

NEW CUPEDIDS FROM THE MIDDLE JURASSIC OF INNER MONGOLIA, CHINA (COLEOPTERA: ARCHOSTEMATA)

JINGJING TAN, DONG REN* and CHUNGKUN SHIH

College of Life Science, Capital Normal University, 105 Xisanhuanbeilu, Haidian District, Beijing 100037, China

*Corresponding author; e-mail: rendong@mail.cnu.edu.cn.

Abstract.— One new genus including two new species of fossil cupedids assigned to family Cupedidae, *Gracilicupes crassicruralis* gen. and sp. nov. and *Gracilicupes tenuicruralis* gen. and sp. nov., is described from the Middle Jurassic Jiulongshan Formation of eastern Inner Mongolia, China.



Key words.— Cupedidae, new genus, new species, Jurassic, Jiulongshan Formation, China.

INTRODUCTION

The Archostemata was erected by Kolbe (1908) and elevated to a suborder by Forbes (1926). It currently contains 4 extant families: Cupedidae, Ommatidae, Micromalthidae and Crowsoniellidae (Lawrence and Newton 1995) and 11 extinct families (Carpenter 1992). The family Cupedidae described here is without inclusion of Ommatinae. And it comprises one of the earliest known fossil beetles and some of the most primitive living beetles (Lawrence 1999). Nowadays this group is small, including only 9 genera within 27 species (Neboiss 1984, Ge and Yang 2004). However, it was abundant in the Permian and the Mesozoic (Ponomarenko 2002, Lubkin 2003). So the study of Mesozoic cupedids is significant in order to understand their relationships.

Up to now, a large fossil Archostemata assemblage has been found in the Mesozoic non-marine sedimentary strata from northern China and 17 extinct genera and 27 extinct species of Cupedidae have been erected (Tan et al. 2004, 2005). Although many fossil insects (Hong 1983, 1985, 1988, 1990, Lin 1976, Ren et al. 1995) have been found in this region, record of fossil beetles from family Cupedidae from the Middle Jurassic of China is scarce. Thus these new fossil specimens, which were collected by us from a small section of the Jiulongshan Formation in Daohugou village, Shantou township, Ningcheng County, Inner Mongolia, China and described here, are important supplement to cupedids record and constitute a new evidence for studying the cupedids' evolution and palaeobiogeography.

Characteristics of the locality

The Jiulongshan Formation is a lacustrine sequence that crops out in northeast part of China (Ren et al. 1995, Tan and Ren 2002). The section at Daohugou village is composed of grey tuffaceous sandstone and sandy mudstone. The paleoenvironment reconstructed for this locality is a volcanic region with mountain streams and lakes (Ren et al. 2002). General reviews of the Middle Jurassic Yanliao insect fauna of North China were given by Hong (1983) and Ren et al. (1995, 1996). It contains a diverse insect fauna composed of complete specimens of Ephemeroptera, Odonata, Plecoptera, Blattodea, Orthoptera, Heteroptera, Homoptera, Neuroptera, Coleoptera, Hymenoptera and Diptera described by Hong (1983), Ren et al. (1995), Ren and Krzemiński (2002), some freshwater conchostracans (Zhang and Shen 1987), salamanders (Gao and Shubin 2003), and some dinosaurs (Ji and Yuan 2002). Surrounding Gymnosperm forests were dominated by Ginkgopsida (*Ginkgoites*, *Ginkgo Baiera*, *Czekanowskia*, *Phoenicopsis*), Coniferopsida (*Pityophyllum*, *Rhipidiocladus*, *Elatocladus*, *Schizolepis*, *Podozamites*), Lycoposidas (*Lycopodites*, *Selaginellites*), Sphenopsida (*Equisetum*), Filicopsida (*Todites*, *Coniopteris*) and Cycadopsida (*Anomozamites*) (Mi et al. 1996). All these paleontological data were interpreted as indicating humid and warm-temperate climate (Tan and Ren 2002). The accurate Ar-Ar and SHRIMP U-Pb dating shows that the age of intermediate-acid volcanic rocks overlying the Daohugou fossil-bearing beds is about 164–165 Ma, and that the age of this fossil-bearing beds is older than or equal to 165 Ma (Chen et al. 2004). Therefore

the age of Daohugou biota is Middle Jurassic (about Bathonian or little older) (Zhang and Shen 1987, Ren et al. 1995, Wang 2000, Ren et al. 2002, Shen et al. 2003).

