

**OVATOCUPES: A NEW CUPEDID GENUS
(COLEOPTERA: ARCHOSTEMATA: CUPEDIDAE)
FROM THE JEHOL BIOTA (LATE JURASSIC) OF
WESTERN LIAONING, CHINA¹**

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ABSTRACT: A new genus, one new species and an unnamed species of fossil cupedids assigned to family Cupedidae, *Ovatocupes alienus* gen. et sp. nov. and *Ovatocupes* sp., is described and illustrated from the Late Jurassic Yixian Formation of western Liaoning, China.

KEY WORDS: *Ovatocupes*, Coleoptera, Archostemata, Cupedidae, Yixian Formation, Jurassic, China

The family Cupedidae includes some of the earliest known fossil beetles and some of the most primitive living beetles (Lawrence 1999). Although the family was described in the 19th century, its phylogenetic position was poorly understood until the early part of the 20th century (Lawrence 1999). In Lacordaire's (1857) major work, the family (then only including *Cupes* Fabricius, 1801) was placed between the Lymexylones and Ptiniore (Lawrence 1999). It was Forbes (1926), Böving and Craighead (1931) who recognized the Archostemata as a suborder equivalent to Adephaga and Polyphaga, based on wing venation and larvae respectively, and considered that this suborder included Cupedidae and Micromalthidae. Nowadays, Archostemata is generally considered to have 4 families composed by both extinct and extant taxa: Cupedidae, Ommatidae, Micromalthidae and Crowsoniellidae (Lawrence and Newton 1995) and 11 extinct families (Carpenter 1992). Placement of Cupedidae within Archostemata is currently generally accepted (Neboiss 1984; Lawrence 1999).

Today, this group is small, including only 9 extant genera and 27 extant species (Neboiss 1984; Ge and Yang 2004), but it was diverse in the Permian and Mesozoic (Lubkin 2003; Ponomarenko 2002), so study of Mesozoic cupedids has been important in understanding the relationships of this family with other Archostemata groups. Despite the rich Mesozoic record of Cupedidae, the most abundant and complete specimens of Archostemata including this family were not described until the 1960s. Ponomarenko (1969) defined Cupedidae in a very broad sense and placed all of the cupedid-like samples from the Triassic to the present in the family Cupedidae.

Recently we recovered a number of well-preserved fossil cupedids from Yixian Formation near Chaomidian village, Beipiao city, Liaoning Province, China. The discovery of these fossils is significant, as most other Chinese Mesozoic

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zoic cupedids represented only by fragmentary remnants, and known only from isolated elytra (Hong and Wang 1976; Hong 1982, 1983). The complete preservation of the new specimens enabled us to determine the characters of the body of these ancient cupedids reported here; based on this, we propose the affinities of these species with extant and extinct groups.

CHARACTERISTICS OF THE LOCALITY

The strata of Yixian Formation are composed mainly of lacustrine sediments intercalated with volcanic rocks (Ren et al. 1995). It contains a large number of Jehol Biota fossils, including the reptile *Sinosauropteryx prima*, the bird *Confuciusornis sauctus*, and angiosperms such as *Archaeofructus liaoningensis* (Hou et al., 1999; Sun et al., 1998; Ding et al., 2001). Paleobotanical data about fossil spores, pollen and plants from Yixian Formation indicates a climate that was warm and moist (Ding et al., 2001).

A large fossil Archostematan assemblage has been previously reported from the Yixian Formation (Lin 1976; Hong and Wang 1976; Hong 1982, 1983, 1984, 1988, 1990; Ren et al., 1995; Wang and Liu 1996; Zhang 1997), including 27 extinct species and 17 extinct genera of Cupedidae (Tan et al., 2005).

The age of the Yixian Formation remains contentious. A Late Jurassic or Early Cretaceous age has been proposed based on both biostratigraphic and radiometric geochronology (Chen 1988; Chen et al., 1998; Wang 1998; Swisher et al., 1999; Zhou et al., 2003). Swisher et al., (1999) determined a younger age of 124.6 ± 0.1 Ma by $^{40}\text{Ar}-^{39}\text{Ar}$, however, some authors (Wang et al., 2004, 2005) maintain that the samples that Swisher analyzed were from intrusive volcanic rocks many millions of years younger, rather than from the fossil-bearing sediments, which they propose were deposited in the Upper Jurassic. At present, we cannot draw a final conclusion about its certain age only based on our current cupedid data from Yixian Formation. Here, we tentatively follow Chen et al. (1998) and Wang et al. (2005) in considering the Yixian Formation Late Jurassic.

