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# A new Early Jurassic insect outcrop in Xinjiang, northwestern China and its stratigraphic significance

DIYING HUANG[1*], YITONG SU[1, 2], YANZHE FU[1, 3], JIAN GAO[1], YUMING LIU[1, 3] & CHENYANG CAI[1, 4]

[1]*State Key Laboratory of Palaeobiology and Stratigraphy, Center for Excellence in Life and Paleoenvironment, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, Nanjing 210008, China.*
[2]*University of Chinese Academy of Science, Beijing 100049, China.*
[3]*University of Science and Technology of China, Hefei 230026, PR China.*
[4]*School of Earth Sciences, University of Bristol, Life Sciences Building, Tyndall Avenue, Bristol BS8 1TQ, UK.*
[*]*Corresponding author. E-mail: dyhuang@nigpas.ac.cn*

Mesozoic insect fossils are abundant in Xinjiang, northwestern China, mainly from the Triassic and Jurassic strata. The first Xinjiang insect fossils found were from the Meiyaogou section, north of Turpan City (Ping, 1935). Ping (1935) did not provide a detailed introduction to the specific stratum due to a limited stratigraphic survey of this area at that time, but it was considered to belong to the Upper Jurassic. The Upper Jurassic strata in the Meiyaogou section were represented mainly by the Sanjianfang Formation, which is characterized by gray-yellow-green sandstone-siltstones with purple-red sandstone strips. However, whether these fossils reported by Ping (1935) were from the Sanjianfang Formation is still uncertain. These insect fossils are known from just two orders: Dermaptera and Plecoptera. The mayfly species *Ephemeropsis tingi* (Demoulin, 1954; Edmunds, 1972; Kluge, 2004) was thought to be significantly different from *Ephemeropsis trisetalis* from the Jehol biota. Another species, *Sinoephemera kingi*, is more similar to a stonefly nymph. *Mesonetopsis zeni*, a taxon thought to be relate to the common component of the Late Jurassic in Central Asia (*Mesoneta*), is in fact an odonatan nymph (Demoulin, 1954).

Hong (1995) studied several insect fossils in the Sanjianfang Formation near the Taizi Village, Qiketai Township, Shanshan County of Tuha Basin, including two species of *Mesobaetis* and another beetle larva. The Sanjianfang Formation is correlated to the lower part of the Toutunhe Formation (Deng *et al*., 2003). In a regional context, it can be correlated to the Tiaojishan Formation in the Yanliao area of China, which is equivalent to the early Late Jurassic (Fang *et al*., 2015; Huang, 2019). Hong (1983) established the Yanliao biota, and Huang (2015, 2016) regarded that the Tiaojishan Formation and its corresponding layers are equivalent to the late assemblage of the Yanliao biota, which can be compared with the Karatau biota of Kazakhstan and the Shar-Teg biota of Mongolia. At present, research on the fossil insects from the Tiaojishan Formation is still in its infancy (Cai & Huang, 2016; Huang *et al*., 2018, 2019). Comparatively fewer fossil insects have been discovered from the relevant strata in China, so our study of insect fossils from the Sanjianfang Formation in Xinjiang is of great significance for understanding the distribution, spread, and evolution of the Yanliao biota.

Fossil insects from the Late Triassic of Xinjiang are abundant, including Plecoptera, Blattodea, Hemiptera, Coleoptera, and Mecoptera (*e.g*., Lin, 1992; Zhang, 1996a; Zhang *et al*., 2003; Zheng *et al*., 2018a). Jurassic insects in Xinjiang are mainly reported from in the Badaowan Formation (Zhang, 1996a, b, 1997a, b; Zhang *et al*., 2003; Deng *et al*., 2010; Yan & Zhang, 2010; Zheng *et al*., 2016, 2018b, 2019), including Odonata, Orthoptera, Hemiptera, Coleoptera, and Mecoptera. In addition to the above-mentioned ones, fossil insects in Xinjiang were also found in the Sangonghe, Xishanyao, and Kyzylurur (Tashdian Formation) formations (Hong, 1983; Zhang, 1997b, 2010; Zhang *et al*., 2003; Wang *et al*., 2019). The discovery and studies of these fossils are significant for understanding the origin and evolution of the Mesozoic entomofaunas in China.