MATERIAL AND METHODS

The specimens were examined with LEICA MZ12.5 dissecting microscope and illustrated with the aid of a drawing tube attached to microscope. Morphological terminology and the system used here mainly follow Ponomarenko (1969, 1997, 2000).

This study is based on two specimens housed in the Key Lab of Insect Evolution and Environmental Changes, the College of Life Science, Capital Normal University, Beijing, China (CNU; Dong Ren, Curator).

The body length was measured from the apex of the mandible to the apex of the abdomen. The body width was measured at base of the elytra. The length of elytra was measured from the base of the elytra to the apex of the elytra.

TAXONOMY

Order **Coleoptera** Linnaeus, 1758

Family **Cupedidae** Lacordaire, 1857

Tribe **Mesocupedini** Ponomarenko, 1969

Gracilicupes gen. nov.

Type species. *Gracilicupes crassicruralis* gen. and sp. nov.

Diagnosis. Head sub-rhombic, broadest at eyes, bearing two pairs of inconspicuous tubercles, without antennal groove ventrally; eyes large; antennae longer than half as long as entire insect, third segment shorter than the first and second one combined in length; pronotum nearly quadrate, as wide as head, angles rounded, with two large elevations.

Etymology. The generic name is a combination of the Latin prefix *gracil-* (meaning "thin") and *Cupes* (type genus of the family). Gender: masculine.

Discussion. *Gracilicupes* can be assigned to the family Cupedidae on the basis of the following characters: (1) separation of its two procoxal cavities; (2) abdominal ventrites overlapping; (3) elytra having several elevated longitudinal ridges and interspaces having rows of large punctures (Aktins 1963, Lawrence 1999).

Following the systematic arrangement of Ponomarenko (1969), the Cupedidae consists of three tribes: Mesocupedini, Priacmini and Cupedini. The new genus is somewhat similar to the tribe Priacmini, such as body slightly subcylindrical and small cells of elytra, but may be excluded from this tribe by head of the new one without distinct dorsal prominences and antennae

longer than half as long as entire insect. Though the new fossil cupedids also resembles the tribe Cupedini, they can be separated from Cupedini by prosternal process not extending behind coxae. So we place the new fossil cupedids in the tribe Mesocupedini by the following characters; (1) head with slightly dorsal prominences; (2) prosternal process not extending to the posterior margin of coxae; (3) quite flat abdominal ventrites; (4) elytral cell slightly quadrate.

At present, Mesocupedini includes three extinct genera: *Mesocupoides* Ponomarenko, 1969 (from the Late Triassic of Kirghiz), *Mesocupes* Martynov, 1926 (from the Late Jurassic of Kazakhstan), and *Anaglyphites* Ponomarenko, 1964 (from the Late Jurassic of Kazakhstan and the Cretaceous of Asia) (Carpenter 1992).

The new genus differs from genus *Mesocupoides* Ponomarenko, 1969 (Ponomarenko 1969) by the head of new genus broadest at eyes and antennal grooves absent on underside of head.

Gracilicupes gen. nov. is closely related to *Mesocupes* Martynov (Martynov 1926, Ponomarenko 1964, 1969), but differs from *Mesocupes* in the head of new genus bearing two pairs of tubercles.

Anaglyphites Ponomarenko, 1964 (Ponomarenko 1964, 1969) may be compared with our fossil cupedids, but it is distinct from the new genus for the third segment of the antennae as long as the first and second segment combined in length.

The key to the genera of Mesocupedini (Ponomarenko 1969) should be supplemented as follows to contain new genus.

