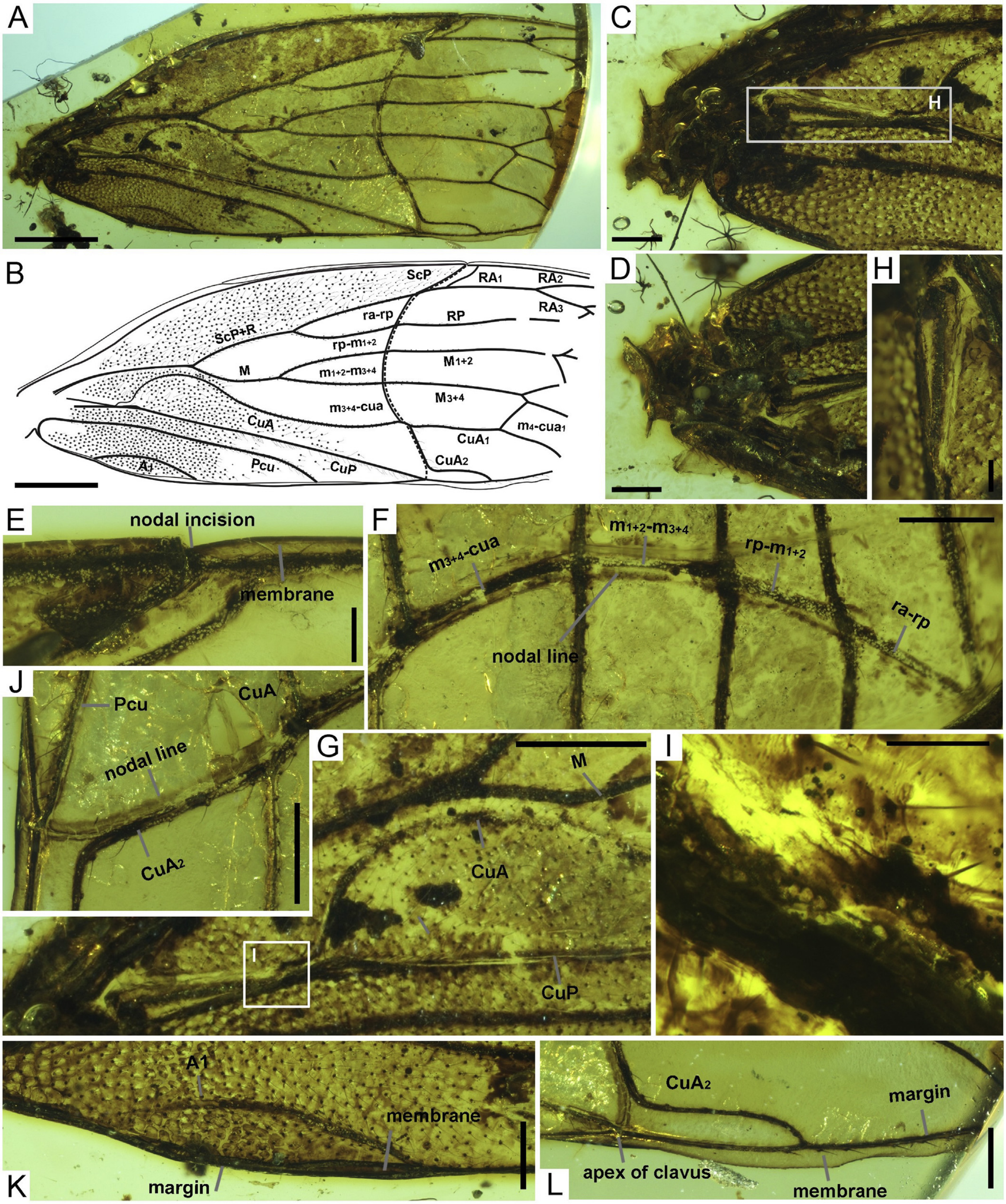

Fig. 1. *Hpanraais problematicus* gen. et sp. nov. NIGP168934, Holotype (A–K). (A) Photograph. (B) Tegmen, line drawing with veins and veinlet explained. (C) Showing the outboard base of the forewing. (D) Showing the inboard base of the forewing. (E) Details of nodal incision and membrane. (F) Details of veinlets of *ra-rp*, *rp-*m_{1+2}, m_{1+2}-m_{3+4}, m_{3+4}-*cua*. (G) Details of vein CuA, and no obvious connection of vein between stem M and CuA. (H) Details of a vein which form a acute angle with the basal section of vein CuP and not connect with vein M. (I) Details of the vein (H) fused with CuP and branching Cua. (J) Details of apical CuA section running along the nodal line with a short vein stalk, then branching into two veins CuA_1 and CuA_2; CuA_2 parallel with the nodal line; the terminals of the nodal line. (K) Showing posterior margin of clavus with the claval membrane. (L) Showing tornus with the postclaval membrane (appendix). Scale bars = 2 mm (A, B), = 0.5 mm (C, D, F, J, K, L), = 0.2 mm (E, H, I), = 1 mm (G).