## Material and methods

Approximately ten beetle elytra were collected from the topmost coal bed of the Badaowan Formation at the Ewirgol Coalmine area, Toksun County, Turpan City, Xinjiang, northwestern China. Fossils were preserved in black shale interbeds of the coal bed.

Fossils were prepared using a sharp knife. Observations were made using an Olympus SZX7

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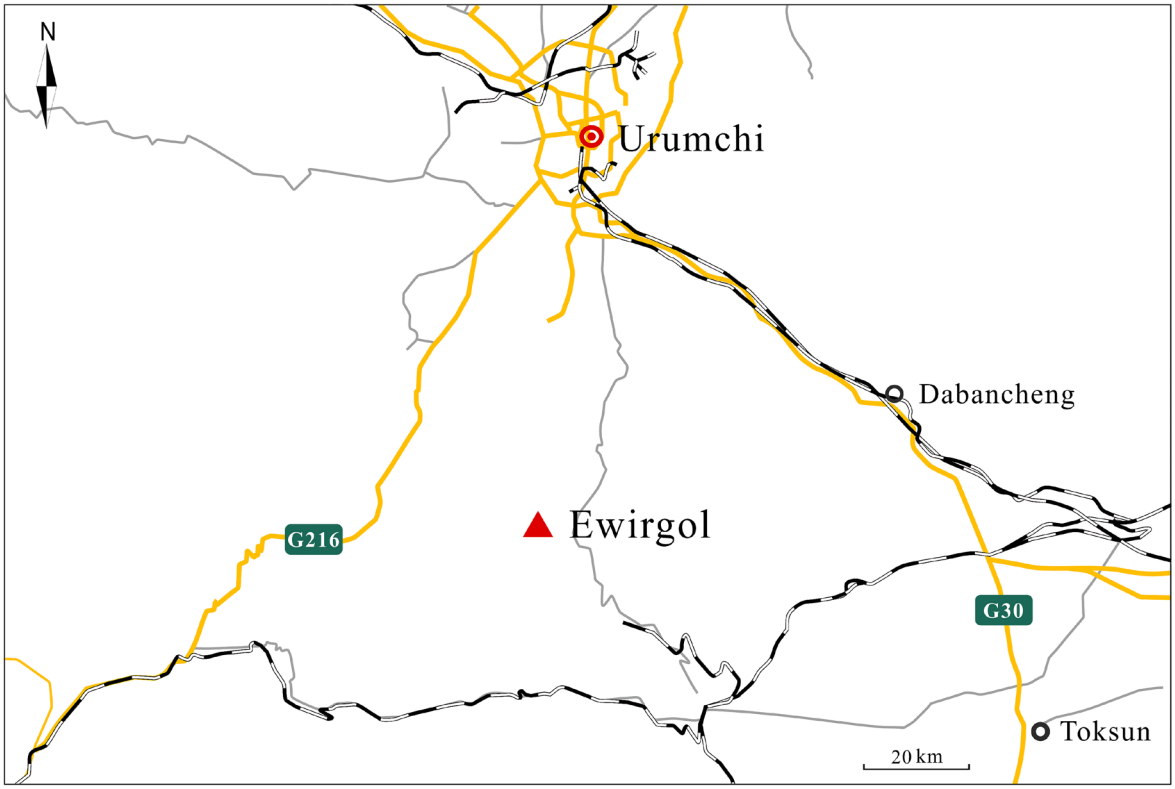


**FIGURE 1.** The map of fossil locality.

microscope. Photographs were taken using a digital camera attached to a Zeiss Discovery® V16 microscope; stacked using Helicon Focus® 6 software. Maps and line drawing were drafted with CorelDRAW® X7 graphic software. The material studied here is deposited in the Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, Nanjing, China.