Key to genera of Mesocupedini

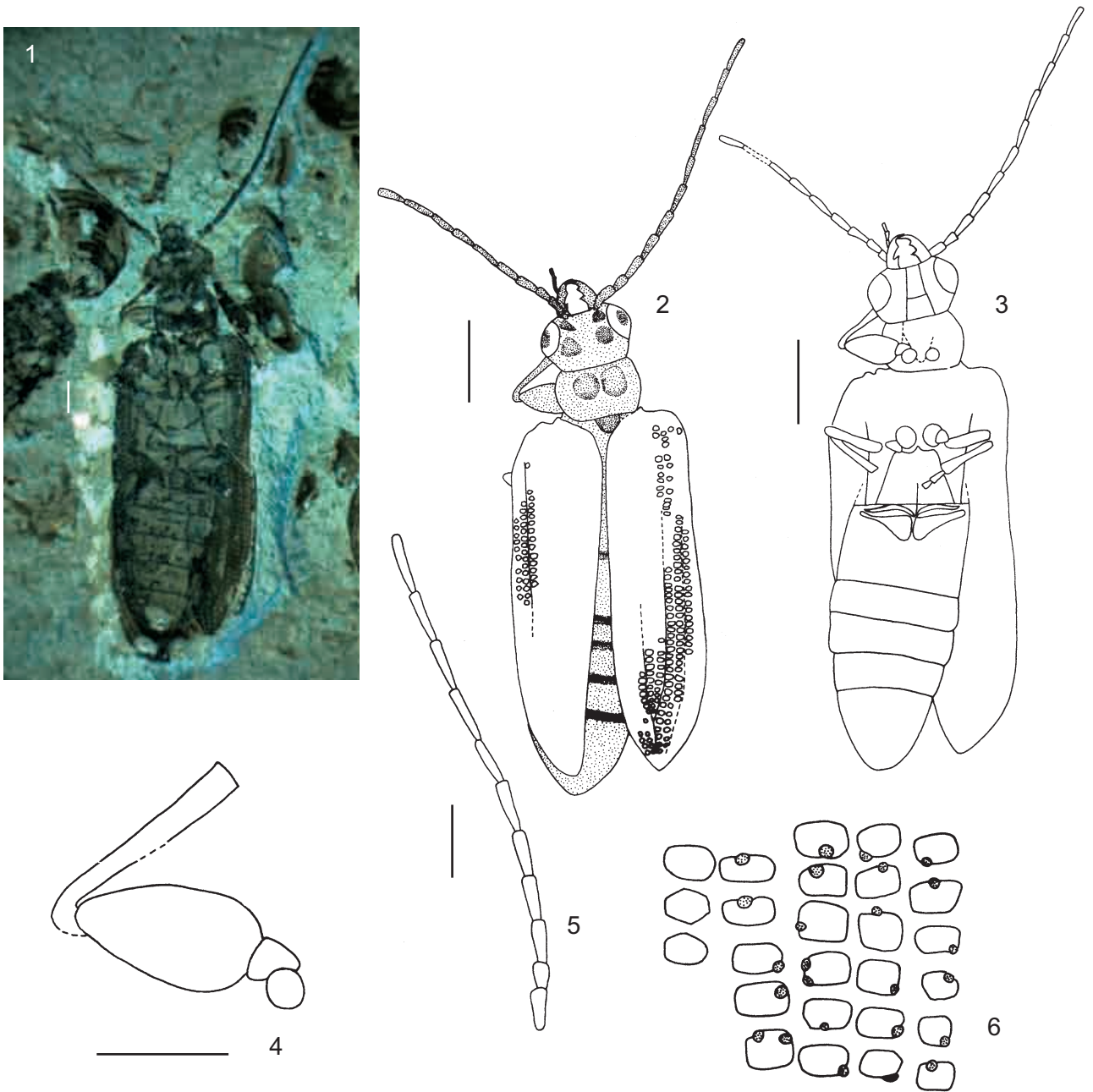
1. Head with antennal groove ventrally
. ***Mesocupoides*** Ponomarenko, 1969
- Head without antennal groove ventrally 2
2. The third segment of the antennae as long as the first and second segment combined in length.
. ***Anaglyphites*** Ponomarenko, 1964
- The third segment of the antennae shorter than the first and second segment combined in length. 3
3. Head with one pair tubercles dorsally
. ***Mesocupes*** Martynov, 1926
- Head with two pairs tubercles dorsally
. ***Gracilicupes*** gen. nov.

Gracilicupes crassicruralis sp. nov.

(Figs 1–6)

Etymology. After the Latin prefix *crass-* (swollen) and *cruralis* (leg), referring to its swollen fore femora.

Diagnosis. A species of the fore femora swollen; metasternum with cross suture; approximately 53 elytral cells form a row.