METHODS

The specimens were examined using a LEICA MZ12.5 dissecting microscope and illustrated with the aid of a drawing tube attachment. Morphological terminology and systematics here follow that of Ponomarenko (1969, 1997, 2000).

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

The following standards were used for characters:

Body length: measured from the apex of the mandible to the apex of the abdomen.

Body width: measured at base of the elytra.

Length of elytra: measured from the base to the apex of the elytra.

SYSTEMATIC ENTOMOLOGY

Order Coleoptera Linnaeus, 1758
Family Cupedidae Lacordaire, 1857
Tribe Cupedini Lacordaire, 1857
Genus *Ovatocupes* gen. nov.

Type species. *Ovatocupes alienus* gen. et sp. nov.

Diagnosis. Body subcylindrical; head apparently ovate; antennae serrate, scape longer and thicker than following segments, third segment longer than second or fourth segment; prothorax transverse, obviously wider than head, with large elevation divided by longitudinal line in middle; anterior angles of pronotum acute, between them two distinct sharp protuberances developed apparently on the anterior margin of pronotum; abdomen with five visible sternites; last visible sternite two times longer than preceding sternite: 7th and 8th elytral longitudinal striae united before apex.

Etymology. The generic name is a combination of the Latin ovatum (meaning "ovate") and *Cupes* (type genus of the family).

Discussion. *Ovatocupes* gen. nov. can be assigned to the family Cupedidae by the separation of the procoxal cavities, and by the tegular articulations of the ventrites (Lawrence 1999). This paper associates our fossil beetles with the tribe Cupedini on the basis of the following shared characteristics: (1) head with apparently dorsal prominences; (2) antennal insertions separated by less than diameter of eyes; and (3) prosternal process extending behind coxae.

At present, Cupedini includes one extinct genus *Miocupes* Ponomarenko, 1973 (Ponomarenko 1973) and three extant genera: *Cupes* Fabricius, 1801, *Prolixocupes* Neboiss, 1959 and *Paracupes* Kolbe, 1898 (Crowson 1962; Atkins 1963).

This new genus can easily be differentiated from the Miocene genus *Miocupes* by the 7th and 8th elytral longitudinal striae united before apex.

Ovatocupes gen. nov. is diagnosable from *Cupes* by the lack of posterior tubercles (Atkins 1963). *Paracupes* may be compared with our studied fossil beetles, but it is distinct from the new genus for its head somewhat quadrate and bearing a pair of conical tubercles.

The new genus is only somewhat similar to the genus *Prolixocupes* in head somewhat oval and serrate antennae (Atkins 1963), but differs from the latter by the following characters: head with one pair of long-elliptical tubercles, scape longer and thicker than following segments, anterior angles of pronotum acute, and 7th and 8th longitudinal striae of elytra only confluent at the extreme apex.

Based on the fossils described below, the new genus includes one new species and an unnamed species.

***Ovatocupes alienus* gen. et sp. nov.**

Figs. 1-6

Diagnosis: Head oval, in dorsal view bearing one pair of long, elliptical tubercles; antennae serrate; prothorax transverse, 1.7 times wider than head, with a large elevation divided by a longitudinal midline, anterior angles of pronotum acute, between them two distinct sharp protuberances developed apparently on the anterior margin of pronotum; scutellum more or less triangular; elytral cells slightly hexagonal.

Description: Body subcylindrical, medium-sized, rather evenly covered with tubercles (Fig. 1).

Head: slightly wider than longer, oval, broadest at eyes, bearing one pair of separated long, elliptical tubercles, slightly longer than lengthwise diameter of eyes (Fig. 2); eyes large; mandibles prominent, incurved; neck-like constriction abrupt.

Antennae (Fig. 5): serrate, with 11 segments, nearly as long as head and thorax taken together, scape longer, thicker than following segments, third segment longer than second or fourth segment, antennal insertions separated by less than diameter of eyes.

