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A new species of Eomeropidae (Insecta: Mecoptera) from the Middle Jurassic of China

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ABSTRACT

The Eomeropidae is a species-poor family with only 11 known fossil species from the Early Jurassic to Palaeogene. A new species of fossil eomeropid, *Tsuchingothauma gongi* sp. nov., is described based on a well-preserved wing from the Middle Jurassic Daohugou deposits of Inner Mongolia, China. Our new species is distinguished from the type species *T. shihi* mainly in having very numerous crossveins and cells; more longitudinal veins: 13 and 11 terminal branches in radial sector and medial field, CuA with 3 terminal branches and A with 7 terminal branches.

1. Introduction

The order Mecoptera (scorpionflies) has an unusual position within insects, and is a group of special significance for understanding the evolution and phylogenetic relationships with the largest and currently most important insect orders, such as the Lepidoptera, Trichoptera, Diptera and Siphonaptera (Krzemiński et al., 2016; Soszyńska-Maj et al., 2016). Until now, more than 600 living species were assigned to only nine families among scorpionflies; however, the fossil insect database EDNA currently comprises 776 species in 231 genera, assigned to 40 families and this number is continually changing (Cai et al., 2008; Bicha, 2010; Mitchell, 2015). The order has a fossil record extending back to the early Permian and arriving at a peak in the Early Cretaceous. From the Late Cretaceous through the Paleogene, fossils of scorpionflies are not so common and the family composition gradually develops a modern appearance (Novokshonov, 2002; Grimaldi and Engel, 2005).

The Eomeropidae is a species-poor family, with only one living species, *Notiothauma reedi* MacLachlan, 1877 is found only in the western Andes of Southern Chile. This remarkable and unique scorpionfly with dark, shining body and flat incumbent wings (cockroach-like body), and is readily attracted to oatmeal bait (Pena, 1968; Remington, 1968). Soszyńska-Maj et al. (2016) recently reviewed these fossil records of the family and provided a genus-level phylogenetic analysis based on wing venation. Fossil records of eomeropids are extremely rare, with only eleven known fossil species ranging in age from the Early Jurassic to Palaeogene (Table 1). Herein, a new species of *Tsuchingothauma* Ren and Shih, 2005 is described based on a well-preserved fossil wing from the Middle Jurassic Daohugou deposits of Inner Mongolia, China.

2. Material and methods

The specimen (wing) was collected from the Middle Jurassic Daohugou beds of Wuha Township, Ningcheng County, Chifeng City, Inner Mongolia, China (Fig. 1).

The Daohugou fossil-bearing strata comprise a set of intercalated, fine-grained lacustrine deposits and fine volcanic ash that unconformably overlie Precambrian rocks (Chen et al., 2004; Gao and Ren, 2006). They are in the in the upper part of the Jiulongshan Formation, consisting of grey tuff, tuffaceous siltstone and mudstone, and are

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Table 1
Fossil record of Eomeropidae.

Taxon	Occurrence	References
Eomerope pacifica Ponomarenko, 1974	Siberia, Late Eocene/ Early Oligocene	Ponomarenko and Rasnitsyn (1974)
Eomerope tortriciformis Cockerell (1909)	Colorado, Late Eocene	Cockerell (1909)
Eomerope macabeensis Archibald et al. (2005)	Canada, Early Eocene	Archibald et al. (2005)
Eomerope simpkinsae Archibald and Rasnitsyn (2018)	America, Early Eocene	Archibald and Rasnitsyn (2018)
Eomerope eonearctica Archibald and Rasnitsyn (2018)	America, Early Eocene	Archibald and Rasnitsyn (2018)
Eomerope asiatica Ponomarenko 1974	Siberia, Late Paleocene	Ponomarenko and Rasnitsyn (1974)
Typhothauma yixianensis Ren and Shih (2005)	China, Early Cretaceous	Ren and Shih (2005)
Typhothauma excelsa Zhang et al. (2012)	China, Early Cretaceous	Zhang et al. (2012)
Tsuchingothauma shihi Ren and Shih (2005)	China, Middle Jurassic	Ren and Shih (2005)
Jurathauma simplex Zhang et al. (2011)	China, Middle Jurassic	Zhang et al. (2011)
Jurachorista bashkuevi Soszyńska-Maj et al. (2016)	England, Early Jurassic	Soszyńska-Maj et al. (2016)