Figures 1–6. *Gracilicupes crassicurualis* gen. and sp. nov., holotype, No. CNU-C-NN2005001. (1) Photograph, holotype; (2) dorsal view; (3) ventral view, (4) fore leg, (5) antennae, (6) outline of cell. Scale bar: 2, 3 = 2mm, 1, 4, 5 = 1mm.

Description. Body medium-sized, slender, covered with tubercles (Fig. 1).

Head. A little wider than long, sub-rhombic, broadest at eyes, bearing two pairs of unobvious tubercles, one at base of antennae, second besides eyes; eyes large; mandible prominent and incurved, tridentate (Fig. 2).

Antennae. Filiform, with 11 segments, longer than half as long as entire insect, second segment shorter than others, third segment shorter than first and second

segments combined in length, following segments more or less homonomous (Fig. 5).

Pronotum. Transverse, 0.6 times as long as wide, as wide as head, angle rounded, anterior and posterior edges straight, the sides slightly arching, without propleuron, disc of pronotum bearing two circle elevation.

Elytron. About 1.5 times as wide as prothorax, longitudinal ridges with small tubercles, 4 times as long as wide, with 10 rows of cells, elytral cells quadrate, with

1–2 black-maculate round its margin (Fig. 6) elongated in the distal part of the elytron, approximately 53 cells formed in row.

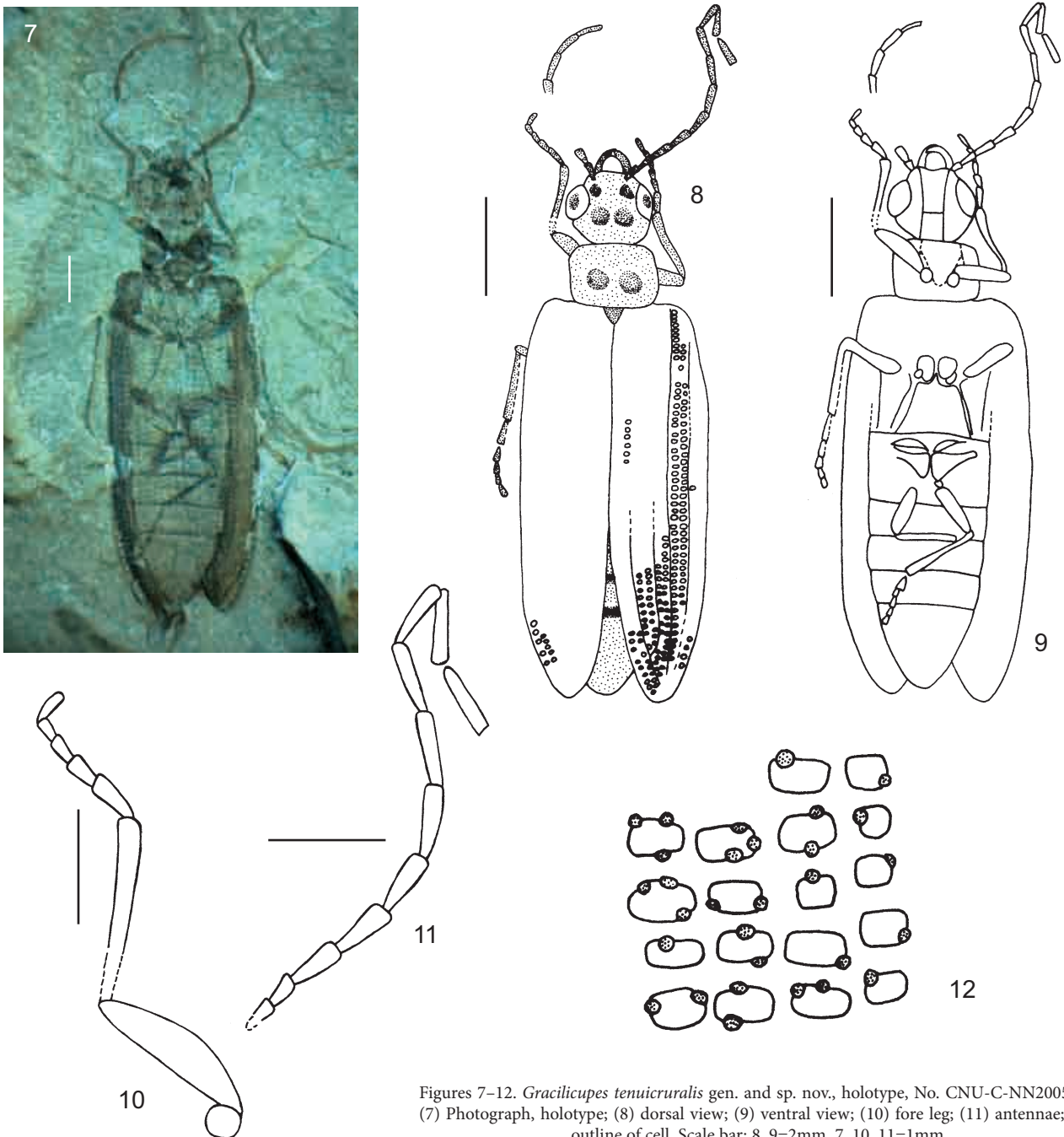
Ventral surface (Fig. 3). Gula rectangular, reaching posterior ridge of the head, gena widely separated along entire distance ventrally. Procoxal cavities separated, circular, small, prosternal process not extending behind coxae. Metasternum trapezoidal, transverse, 1.4 times as wide (at posterior margin) as long; cross suture developed on metasternum. Abdomen narrowed from the base of