M_{1+2} and M_{3+4} (*im*), M_{3+4} and CuA (*m_{3+4}-cua*), preforking short section of CuA, basal section of CuA2 and between bent of CuA and apex of clavus. Marginal membrane on clavus and tornus narrow (Fig. 1K, 1L).

4. Discussion

Hpanraais problematicus gen. et sp. nov. can be distinguished easily from other genera and species of Tettigarctidae by the wing characters: the basal of stem CuA strongly curved anteriorly, and the most base of CuA fused with a vein; this vein forming an acute angle with the basal section of vein CuP, then fused with CuP as well as branching CuA; the distal section of CuA stronger than basal two-third of CuA vein; no obvious connection of vein between stem M and CuA; veinlets *ra-rp*, *rp-m_{1+2}*, *m_{1+2}-m_{3+4}*, and *m_{3+4}-cua* are distinct and parallel to the nodal line. The genera *Macrotettigarcta* Chen & Wang, *Maculaprosbole* Zheng, Chen & Wang, *Tianyuprosbole* Chen, *Shuraboprosbole* Becker-Migdisova, *Sanmai* Chen, Zhang & Wang are similar to the new genus in vein RA forked in three branches; vein M_{3+4} forked; CuA_2 sinuous; the base of CuA_2 and the apical of CuA section running along nodal line; wing margin rounded beyond claval apex; apical cell behind CuA different to next anterior cell; costal area wider than cubital cell (see Shcherbakov, 2008). However, besides the above key characters, *Macrotettigarcta* Chen & Wang, *Maculaprosbole* Zheng, Chen & Wang, *Tianyuprosbole* Chen are also similar to *Hpanraais* gen. nov. in pattern of RA which is forking into three branches, and CuA_2 is very sinuous, S-shaped, but these genera present distinct nodal incision and vein CuA connected with vein M. *Shuraboprosbole* Becker-Migdisova and *Sanmai* Chen, Zhang & Wang present inconspicuous nodal incision similar to the studied fossil, but branch RA in these genera is forked into two branches and terminal CuA_2 is short, or placed along nodal line.

Up to now, the family of Tettigarctidae, besides the new genus *Hpanraais* gen. nov., comprises 22 extinct genera with 38 species. Among all described records, five genera: *Hirtaprosbole* Liu et al. (2016), *Macrotettigarcta* Chen & Wang, *Maculaprosbole* Zheng, Chen & Wang, *Sanmai* Chen, Zhang & Wang and *Shuraboprosbole* Becker-Migdisova, are from the Middle/Late Jurassic of Daohugou, Inner Mongolia, China; one genus – *Turutanovia* Becker-Migdisova, 1949 – is from middle Jurassic of central Inner Mongolia, China; one genus, *Protabanus* Hong, are from the middle Jurassic of Liaoning, China; and one genus, *Sunotettigarcta* Hong, 1982, is from the middle Jurassic of Hebei, China (see a review in Moulds, 2018). This appears to provide unequivocal evidence for the diversity of Tettigarctidae in middle or middle/late Jurassic of northern China. Moreover, more than 70 percent of the fossil genera of Tettigarctidae come from Jurassic deposits of Tadzhikistan, Kazakhstan, Russia, China, Germany and England (see a review in Moulds, 2018), suggesting there might be the radiation of Tettigarctidae on the Laurentia during Jurassic, but the relatively poorer fossil record of Tettigarctidae in the southern hemisphere, especially in Africa where the clade has not been found. Nevertheless with more discoveries of fossil Tettigarctidae with exquisitely preserved body structures, it may suggest that current classification might not effectually reflect evolutionary relationships of Tettigarctidae (Wang et al., 2009; Li et al., 2012; Chen et al., 2014; Chen et al., 2016; Liu et al., 2016). For the Cretaceous, only seven genera with seven species from Russia, China, Mongolia, Belgium, Tunisia, and Brazil (see a review in Moulds, 2018) are reported. The newly described specimen of *Hpanraais problematicus* gen. et sp. nov. from Burmese amber provide not only the new fossil record of Tettigarctidae in the Cretaceous, but also extends the palaeodistribution of this family during mid-Cretaceous to the area of recent Myanmar. More systematic and revisionary works supported by collecting more fossil evidence should be carried out, for the better definition and understanding of the Tettigarctidae.

5. Conclusions

A new tettigarctid, *Hpanraais problematicus* gen. et sp. nov., is described from mid-Cretaceous Burmese amber. Our find exhibits different forewing features and adds data to the taxonomic diversity of extinct Tettigarctidae, enhancing our understanding of the distribution and diversity of Mesozoic tettigarctids.

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