

New discovery of Palaeontinid fossils from the Middle Jurassic in Daohugou, Inner Mongolia (Homoptera, Palaeontinidae)

WANG Ying, REN Dong[†] & SHIH ChungKun

College of Life Science, Capital Normal University, Beijing 100037, China

Three new species of fossil Palaeontinidae are described from Daohugou Village, Inner Mongolia, China: *Daohugoucossus shii* sp. nov., *D. parallelivenius* sp. nov., *D. lii* sp. nov. The diagnosis of *Daohugoucossus* Wang, Zhang and Fang, 2006 is revised. These materials are the first complete fossil palaeontinids in the Middle Jurassic of the world. Based on observation of these new specimens, Sc of this new genus has the following combined characters: joined with R at base, diverged near M separation, coalesced with R before the nodal line, extended beyond the nodal line and fused with R₁ before distal end. Due to the Sc characteristics mentioned above, the genus *Liaocossus* Ren, Yin and Dou, 1998 can be well distinguished from “*Ilerdocossus*-complex”.

Palaeontinidae, new species, fossil, Middle Jurassic, Inner Mongolia

Palaeontinidae is an extinct family, which existed from Permian to Cretaceous. Until now, it included 32 genera and 66 species, distributed in the Kyrgyzstan (Triassic of Issyk-kue and Sulucta, Jurassic of Sai-Sagul), Turkmenistan (Jurassic of Karabas-Tau), China (Permian of Inner Mongolia, Jurassic of Xinjiang, Hebei, Liaoning, Gansu and Inner Mongolia), Russia (Jurassic of Iya, Ust-Baley and Irkutsk, Early Cretaceous of Transbaikalia), Tadzhikistan (Jurassic of Shurab), Kazakhstan (Jurassic of Turgay), Australian (Triassic of Ipswich), South Africa (Triassic of Bird's River), Brazil (Cretaceous) and Spain (Late Jurassic to Early Cretaceous)^[1–3].

Based on three well-preserved fossil specimens collected from the Middle Jurassic Jiulongshan Formation at Daohugou Village, Ningcheng County, Inner Mongolia in China, the diagnosis of *Daohugoucossus* Wang, Zhang and Fang, 2006 is revised.

The age of the Daohugou fossil-bearing beds remains a focus of discussion among paleoentomologists. It had been proposed as Middle Jurassic^[2–11], Late Jurassic^[12] or Early Cretaceous^[13]. We believe that it should be the

Middle Jurassic (Jiulongshan Formation)^[14].

1 Material and methods

The specimens were examined by the dissecting microscope (Type: LEICA MZ12.5) and illustrated with the aid of drawing tube. All fossil specimens studied here are deposited in the Key Lab of Insect Evolution and Environmental Change, College of Life Science, Capital Normal University, Beijing, China.

The wing venation nomenclature used in this paper is based on the interpretation of Becker-Migdisova^[15]: Sc, subcosta; R₁, the first branch of anterior radial vein; R₂, the second branch of anterior radial vein; Rs, posterior radial vein; M₁, anterior branch of the media; M₂, the second branch of the media; M₃, the third branch of the media; M₄, the forth branch of the media; CuA₁, the an-

Received August 31, 2006; accepted November 3, 2006

doi: 10.1007/s11430-007-0029-5

[†]Corresponding author (email: rendong@mail.cnu.edu.cn)

Supported by the National Natural Science Foundation of China (Grant Nos. 30025006, 30370184 and 30430100), Beijing Natural Science Foundation Program (No. 5032003), the Scientific Research Key Program (Grant No. KZ200410028013) and the PHR Project of Beijing Municipal Commission of Education.

terior branch of the cubitus; CuA₂, the second branch of the cubitus; CuP, postcubital vein; A₁, the anterior branch of anal vein; A₂, the second branch of anal vein; r-m, crossvein connects the posterior radial vein and the anterior branch of the media; m₄-cua, crossvein connects the forth branch of the media and the anterior branch of the cubitus.