fourth visible sternum, first visible abdomen sternum longer than other ones, last visible sternite 2.4 times as long as the previous one, its apex slight tapered.

Legs. Fore femora swollen (Fig. 4).

Measurements (mm): body length, 12.5; body width, 3; elytron length, 8.6.

Type material. Holotype: a well preserved almost complete body with elytra, registration No. CNU-C-NN2005001, Daohugou village, Shantou township, Ningcheng County, Inner Mongolia, China-Middle Jurassic.



Figures 7–12. *Gracilicupes tenuicruralis* gen. and sp. nov., holotype, No. CNU-C-NN2005002. (7) Photograph, holotype; (8) dorsal view; (9) ventral view; (10) fore leg; (11) antennae; (12) outline of cell. Scale bar: 8, 9=2mm, 7, 10, 11=1mm.

Gracilicupes tenuicruralis sp. nov.

(Figs 7–12)

Etymology. After the Latin prefix *tenu* – (slender) and *cruralis* (leg), referring to its slender fore femora.

Diagnosis. A species of the fore femora slender; metasternum only with transverse suture, without longitudinal suture; approximately 51 elytral cells form a row.

Description. Body medium-sized, slender, covered with tubercles (Fig. 7).

Head (Fig. 8). Sub-quadrate, broadest at eyes, bearing two pairs of tubercles, one at the base of antennae, the second besides eyes; eyes large; mandible prominent and incurved.

Antennae. Filiform, with 11 segments, longer than half as long as entire insect, first and second segment equal, the third segment shorter than the first and second segments combined in length, following segments more or less homonomous (Fig. 11).

Prothorax. Transverse, 0.7 times as long as wide, as wide as head, the disc of the pronotum bearing two circular elevation, anterior angle rounded, anterior and posterior edges straight, the sides slightly arching, without propleuron.

Elytron. About 1.5 times as wide as prothorax, longitudinal ridges with small tubercles, 4.2 times as long as wide, with 10 rows of cells; elytra not longer than the abdomen, dehiscent terminally; elytral cell small, quadrate, with 1–3 black-maculate round its margin (Fig. 12), elongated in the distal part of the elytron; approximately 51 cells form a row.

Ventral surface (Fig. 9). Gula rectangular, reaching posterior ridge of the head; genae widely separated along entire distance ventrally. Procoxal cavities separated, circular and very small, prosternal process not extending behind coxa. Metasternum trapezoidal, transverse, 1.6 times as wide (at posterior margin) as long, without longitudinal suture. Abdomen narrowed from the base of forth visible sternum, first visible abdomen sternite longer than other ones, last visible sternite 2.3 times as long as the previous one, its apex slight round.

Legs. Fore femora slender (Fig. 10); tarsi five-jointed, first segment longer than other ones.

Measurements (mm): body length, 11.5; body width, 2.5; elytron length, 7.5.