## Geological setting

The Late Paleozoic (from the Late Carboniferous) to Mesozoic strata were continuously deposited and well exposed in the Ewirgol area of Toksun County, Xinjiang (Fig. 1). In particular, the Jurassic strata have clear outcrops and obvious boundaries. It is the representative area of biostratigraphy during this period, but relevant stratigraphic work is rarely reported. Recently, we conducted a short-term investigation of the Jurassic strata in the Ewirgol Coalmine. The insect fragments were found from the topmost coal bed of the Badaowan Formation, which is very close to the boundary of the Badaowan and Sangonghe formations. The boundaries between these two formations are obvious, and a set of complex conglomerate is developed at the bottom of the Sangonghe Formation. Therefore, the information about the insect fossils layers is accurate and these fossils bear some potential significance for reconstructing the palaeoenvironment and palaeoclimate.

The Jurassic strata in the Ewirgol Coalmine are represented by the Badaowan, Sangonghe, Xishanyao and Sanjianfang formations from bottom to top, respectively. The Xishanyao Formation is the major reservoir level for coal mines. The Badaowan Formation in this area is mainly gray-yellow sandstone and fine conglomerate, representing a set of river facies deposits; and a coal seam of about 10 meters thick is developed at the top. A small amount of carbonaceous shale and carbonaceous siltstone are contained in the coal seam containing numerous plant debris and a few insect fragments. The Sangonghe Formation is a set of sandstone-based sediments with uniform conglomerate and plant debris layers, the lower part is silty shale (*ca*. 8 m thick), and the bottom is a set of stable complex conglomerate, which are river-lake sediments. The thickness of the conglomerate is about 10–30 cm. The gravel components are mostly quartzite, limestone and metamorphic rocks. The gravel diameter is mainly 2–15 cm, relatively flattened. The sorting is very poor, the roundness is general. The bottom of this conglomerate represents a disconformity (Fig. 2).

The Badaowan and Sangonghe formations are well


**FIGURE 2.** The geological setting of the Early Jurassic fossil outcrop at Ewirgol, Toksun, Xinjiang. **A**, The boundary between the Badaowan Formation (coal bed) and the Sangonghe Formation (silty shale). **B**, The bottom conglomerate of the Sangonghe Formation. **C**, Close up view of the complex conglomerate. **D**, Fossil insect excavation within the coal bed. **E**, Topmost coal bed of the Badaowan Formation. **F**, A big cliff that forms the coal bed.