2 Systematic descriptions

Family Palaeontinidae Handlirsch, 1906

Genus *Daohugoucossus* Wang, Zhang and Fang, 2006

Type species: *Daohugoucossus solutus* Wang, Zhang and Fang, 2006.

Species included:

Four species: *D. solutus*, Wang, Zhang and Fang, 2006, *D. shii* sp. nov., *D. parallelivenius* sp. nov. and *D. lii* sp. nov.

Revised diagnosis. Fore wings Sc reduced and united anteriorly with R, departing from R at the point of basal crossvein m-cua connected with M, and then fused with R again, at last extending beyond the nodal line and terminating on R₁. Rs simple; M four-branched, M₁₊₂ separating distad of M₃₊₄; CuA curved, irregular and connected with M by two transverse veins. A 2-branched, and A₂ with branches. Nodal line present. Tegmina elongated, narrow in the basal part.

Hind wings smaller than fore wings, with elongate and sharp apically, costal margin curved posterior, formed a prominent indentation, Sc coalesced with R just before R ramification; Rs coalesced with M₁ for a considerable interval before separating; Rs, M₁ and M₂ straight for distal half; M₃₊₄ long, in contact but not coalesced with CuA; CuA bifurcating at the same level of indentation; medial area very narrow; A₂ terminating in anal margin. All wings with distinct color patterns.

Notes: The modified diagnosis is based on the type species described by Wang, Zhang and Fang, 2006^[3] and the new materials described here.

Remarks: A new genus *Daohugoucossus* Wang, Zhang and Fang, 2006 was erected based on a single hind wing only. The material described here is the first complete fossil palaeontinids specimen in the Middle Jurassic of the world, especially well preserved fore wings, abdomen and legs.

This new fossil palaeontinid can be assigned to the genus *Daohugoucossus* Wang, Zhang and Fang, 2006 based on the following shared characteristics on hind wing: (1) costal margin curved posterior, formed a prominent indentation; (2) Rs coalesced with M₁ for a considerable interval before separating; (3) Rs, M₁ and M₂ straight for distal half; and (4) M₃₊₄ long, in contact but not coalesced with CuA.

