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# An insect wing discovered in the Early Permian Taiyuan Formation (Shanxi Province, China)

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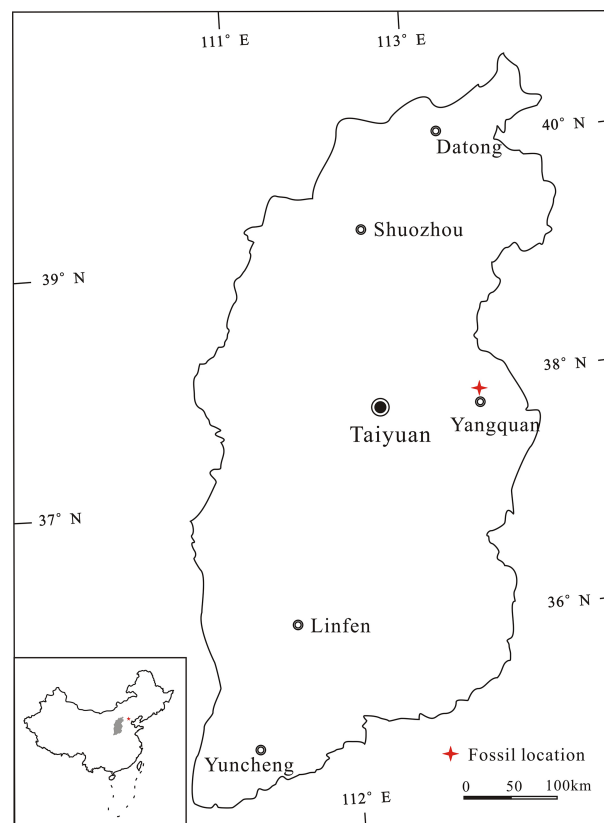
**Abstract.** The first discovery of an insect wing from the Taiyuan Formation, near Yangquan City, Shanxi Province, China, is described. The combination of its wing venation characters makes it difficult to assign it to any known major Paleozoic group. The comparison is made among the new material, stem-Orthoptera species, and “fossil Grylloblattodea”. Further investigation on fossil insects from this locality is needed.

## 1 Introduction

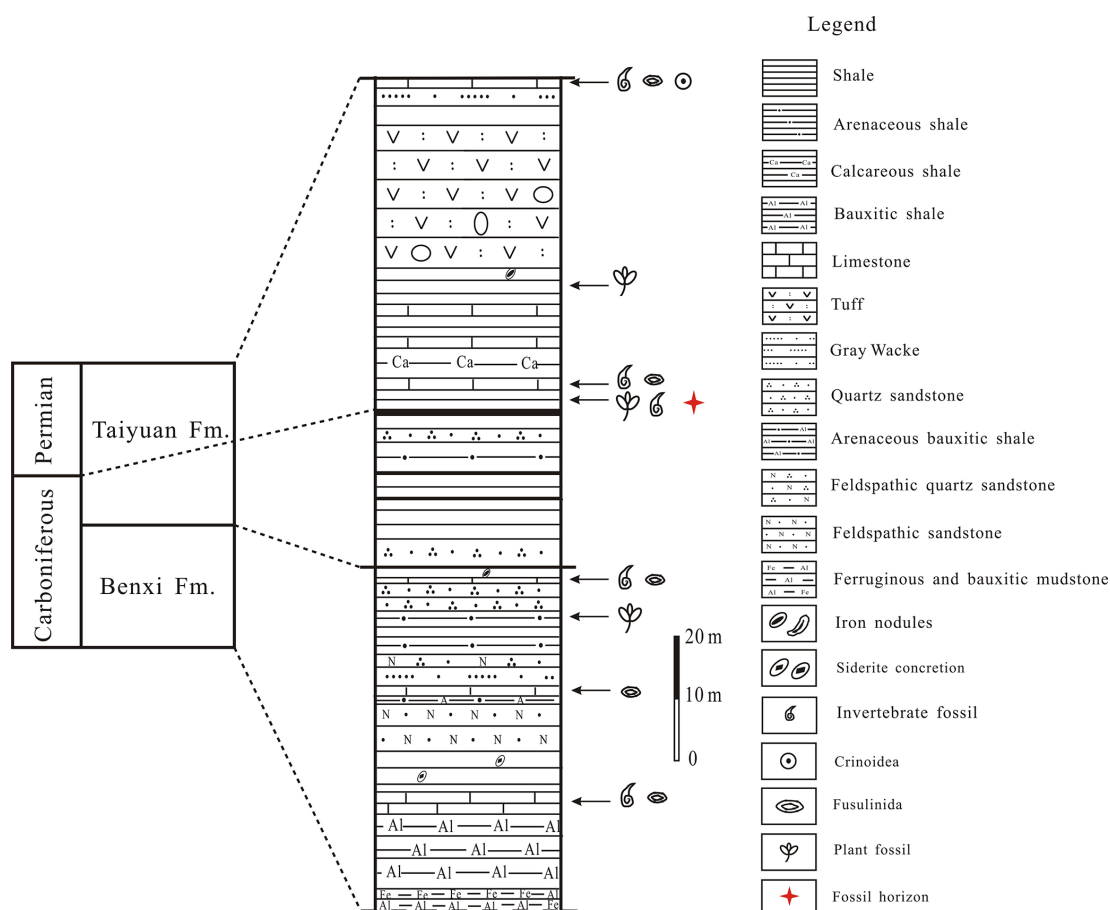
The Taiyuan Formation (near Yangquan City, Shanxi Province, China) is composed of a group of deposits of continental–oceanic interaction facies, consisting of sandstone, dark grey shale (mudstone), limestone and coal, and is considered to be the Late Pennsylvanian to Early Permian age for the whole Taiyuan Formation (Wu, 1995; Wang, 2010). The remains of a fossil insect wing were recovered recently in the middle part of the Taiyuan Formation. According to the study of the fossil plants, brachiopods, gastropods, corals, crinoids, fusulinids and ostracods (Ge et al., 1985; Gao, 1988; Fan et al., 1999; Wan et al., 2017; Zhang, 2017), the fossil horizon is of Asselian age (Early Permian). Herein we provide a description of the insect remains.