Pronotum: 1.4 times as wide as long, 1.7 times wider than head, anterior, posterior margins of pronotum slightly arching, anterior angles of pronotum acute, apparently extending, between them two distinct sharp protuberances developed apparently on the anterior margin of pronotum, lateral sides slightly arching, without propleuron; central disc with two subrectangular tubercles.

Scutellum: sub-triangular.

Elytron: width about 1.5 times that of prothorax, longitudinal ridges with small tubercles, 3.5 times as long as wide, epipleural rim wide, with 10 rows of cells; elytra slightly longer than abdomen, apex dehiscent; 7th and 8th longitudinal striae united before apex; elytral cells slightly hexagon, without black-maculate round its margin (Fig. 6), more than 29 cells form a row.

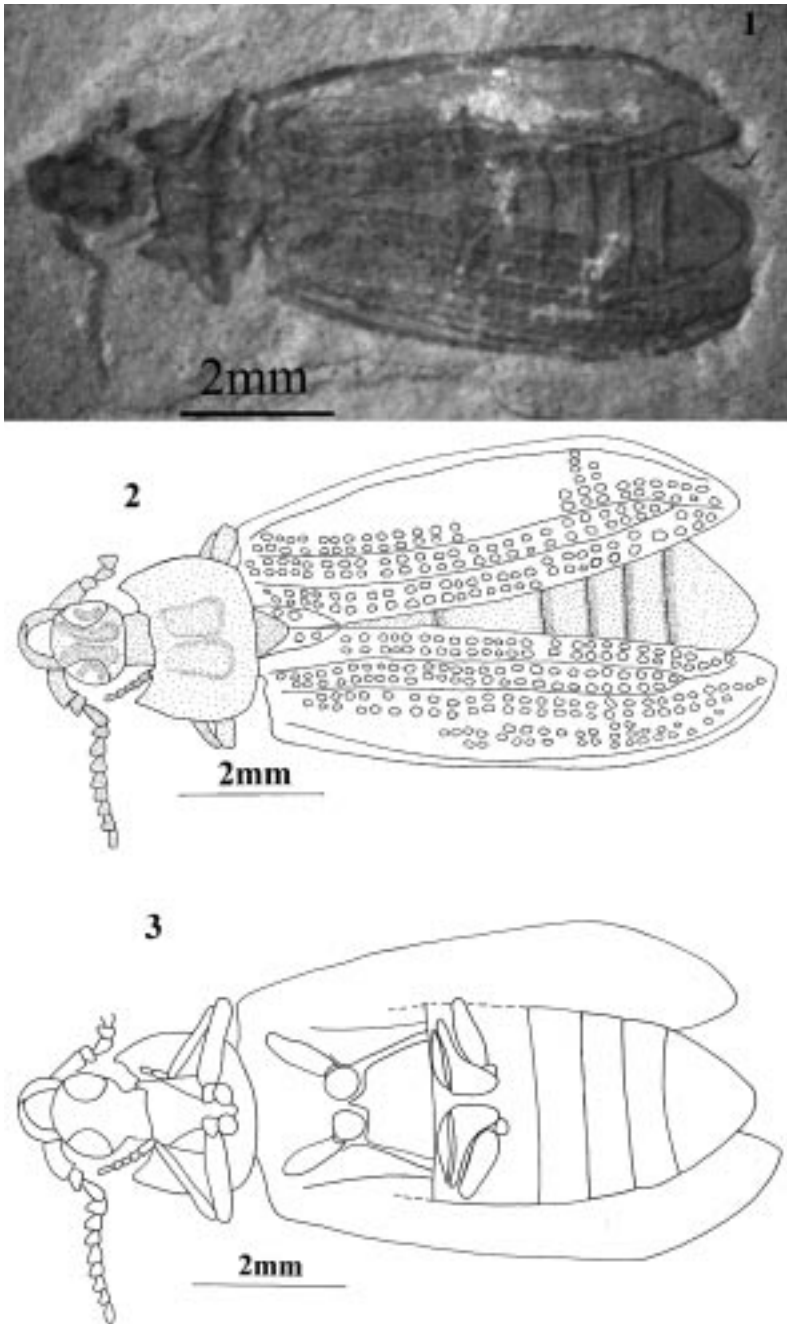
Ventral surface: procoxae not contiguous, circular, small, prosternal process extending behind coxae, notopleural suture straight, pleurosternal suture running oblique to procoxae (Fig. 4). Metasternum without longitudinal suture. Abdomen with five visible ventrites with marked relief, last ventrite 2.4 times as long as previous, apex slightly rounded.