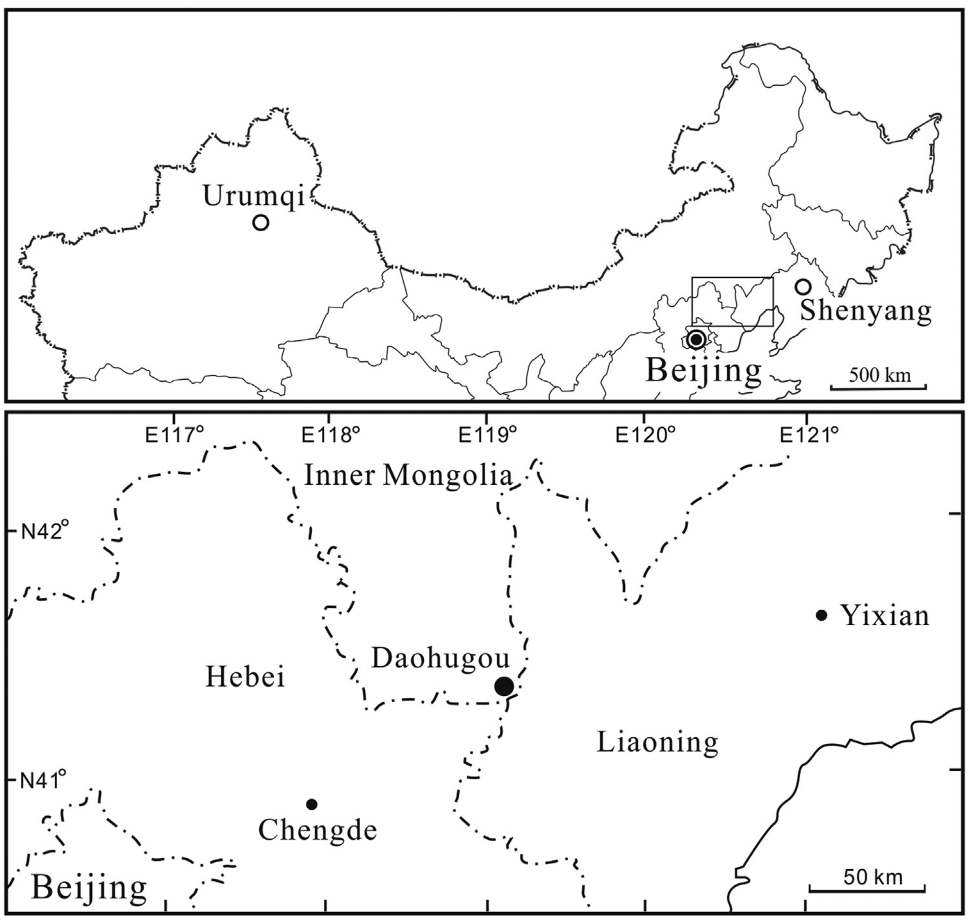

Fig. 1. Geographical position of the fossil insect locality.

now considered to be one of the most important insect lagerstatten (Wang et al., 2013). The age of the fossil-bearing strata is still debatable. The radiometric dating of the overlying ignimbrite studied by different researchers yielded a similar radiometric age: 164–152 Ma (He et al., 2004; Liu et al., 2006), a Middle Jurassic or early Late Jurassic age. The palaeoclimate in Daohugou during mid-Jurassic times is thought to have been warm temperate (Rees et al., 2000; Wang et al., 2013). The specimen is housed in the Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences (NIGPAS).