## 2 Material and methods

The specimen (SXMG IV 0479 and SXMG IV 0480, part and counter-part, respectively) is housed at the Shanxi Mu-



**Figure 1.** Locality of the insect fossil near Yangquan City, Shanxi Province, China.



**Figure 2.** The stratigraphic column of the Taiyuan Formation, near Yangquan City, Shanxi Province, China. The arrow indicates the fossil horizon.

seum of Geology. It was examined using a Leica M165C microscope, and a handmade draft drawing was prepared with the aid of a drawing tube, under dry conditions (the specimen might be damaged by ethanol immersion). A photograph was taken using a Canon EOS 70D digital camera (Cannon, Tokyo, Japan) coupled to a Canon MP-E 65 mm macro lens and was optimized using Adobe Photoshop CC. The final drawing was performed using Adobe Illustrator CC (Adobe systems, San Jose, CA, USA), with the help of both the handmade draft drawing and optimized photograph.

In the context of the serial insect wing pattern (Lameere, 1922, 1923), we resort to homologies proposed by Béthoux and Nel (2002) for Orthoptera and their stem-relatives, as follows: ScP, posterior subcosta; RA, anterior radius; RP, posterior radius; MA, anterior media; MP, posterior media; CuA, anterior cubitus; CuP, posterior cubitus; CuPa, anterior branch of CuP. Note that we discuss an alternative interpretation of the wing venation of the specimen that does not imply that it is a stem-Orthoptera. The adopted terminology applies.