Legs: femur and tibia of fore legs slightly longer than ones of middle and hind legs, tarsus five-segmented.

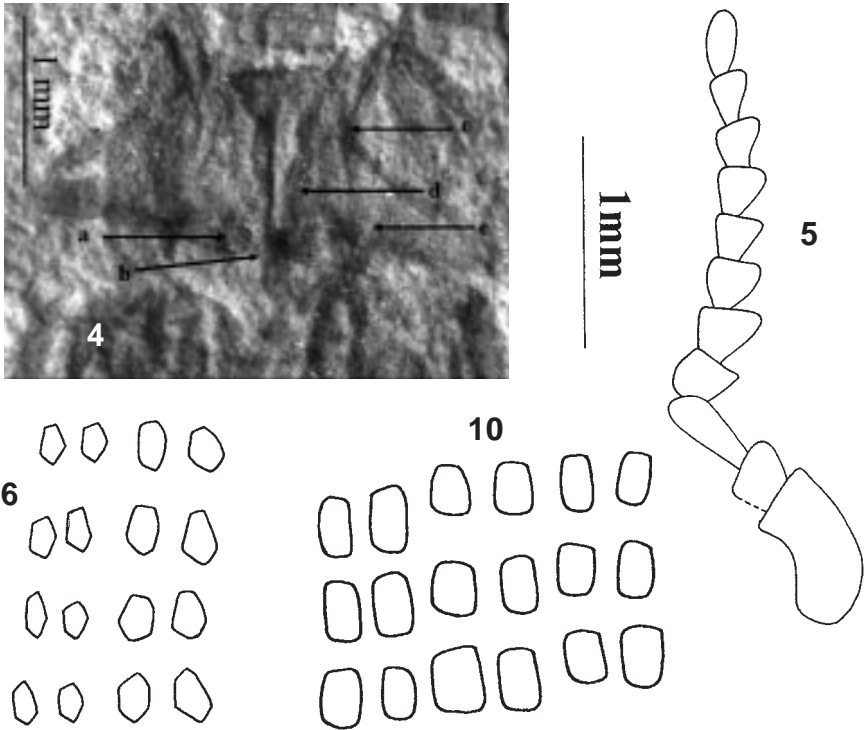
Measurements (mm): body length, 9.5; body width, 3; elytron length, 7.

Type material. Holotype: a well preserved almost complete body with elytra, registration No. CNU-C-LBC2005001; collected from Yixian Formation, near Chaomidian village, Beipiao City, Liaoning Province, China; specimen housed in the Key Lab of Insect Evolution & Environmental Changes, the College of Life Science, Capital Normal University, Beijing, China (CNUB).

Etymology. From the Latin '*alienus*,' referring to the unusual shape of the head.



Figs.1-3. *Ovatocupes alienus* gen. et sp. nov., holotype, No. CNU-C-LBC2005001. 1. Photograph. 2. Dorsal view. 3. Ventral view.



Figs.4-6. 4. *Ovatocupes alienus* gen. et sp. nov., holotype, No. CNU-C-LBC2005001. Photograph of prosternum, a. procoxae, b. prosternal process, c. notopleural suture, d. pleurosternal suture, e. right femur. 5. Antennae. 6. Elytral cells. Fig. 10. *Ovatocupes* sp., No. CNU-C-LBC2005002. Outline of elytral cells.