Comparison. The differences between *G. crassicruralis* gen. and sp. nov. and *G. tenuicruralis* gen. and sp. nov. are readily apparent. Both of them can be discriminated by the following characters: longitudinal suture on metasternum or without; fore femora swollen or slender; different size of elytral cells and different number of black-maculate round margin of cell.

Type material. Holotype: a well preserved almost complete body with elytra, registration No. CNU-C-NN2005002, Daohugou village, Shantou township, Ningcheng County, Inner Mongolia, China-Middle Jurassic.

ACKNOWLEDGEMENTS

This research is supported by the National Natural Science Foundation of China (Nos. 30025006, 30370184, 30430100, 30200025), Beijing Natural Science Foundation Program (No. 5032003), Scientific Research Key Program (KZ200410028013) and RCQJ Project of Beijing Municipal Commission of Education. We are very grateful to two anonymous reviewers for their valuable comments on the manuscript.

REFERENCES

- Carpenter, F. M. 1992. Coleoptera, pp. 279–282. *In*: Treatise on Invertebrate Paleontology, Part R, Arthropoda 4, (3), Geological Society of America, Boulder, Colorado, and University of Kansas, Lawrence, Kansas.
- Chen, W., Ji, Q., Liu, D. Y., Zhang, Y., Song, B. and X. Y. Liu. 2004. Isotope geochronology of the fossil-bearing beds in the Daohugou area, Ningcheng, Inner Mongolia. *Geological Bulletin of China*, 23(12): 1165–1169. [In Chinese with English abstract].
- Forbes, W. T. M. 1926. The wing-folding patterns of the Coleoptera. *Journal of the New York Entomological Society*, 34: 42–115.
- Gao K. Q. and Shubin, N. H. Earliest known crown-group salamanders. *Nature*, 2003, 422: 424–428.
- Ge, S. Q. and X.K. Yang. 2004. Two new Chinese species of Tenomerga Neboiss (Coleoptera: Cupedidae), with a world catalog of the genus. *Proceedings of the Entomological Society of Washington*, 106(3): 631–638.
- Hong, Y.C. 1983. Middle Jurassic Fossil Insects in North China. Geological Publishing House, Beijing, pp. 79–92. [In Chinese].
- Hong, Y.C. 1985. New fossil insects of Xiahuayuan Formation in Yuxian Country, Hebei Province. *Bulletin Tianjin Institute Geologic Mine Research*, 13: 131–138. [In Chinese].
- Hong, Y. C. 1988. The study of early Cretaceous insects of “Kezuo”, west Liaoning. *Professional Papers of Stratigraphy and Palaeontology*, 18: 76–91. [In Chinese].
- Hong, Y. C. 1990. Insect fossils of Laiyang Formation. *The Stratigraphy and Palaeontology of Laiyang Basin, Shandong Province*. Geological Publishing House, Beijing, pp. 105–120 [In Chinese].
- Ji, Q. and C. X. Yuan. 2002. Discovery of two kinds of protofeathered pterosaurs in the Mesozoic Daohugou Biota in the Ningcheng region and its stratigraphic and biologic significance. *Geological Review*, 48: 221–224. [In Chinese with English abstract].
- Kolbe, H. J. 1908. Mein System der Coleopteren. *Zeitschrift fuer Wissenschaftliche Insektenbiologie*, 4: 116–400.
- Lawrence J.F. and A.F. Newton. 1995. Families and subfamilies of Coleoptera (with selected genera, notes and references, and data on family-group names). *In*: Pakaluk J. and A. S. Ślipiński, (eds.) *Biology, Phylogeny, and Classification of Coleoptera: Papers Celebrating the 80th Birthday of Roy A. Crowson*. Warsaw: Muzeum i Instytut Zoologii PAN, 779–1006.
- Lawrence, J. F. 1999. The Australian Ommatidae (Coleoptera: Archostemata): new species, larva and discussion of relationships. *Invertebrate Taxonomy*, 13: 369–390.
- Lin, Q. B. 1976. The Jurassic fossil insects from Western Liaoning. *Acta Palaeontologica Sinica*, 15(1): 97–115. [In Chinese].
- Lubkin, S. H. 2003. *Paracupes svitkoi* (Coleoptera: Cupedidae) a new species from the Cretaceous of New Jersey. *Acta Zoologica cracoviensia*, 46: 189–194.
- Martynov, A.V. 1926. To the knowledge of the fossil insects of the Jurassic states of Turkestan, 5. *Ezhgodnik russkogo*