### 3 Systematic descriptions

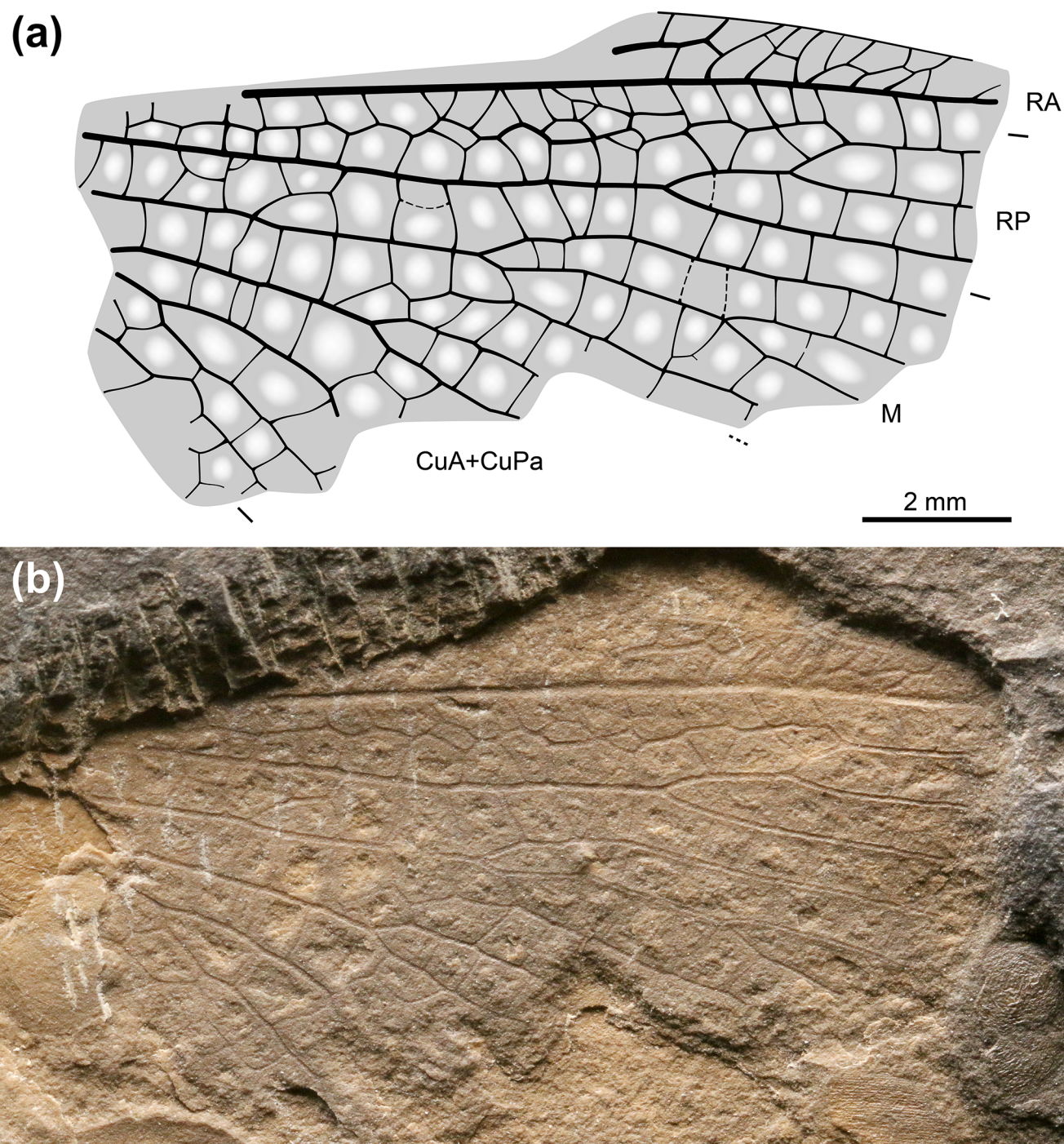
Class **Insecta** Linnaeus, 1758

Infraclass **Neoptera** Martynov, 1923

Order incertae sedis

Specimen SXMG IV 0479 and SXMG IV 0480: positive and negative imprints of a right wing (presumably forewing), basal part, posterior and distal parts missing; preserved part 12.9 mm long, 6.6 mm wide; anterior wing margin partly visible; only the very distal part of ScP visible, reaching anterior wing margin; RA very strong, emitting few anterior veinlets; RP forked shortly before the end of ScP, posteriorly pectinate, with three branches (anterior-most branch arising obliquely); area between RA and RP broad, with the broadest part 1.3 mm wide; 2–3 rows of cells in the area between RA and RP basal to second fork of RP (then, single row of cells); *M* neither clearly concave nor desclerotized, forked earlier than RP, with 3 (4?) preserved branches; CuA + CuPa with five strongly preserved branches; except for the RA–RP area, inter-venal areas with a single row of cells (occasionally with





**Figure 3.** Putative stem-Orthoptera from the Taiyuan Formation (SXMG IV 0480): (a) interpretative drawing (see text for alternative interpretation) and (b) photograph (flipped horizontally).

reticulations); center of individual cells split unevenly, indicating lack of pigmentation (and, conversely, the presence of pigmentation in the remaining areas).

#### 4 Discussion

Because of its incompleteness and its unusual combination of character states, the new specimen remains difficult to assign to any of the major groups of Paleozoic insects. The very long RP is an unusual feature which can be found in some stem-

Orthoptera but also in the so-called “fossil Grylloblattodea”. Among the former, *Cacurgus spilopterus* Handlirsch (1911) (see revision by Béthoux, 2006) also possess a very long stem of M, which one can recognize in the specimen. The remaining, more posteriorly located branches would then belong to CuA + CuPa. This proposal, however, is challenged by the respective ages of *C. spilopterus* (Pennsylvanian) and of the locality (early Permian).

It remains possible to interpret all visible branches posterior to RP as belonging to MA and MP, in which case M is forked more basally than under the previous interpretation. We are not aware of a stem-Orthoptera displaying such a long RP stem in conjunction with a basal MA/MP fork. This combination is known in several “fossil Grylloblattodea”, such as representatives of the family Ideliidae (Storozhenko, 1998; Aristov, 2002), known from various Permian localities. However, “Grylloblattodea” commonly possess a clearly concave and desclerotized MP, traits which none of the preserved veins display. Moreover, CuA is usually abundantly branched in this group, and it is not evident whether the wing could accommodate this system.

Hopefully this discovery will prompt further investigation in the corresponding locality, which might provide useful data on the actual affinities of the current specimen.

**Data availability.** The new material included in the paper is accessible and deposited in the Shanxi Museum of Geology, Taiyuan, China, and all data are included in the description.

**Author contributions.** JW and DR collected the material and contributed to the geological section; OB and YC prepared the paper and contributed to the editing.

**Competing interests.** The authors declare that they have no conflict of interest.

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