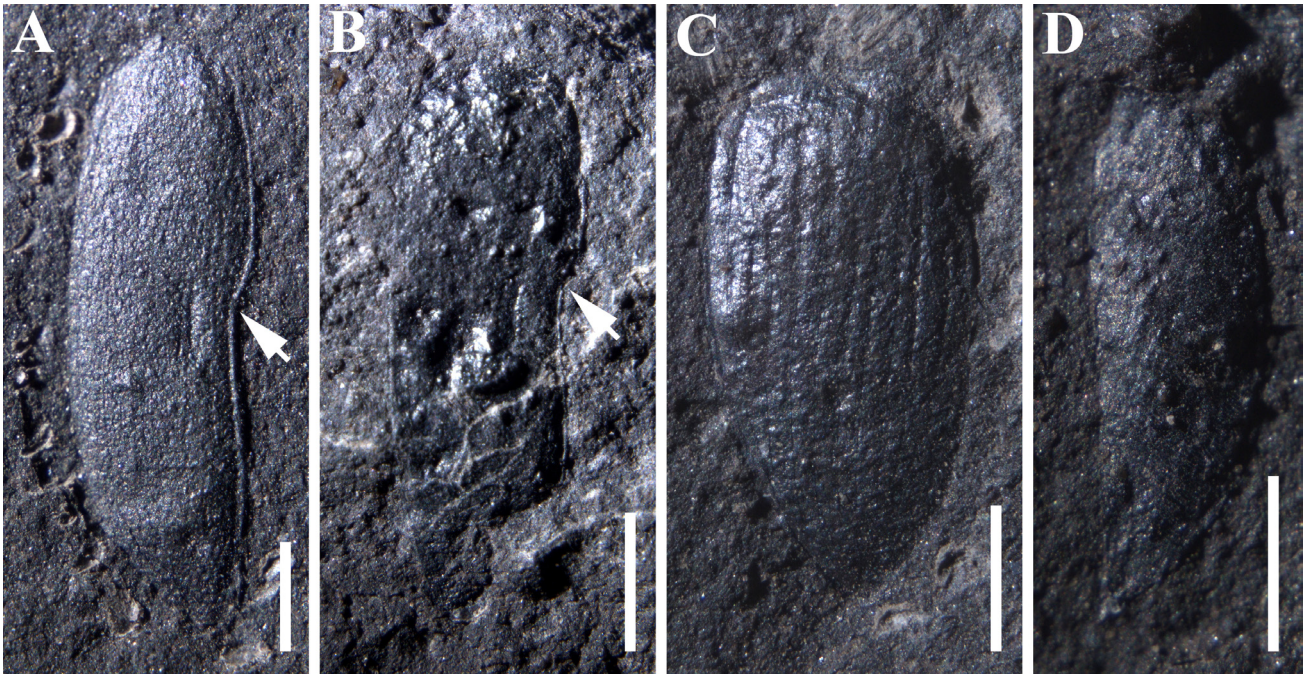


**FIGURE 3.** Beetle elytra from the Lower Jurassic Badaowan Formation at Ewirgol, Toksun, Xinjiang. **A**, An elytron (NIGP171319) of Schizophoridae. **B**, Another schizophorid elytron (NIGP171320). **C**, An unidentified elytron (NIGP171321) of Polyphaga. **D**, An unidentified elytron (NIGP171322). **A** and **B**, white arrow indicating a typical feature of schizophorid elytron, a hollow in outer edge. Scale bars = 1 mm in **A**, **C**, **D**, and 2 mm in **B**.

developed in the Junggar and Tuha basins in Xinjiang. In the southern margin of the Junggar basin (*e.g.*, Haojiagou section), they are mostly conformable contacts. The boundary is not very clear with a set of medium-thick sandstones at the bottom of the Sangonghe Formation. Therefore, different authors have different opinions as to subdivisions. A thick layer of conglomerate is formed at the bottom of the Sangonghe Formation in the Xidagou section of the Jimsar County in the northeastern margin of the Junggar basin, which is in unconformity contact with the underlying Badaowan Formation. A set of variegated conglomerate was also developed at the bottom of the Sangonghe Formation in the Tuziakeneigou section of Karamay (Deng *et al*., 2010). The boundary between the Badaowan and Sangonghe formations in the Ewirgol area is not completely similar, indicating a significant sedimentary discontinuity in the late sedimentation of the Badaowan Formation. These unconformable or disconformable planes generally develop on the edge of a large basin or within a small basin, and the Early Jurassic sedimentation in the Ewirgol area may belong to the latter.

## Results

The black shale interbeds of the topmost coal bed in the Badaowan Formation have yielded very rich plant fragments and a few fossil insect fragments. Approximately ten beetle elytra have been examined, mainly belonging to the suborders Polyphaga and Archostemata (Fig. 3). They are three-dimensionally preserved and always isolated and complete. These fossils represent a diverse beetle assemblage by general appearances of these specimens. Among them, two schizophorid elytra are of particular interest. Schizophoridae presently contains 25 genera nearly 50 species (Jarzembowski *et al*., 2012; Tan *et al*., 2013). The fossil record of the family ranges from the Permian to the Early Cretaceous (Tan *et al*., 2013; Yu *et al*., 2019). Isolated schizophorid elytra are commonly found from the Early Triassic to the Late Jurassic. The present two schizophorid elytra clearly belong to two species, indicating a rise of their palaeodiversity in the Early Jurassic.

Fossil insects from the Late Yongfeng Stage (corresponding to the Badaowan Formation; *i.e*., Pliensbachian, see Huang, 2019) from the studied area seem to be diverse, although only some isolated elytra have been found to date. The palaeoenvironment of this area is supposed to represent forest and marsh. This new finding provides an additional opportunity to study the Early Jurassic insects from China, since the deposits of an early-middle Early Jurassic age were not developed in eastern China.

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