The specimen was examined dry and under alcohol, photographs being taken using a ZEISS Stereo Discovery V16 microscope system, All images are digitally stacked photomicrographic composites of approximately 10 individual focal planes obtained using the free software Combine ZP for a better illustration of the 3D structures. The figures were prepared with CorelDraw X7 and Adobe Photoshop CS3. Nomenclature of wing venation used in this paper follows Willmann (1989), with some modifications; special vein abbreviations are as follows: ORs, origin of Rs; FRs, first fork of Rs; FM, first fork of M.

3. Systematic palaeontology

Order: Mecoptera Packard, 1886
Family: Eomeropidae Cockerell, 1909
Genus: *Tsuchingothauma* Ren and Shih, 2005
Species *Tsuchingothauma gongi* sp. nov.

3.1. Etymology

The specific epithet honours the fossil collector, Baode Gong.

3.2. Holotype

NIGP169519, The insect is incomplete, with only one wing preserved (part and counterpart).

3.3. Locality and horizon

The specimen was collected in the Middle Jurassic Daohugou beds of Wuha Township, Ningcheng County, Chifeng City, Inner Mongolia, China.

3.4. Diagnosis

The main distinctive characters of the new species are as follows: very numerous crossveins and cells; three Sc branches clearly distinguished; Rs 13-branched, Rs_8 forking earliest, a little beyond the middle of wing, Rs_1 and Rs_2 forking latest, at about 8/9^{ths} of the wing length; M 11-branched, M_{1+2} about twice as long as M_{3+4+5}; CuA 3-branched and A 7-branched, well defined.

3.5. Description (Figs. 2 and 3)

Only one wing preserved, base of wing narrow, apex broadly rounded, pterostigma invisible; length about 3.52 cm, maximum width 1.19 cm, length/width ratio 2.96; with rich venation, numerous crossveins and cells. Sc long but not straight, with 3 terminal branches, vein Sc_3 reaching the wing margin at 3/4^{ths} wing length, at the level where M_5 reaches outer margin, long crossvein between the base of Sc and apical margin; base of R very strong and R almost straight nearly along the whole length, three crossveins between R and Rs_{1+2}; Rs with 13 terminal branches, arising from R (ORs) and forking (FRs) early, at about 1/4th and 1/3th of wing length, respectively, Rs_{1+2} very straight, Rs_8 forking earliest, a little beyond the middle of wing, Rs_1 and Rs_2 forking latest, at about 8/9^{ths} of wing length; M with 11 terminal branches, a very strong crossvein between the base of M and CuA_{1+2}, forking (FM) early, at the level very little beyond FRs, M_{1+2} about twice as long as M_{3+4+5}, M_{6+7} forking a little beyond FM, M_{10+11} about 1/8th length of M_{8+9}. CuA with 3 terminal branches, not straight, forking at the base of wing, CuA_{1+2} 1.16 cm, CuA_1 forking very late and reaching the wing margin before the middle of wing, 8 crossveins between CuA_3 and CuP, CuP simple, broken-linelike; A simple, with 7 terminal branches, A_1 longest and A_7 shortest, 14 crossveins between A_1 and A_7.

4. Discussion

The genus *Tsuchingothauma* with the type species *T. shihi* was erected based on two specimens from the Middle Jurassic Jiulongshan Formation in Daohugou Village, Ningcheng County, Inner Mongolia, China (Ren and Shih, 2005). Our new specimen undoubtedly belongs to *Tsuchingothauma* as evidenced by the combination of the following characters: length about 3.52 cm, maximum width 1.19 cm, length/width ratio 2.96:1; a long crossvein between the base of Sc and apical margin; R simple and strong; Rs with 13 terminal branches, arising from R (ORs) and forking (FRs) early, at about 1/4th and 1/3th of wing length, respectively; the location of FM at about 1/3th of wing length (Fig. 4); with a strong crossvein between the base of M and CuA_{1+2} (Ren and Shih, 2005).