***Ovatocupes* sp.**

Figs. 7-10

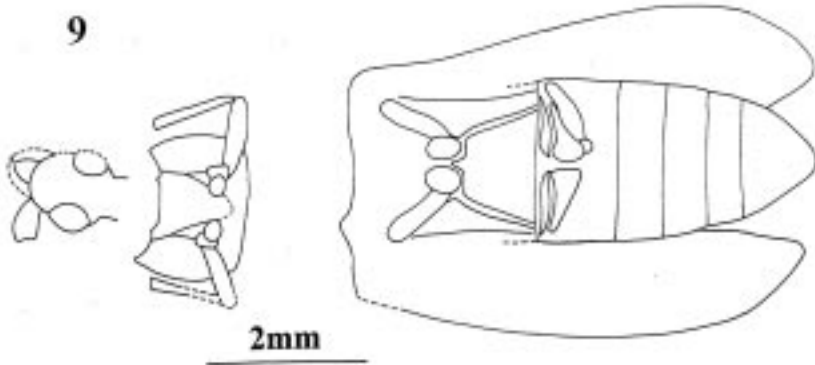
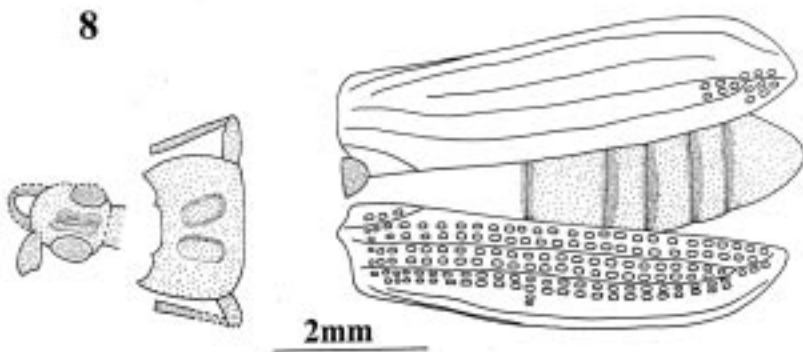
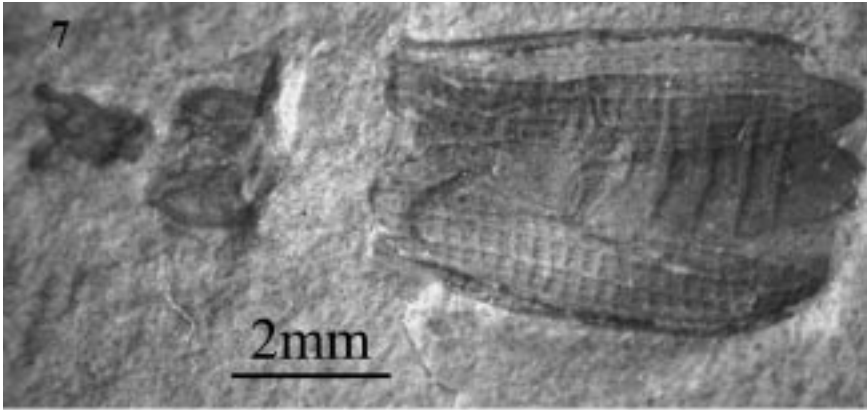
Description: Body subcylindrical, medium-sized, rather evenly covered with tubercles (Fig. 7).

Head: slightly longer than wide, ovate, broadest at eyes, bearing one pair of consistent long, elliptical tubercles (Fig. 8), slightly equal to lengthwise diameter of eyes; eyes large; mandible prominent, incurved; neck-like constriction abrupt.

Antennae: only one visible scape.

Pronotum: 0.6 times as long as wide, 2.2 times wider than head, anterior margin of pronotum slightly arching, anterior angles acute, apparently extending, between them two distinct sharp protuberances developed apparently on the anterior margin of pronotum, posterior margin straight, lateral sides slightly arching, without propleuron; central disc with two subrectangle elevation.

Scutellum: more or less semicircle.



Figs. 7-9. *Ovatocupes* sp., No. CNU-C-LBC2005002. 7. Photograph. 8. Dorsal view. 9. Ventral view.

Elytron: about 1.5 times as wide as prothorax, longitudinal ridges with small tubercles, 3.9 times as long as wide, epipleural rim wide, with 10 rows of cells; elytra slight longer than abdomen, apex dehiscent; 7th and 8th longitudinal striae united before apex; elytral cell slight rectangle, without black-maculate round its margin (Fig.10), approximately 28 cells formed a row.