- paleontologicheskogo obshchestva, 5: 1-38. [In Russian with English summary].
- Mi, J., Sun, C., Sun, Y., Cui, S. and Y. Ai. 1996. Early-Middle Jurassic phytoecology and coalaccumulating environments in Northern Hebei and Western Liaoning. Geological Publishing House, Beijing, pp. 1-169.
- Neboiss, A. 1984. Reclassification of *Cupes* Fabricius (s. lat.), with descriptions of new genera and species (Cupedidae: Coleoptera). Systematic Entomology, 9: 443-477.
- Ponomarenko, A.G. 1964. New beetles of of the family Cupedidae from the Jurassic of Karatau. Paleontologicheskii Zhurnal, 2: 49-61. [In Russian].
- Ponomarenko, A.G. 1969. Historical development of archostemate beetles. Trudy Paleontologicheskogo Instituta AN SSSR, 125: 70-115. [In Russian].
- Ponomarenko, A.G. 1997. New beetles of the family Cupedidae from the Mesozoic of Mongolia. Ommatini, Mesocupedini, Priacmini. Paleontological Journal, 31: 389-399.
- Ponomarenko, A.G. 2000. Beetles of the family Cupedidae from the lower Cretaceous Locality of Semen, Transbaikalia. Paleontological Journal, 34: 317-322.
- Ponomarenko, A.G. 2002. Superorder Scarabaeida Laicharting, 1781. Order Coleoptera Linne, 1758 The beetles. In: Rasnitsyn, A.P. and D.L.J. Quicke, (eds.), History of Insects. Kluwer Academic Publishers, Dordrecht, The Netherlands, pp. 167-176.
- Ren, D., Lu, L.W., Ji, S. A. and Z.G. Guo. 1995. Faunae and Stratigraphy of Jurassic-Cretaceous in Beijing and the adjacent areas. Seismic Publishing House, Beijing, pp. 73-90. [In Chinese with English summary].
- Ren, D. and L. W. Lu. 1996. Late Mesozoic Fauna Assemblages of Yanliao Area, North China. Acta Geoscientia Sinica, 17 (Suppl.): 148-154. [In Chinese with English abstract].
- Ren, D., Gao, K.Q., Guo, Z.G., Ji, S.A., Tan, J. J. and Z. Song. 2002. Stratigraphic division of the Jurassic in the Daohugou area, Ningcheng, Inner Mongolia. Geological Bulletin of China, 21(8-9): 584-591. [In Chinese with English abstract].
- Ren, D. and W. Krzemiński. 2002. Eoptychopteridae (Diptera) from the Middle Jurassic of China. Annales Zoologici, 52(2): 207-210.
- Shen, Y. B., Chen, P. J. and D. Y. Huang. 2003. Age of the fossil conchostracans from Daohugou of Ningcheng, Inner Mongolia. Journal of Stratigraphy, 27(4): 311-313.
- Tan, J. J. and D. Ren. 2002. Palaeoecology of insect community from the Middle Jurassic Jiulongshan formation in Ningcheng county, Inner Mongolia, China. Acta Zootaxonomica Sinica, 27(3): 428-434. [In Chinese with English abstract].
- Tan, J. J., Ren, D., Li, N.N. and Z. L. Liu. 2004. Current knowledge of Mesozoic Coleoptera in China. Acta Zootaxonomica Sinica, 29(4): 683-691 [In Chinese, English abstract].
- Tan, J. J., Ren, D. and M. Liu. 2005. New Ommatidis from the Late Jurassic of western Liaoning, China (Coleoptera: Archostemata). Insect Science, 2005(12): 211-220.
- Wang, S. 2000. The Stratigraphical Monographies of China: Jurassic. Geological Publishing House, Beijing, pp. 1-154. [In Chinese with English abstract].
- Zhang, W. and Y. B. Shen. 1987. Discovery of Jurassic conchostracans with well-preserved soft parts and notes on its biological significance. Acta Palaeontologica Sinica, 26(2): 127-145

Received: June 15, 2005

Accepted: October 5, 2005