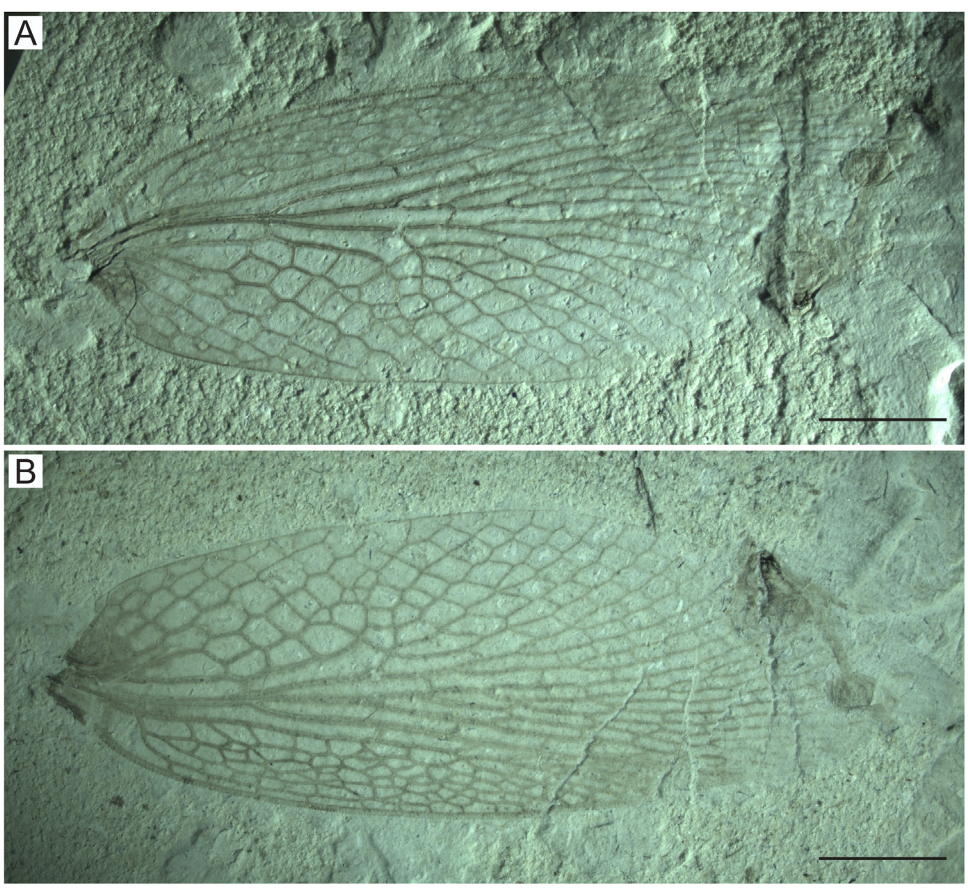

Fig. 2. Wing of *Tsuchingothauma gongi* sp. nov., holotype NIGP169519. A, part; B, counterpart. Scale bars represent 5 mm.'.