Ventral surface: procoxal cavities separated, circular, small; prosternal process extending behind coxae (Fig. 9); notopleural suture straight, pleurosternal suture running oblique to coxa of fore legs. Metasternum without longitudinal suture. Abdomen with five visible sternites, last sternite 2.4 times as long as former one, apex slightly rounded.

Measurements (mm): body length, 8.9; body width, 3.5; elytron length, 5.9.

Discussion: The form of head and prothorax imply that this beetles can be placed in this new genus, but are insufficient to erect a new species because most of antennal segments are absent. This specimen (No. CNU-C-LBC2005002) can be distinguished from *O. alienus* gen. et sp. nov. by the following characters: the size of long-elliptical tubercles on the head, the position of two elevations at central disc of prothorax, and the form of scutellum and cells of elytron. However, the differences of the specimen (No. CNU-C-LBC2005002) and *O. alienus* gen. et sp. nov. are not very obvious and more likely to be the result of intra-specific variation or sexual dimorphs. The taxonomic position of this specimen will not be confirmed until more complete specimens associated with it are discovered.

Material. An almost complete body with elytra, but most antennal segments absent, registration No. CNU-C-LBC2005002; collected from Yixian Formation, near Chaomidian village, Beipiao City, Liaoning Province, China; specimen housed in the Key Lab of Insect Evolution & Environmental Changes, the College of Life Science, Capital Normal University, Beijing, China (CNUB).

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LITERATURE CITED

- Atkins, M. D. 1963. The Cupedidae of the World. *The Canadian Entomologist* 95: 140-162.
- Böving, A. G. and F. C. Craighead. 1931. An illustrated synopsis of the principal larval forms of the order Coleoptera. *Entomologica Americana* 11: 1-351.

- Carpenter, F. M.** 1992. Coleoptera. *In*, Treatise on Invertebrate Paleontology, Part R, Arthropoda 4, (3). Lawrence/Kansas: Geological Society of America and University of Kansas, U.S.A. 655pp.
- Chen, P. J.** 1988. Distribution and migration of the Jehol Fauna with reference to non-marine Jurassic-Cretaceous boundary in China. *Acta Palaeontologica Sinica*, 27: 659-683.
- Chen, P. J., Z. M. Dong, and S. N. Zhen.** 1998. An exceptionally well-preserved theropod dinosaur from the Yixian Formation of China. *Nature*, 391: 147-152.
- Crowson, R. A.** 1962. Observations on the beetle family Cupedidae, with descriptions of two new forms and a key to the recent genera. *Annals and Magazine of Natural History*, (13)5: 147-157.
- Ding, Q. H., L. D. Zhang, S. Z. Guo, C. J. Zhang, Y. D. Peng, B. Jia, S. W. Chen, and D. H. Xing.** 2001. The stratigraphic sequence and fossil bearing horizon of the Yixian Formation in western Liaoning, China. *Geology and Resources*, 10 (4): 193-198.
- Fabricius, J. C.** 1801. *Systema Eleutheratorum. Kiliae*, 2: 66.
- Forbes, W. T. M.** 1926. The wing-folding patterns of the Coleoptera. *Journal of the New York Entomological Society*, 34: 42-115.
- 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. and W. Wang.** 1976. Inner Mongolia Volume. *In*, Palaeontological Atlas of North China. Geological Publishing House, Beijing, China. pp. 81-87.
- Hong, Y. C.** 1982. Mesozoic Fossil Insects of Jiuquan Basin in Gansu Province. Geological Publishing House, Beijing, China. 182pp.
- Hong, Y. C.** 1983. Middle Jurassic Fossil Insects in North China. Geological Publishing House, Beijing, China. 223pp.
- Hong, Y. C.** 1984. New fossil insects of Laiyang Group from Laiyang basin, Shandong Province. *Professional papers of Stratigraphy and Palaeontology*, 18: 31-41.
- Hong, Y. C.** 1988. New fossil insects of Lenchuiwu formation, northeastern Jiangxi. *Professional Papers of Stratigraphy and Palaeontology*, 21: 172-178.
- Hong, Y. C.** 1990. Insect fossils of Laiyang Formation. *In*, The Stratigraphy and Palaeontology of Laiyang Basin, Shandong Province. Geological Publishing House, Beijing, China. pp. 105-120.
- Hou, L. H., L. D. Martin, and Z. H. Zhou.** 1999. A diapsid skull in a new species of the primitive bird *Confuciusornis*. *Nature*, 399: 679-682.
- Lacordaire, J. T.** 1857. Histoire naturelle des insectes. Genera des Coléoptères ou exposé méthodique de critique de tous les genres proposés jusqu'ici dans cet ordre d'insectes. Paris: Roret Vol. 4: 554.
- 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 Slipinski, S. A. (eds), *Biology, Phylogeny, and Classification of Coleoptera: Papers Celebrating the 80th Birthday of Roy A. Crowson*. Muzeum i Instytut Zoologii PAN, Warsaw, Poland. pp. 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).
- Linnaeus, C.** 1758. *Systema Naturae. Holmiae*, 10th Edition. 324pp.
- Lubkin, S. H.** 2003. *Paracupes svitkoi* (Coleoptera: Cupedidae) a new species from the Cretaceous of New Jersey. *Acta Zoologica Cracoviensia*, 46: 189-194.