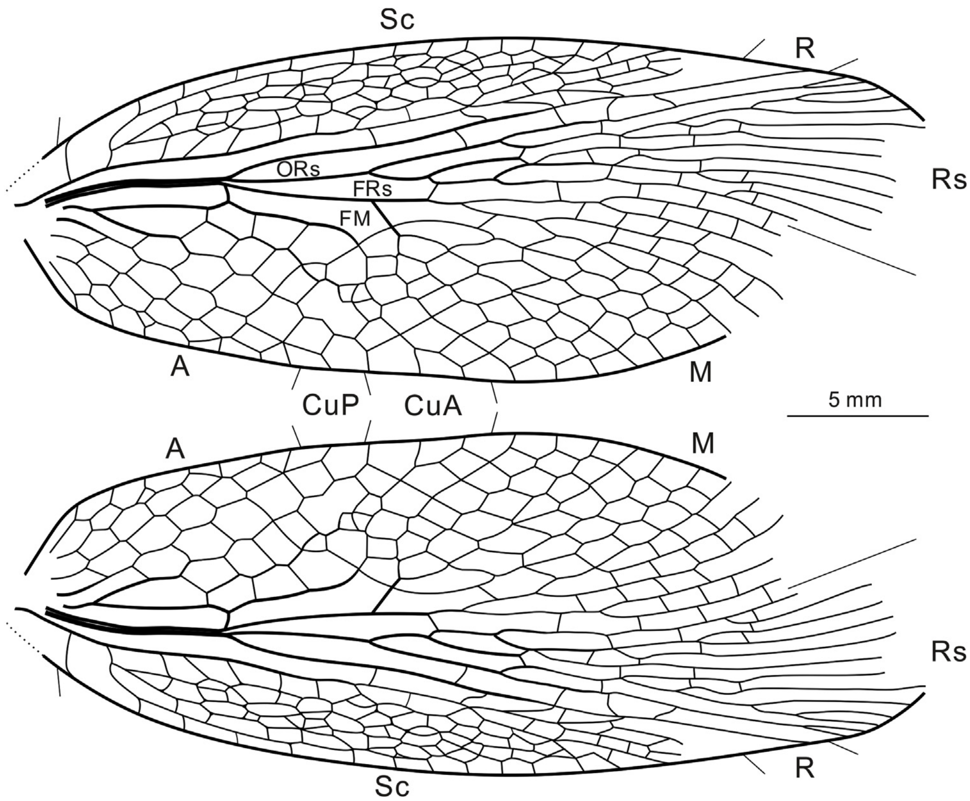

Fig. 3. Line drawings of wing venation of *Tsuchingothauma gongi* sp. nov., holotype NIGP169519. Above, part; below, counterpart.

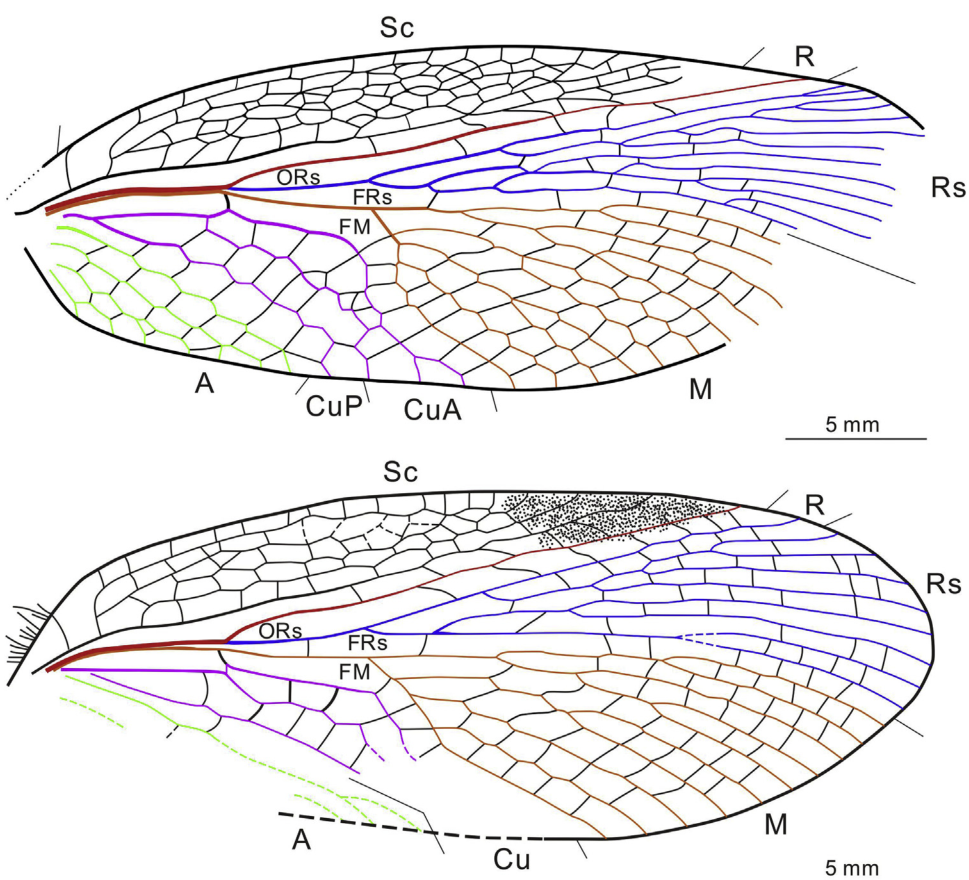

Fig. 4. Line drawings of wing venation of *Tsuchingothauma gongi* (above) and *T. shihi* (below). Partition of wing venation of *T. shihi* in Ren and Shih (2005) is modified.

Tsuchingothauma gongi can be distinguished from *T. shihi* mainly by the presence of smoother base of wing and more crossveins and cells, more longitudinal veins in radial sector and medial field (13 and 11 in *T. gongi,* 9 and 10 in *T. shihi*) and CuA with 3 terminal branches and A with 7 terminal branches (Fig. 4). In addition, some details of our new species are different from *T. shihi*, such as Rs_8 forking earliest, a little beyond the middle of wing; Rs_1 and Rs_2 forking latest, at about 8/9^{ths} of wing length; M_{1+2} about twice as long as M_{3+4+5}.

Three species of fossil eomeropids have been reported from the Early Jurassic and Middle Jurassic (Table 1). The vein density of *Tsuchingothauma gongi* is the highest in all fossil records and second only to the current species *Notiothauma reedi*. Soszyńska-Maj et al. (2016) mentioned that the increase in vein density of *Tsuchingothauma shihi* and *Notiothauma reedi* is an adaptation to reduce abrasive damage from leaf litter or tree bark (Archibald et al., 2005), but they also suggested that the reduction in vein density of other Jurassic genera (*Jurachorista*,*Jurathauma*) means a more exposed lifestyle and better flight capabilities. Our fossil provides evidence for the diversity of vein density in Jurassic eomeropids, which makes it more remarkable but puzzling. We find it difficult to resolve the venational evolution of eomeropids based on the available data, and for the time being, prefer to wait for more material of fossil eomeropids.

5. Concluding remarks

A new species of Eomeropidae, *Tsuchingothauma gongi* sp. nov., is described from the Middle Jurassic Daohugou beds of China. It represents not only the fourth fossil species of Jurassic eomeropids, but also the sixth species of Mesozoic eomeropids. It is distinctly different from the type species of *Tsuchingothauma* mainly in having more longitudinal veins. Our find augments the diversity of Jurassic eomeropids and enhances our understanding of the diversification of Mesozoic eomeropids.

Declaration of Competing Interest

Here, we declare no competing interests.