- Neboiss, A.** 1959. On the family Cupedidae, Coleoptera. Proceedings of the Royal Society of Victoria, 72(1): 12-20.
- 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.** 1969. Historical development of Archostematean beetles. Trudy Paleontologicheskogo Instituta AN SSSR, 125: 70-115.
- Ponomarenko, A. G.** 1973. Erster fund eines cupediden in neogen Europas (Coleoptera: Cupedidae). Vestnik Ceskoslovenske Spolecnosti Zoologicke, 37: 101-103.
- 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 et al.(eds.): History of insects. Dordrecht, The Netherlands: Kluwer Academic Publishers, pp167-176.
- Ren, D., L. W. Lu, S. A. Ji, and Z. G. Guo.** 1995. Fauna and Stratigraphy of Jurassic-Cretaceous in Beijing and the adjacent areas. Seismic Publishing House, Beijing, China. 222pp.
- Sun, G., D. L. Dilcher, S. L. Zheng, and Z. K. Zhou.** 1998. In search of the first flower: a Jurassic angiosperm, *Archaeofructus*, from Northeast China. Science, 282(5394): 1692-1695.
- Swisher, C. C. III., Y. Q. Wang, X. L. Wang, X. Xu, and Y. Wang.** 1999. Cretaceous age for the feathered dinosaurs of Liaoning, China. Nature, 400: 58-61.
- Tan, J. J., D. Ren, and M. Liu.** 2005. New Ommatidis from the Late Jurassic of western Liaoning, China (Coleoptera: Archostemata). Insect Science, 2005 (12): 211-220.
- Wang, W. L. and M. W. Liu.** 1996. A new species of Notocupes from the Cretaceous of Laiyang Basin, Shandong Province. Memoirs of Beijing Natural History Museum, 55: 79-82.
- Wang, W. L., L. J. Zhang, S. L. Zheng, Y. J. Zheng, H. Zhang, Z. T. Li, and F. L. Yang.** 2004. A new study on the stratotype and biostratigraphy of the Yixian stage in Yixian-Beipiao region, Liaoning—establishment and study of stratotypes of the Yixian stage. Acta Geologica Sinica, 78 (4): 433-447.
- Wang, W. L., L. J. Zhang, S. L. Zheng, D. Ren, Y. J. Zheng, Q. H. Ding, H. Zhang, Z. T. Li, and F. L. Yang.** 2005. The age of the Yixian stage and the boundary of Jurassic-Cretaceous—the establishment and study of stratotypes of the Yixian stages. Geological Review, 51(3): 234-242.
- Wang, X. L.** 1998. Stratigraphic sequence and vertebrate-bearing beds of the lower part of the Yixian Formation in Sihetun and neighbouring area, western Liaoning, China. Vertebrata Palasiatica, 36: 81-101.
- Zhang, H. C.** 1997. Early Cretaceous insects from the Dalazi formation of the Zhixin Basin, Jilin Province, China. Palaeoworld, 7: 86-93.
- Zhou, Z. H., P. M. Barrett, and J. Hilton.** 2003. An exceptionally preserved lower Cretaceous ecosystem. Nature, 421: 807-814.