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References

Archibald, S.B., Rasnitsyn, A.P., 2018. Two new species of fossil *Eomerope* (Mecoptera: Eomeropidae) from the Ypresian Okanagan Highlands, far-western North America, and Eocene Holarctic dispersal of the genus. The Canadian Entomologist 150, 393–403.
Archibald, S.B., Rasnitsyn, A.P., Akhmetiev, M.A., 2005. Ecology and distribution of Cenozoic Eomeropidae (Mecoptera), and a new species of *Eomerope* Cockerell from the Early Eocene McAbee locality, British Columbia, Canada. Annals of the Entomological Society of America 98, 503–514.
Bicha, W., 2010. A review of the scorpionflies (Mecoptera) of Indochina with the description of a new species of *Neopanorpa* from Northern Thailand. Zootaxa 2480, 61–67.
Cai, L.J., Huang, P.Y., Hua, B.Z., 2008. *Sinopanorpa*, a new genus of Panorpidae (Mecoptera) from the Oriental China with descriptions of two new species. Zootaxa 1941, 43–54.
Chen, W., Ji, Q., Liu, D.Y., Zhang, Y., Song, B., Liu, X.Y., 2004. Isotope geochronology of the fossil-bearing beds in the Daohugou area, Ningcheng, Inner Mongolia. Geological Bulletin of China 23, 1165–1169 (In Chinese with English abstract).
Cockerell, T.D.A., 1909. Description of Tertiary insects, VI. American Journal of Science 27, 381–387.
Gao, K.Q., Ren, D., 2006. Radiometric dating of ignimbrite from Inner Mongolia provides no indication of a post-Middle Jurassic age for the Daohugou beds. Acta Geologica Sinica 80, 42–45.
Grimaldi, D., Engel, M.S., 2005. Evolution of the insects. Cambridge University Press, New York 755 pp..
He, H.Y., Wang, X.L., Zhou, Z.H., Zhu, R.X., Jin, F., Wang, F., Ding, X., Boven, A., 2004. 40Ar/39Ar dating of ignimbrite from Inner Mongolia, northeastern China, indicates a post-Middle Jurassic age for the overlying Daohugou Bed. Geophysical Research Letters 31, L20609.
Krzemiński, W., Soszyńska-Maj, A., Kopeć, K., 2016. The significance of fossil material in understanding the homology of Mecoptera wing venation. Fossil x 3 Edinburgh 2016, abstracts.
Liu, Y.Q., Liu, Y.X., Ji, S.A., Yang, Z.Q., 2006. U-Pb zircon age for the Daohugou Biota at Ningcheng of Inner Mongolia and comments on related issues. Chinese Science Bulletin 51, 2634–2644.
MacLachlan, R., 1877. On *Notiothauma reedi*, a remarkable new genus and species of Neuroptera from Chile, pertaining to the family Panorpidae. Transactions of the Entomological Society of London 877, 427–430.
Mitchell, A.A., 2015. EDNA, The Fossil Insect Database. updated at. http://www.http.com//edna.palasshosting.org (Accessed 9 September 2015). .
Novokshonov, V.G., 2002. Order Panorpida Latreille. In: Rasnitsyn, A.P., Quicke, D.L.J. (Eds.), History of insects, 1802. Kluwer Academic, Dordrecht, pp. 194–199.
Pena, L.E., 1968. Natural history notes on *Notiothauma*. Discovery 4, 43–44.
Ponomarenko, A.G., Rasnitsyn, A.P., 1974. New Mesozoic and Cenozoic Protomecoptera. Paleontological Journal 8, 493–507.
Remington, C.L., 1968. A rare and primitive winged insect from Chile. Discovery 4, 37–41.
Rees, P.M., Ziegler, A.M., Valdes, P.J., 2000. Jurassic phytogeography and climates: new data and model comparison. In: Huber, B.T., Macleod, K.G., Wing, S.L. (Eds.), Warm climates in Earth history. Cambridge University Press, Cambridge, U.K, pp. 297–318.
Ren, D., Shih, C.K., 2005. The first discovery of fossil eomeropids from China (Insecta, Mecoptera). Acta Zootaxonomica Sinica 30, 275–280.
Soszyńska-Maj, A., Krzemiński, W., Kopeć, K., Coram, R.A., 2016. Phylogenetic relationships within the relict family Eomeropidae (Insecta, Mecoptera) based on the oldest fossil from the Early Jurassic (Sinemurian) of Dorset, southern England. Journal of Systematic Palaeontology 14, 1025–1031.
Wang, B., Zhang, H.C., Jarzembowski, E.A., Fang, Y., Zheng, D.R., 2013. Taphonomic variability of fossil insects: a biostratinomic study of Palaeontinidae and Tettigarctidae (Insecta: Hemiptera) from the Jurassic Daohugou Lagerstätte. Palaios 28, 233–242.
Willmann, R., 1989. Evolution und phylogenetisches System der Mecoptera. Abhandlungen der Senckenbergischen Naturfor-schenden Gesellschaft 544, 1–153.
Zhang, J.X., Shih, C.K., Petrulevičius, J.F., Ren, D., 2011. A new fossil eomeropid (Insecta, Mecoptera) from the Jiulongshan Formation, Inner Mongolia, China. Zoosystema 33, 443–450.
Zhang, J.X., Shih, C.K., Ren, D., 2012. A new fossil eomeropid (Insecta, Mecoptera) from the Yixian Formation, Liaoning, China. Acta Zootaxonomica Sinica 37, 68–71.