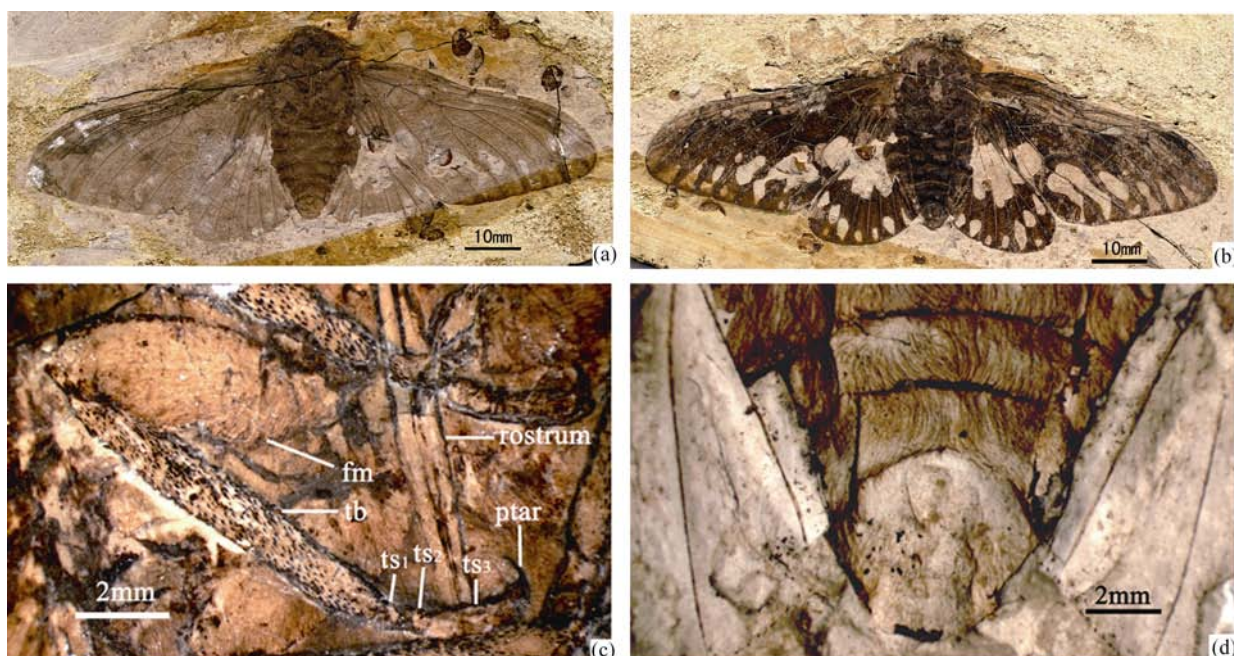


Figure 1 *Daohugoucossus shii* gen. et sp. nov. (a) Photograph of part, holotype, No. CNU-H-NN2006005-1; (b) photograph of counterpart, No. CNU-H-NN2006005-2; (c) photograph of middle leg. fm, femur; tb, tibia; ts1, first tarsus; ts2, second tarsus; ts3, third tarsus; ptar, pretarsus. (d) photograph of abdomen with hairs.



Figure 2 *Daohugoucossus parallelivenius* gen. et sp. nov., photograph of holotype, No. CNU-H-NN2006006.



Figure 3 *Daohugoucossus lii* gen. et sp. nov., photograph of holotype, No. CNU-H-NN2006010.

***Daohugoucossus shii* sp. nov. (Figures 1 and 4)**

Etymology: This species is named after Mr. Shi Yan for his collecting Daohugou fossils.

Holotype: Body with wings compression, part and counterpart, No.: CNU-H-NN2006005-1, CNU-H-NN2006005-2.

Horizon and locality: Jiulongshan Formation, Middle Jurassic, Daohugou Village, Ningcheng County, Inner Mongolia in China.

Description: The new species is established based on a well-preserved specimen consisting of a body with a pair of fore wings and hind wings. Head with a pair of large eyes; and a long rostrum with 2 visible segments, extended beyond the thorax. Postclypeus narrower than frons, with blurry boundary between them. On the ventral view, legs partly preserved; femora, tibiae and part of tarsi and pretarsi of all legs visible, femora stout and subequal in length, tarsi 3-segmented, third segment of tarsi longer than other two segments. Abdomen with 6 visible segments and clothed with dense hairs.

Fore wings tegmina. CP and nodal line present. Sc reduced and united anteriorly with R, departing from R at the point of basal crossvein m-cua connected with M, and then coalesced with R again nearly at the same level

of M branching into M_{1+2} and M_{3+4} , at last extending beyond the nodal line and terminating on R_1 . R_1 little upwards before ending in the distal, Rs simple and deriving from R little before Sc fused with R; there is a short crossvein r-m between Rs and M. M four-branched, and bifurcating into M_{1+2} and M_{3+4} beyond the nodal line; M_{1+2} separating distad of M_{3+4} . CuA connected with the stem of M by two transverse veins and also connected with M_4 by a long crossvein; CuA originating at wing base, curving sharply before it bifurcating at nodal line; CuA₂ nearly paralleling from CuA₁. CuP simple and straight. A 2-branched. Tegmina elongated, narrow in the basal part.

Hind wings smaller than fore wings, costal margin curved posteriorly, formed a prominent indentation, Rs coalesced with M_1 for a considerable interval before separating. M_{3+4} fused with CuA and soon departed from the latter. All wings with distinct color pattern.

Body 36 mm long, 18 mm wide; fore wing 48 mm long, 23 mm wide; hind wing 30 mm long, 16 mm wide.

Comparison: This species is similar to *Daohugoucossus solutus* Wang, Zhang and Fang, 2006^[3], but can be distinguished from the latter in the following features on the hind wing: M_{3+4} branching at the same level of CuA branching into CuA₁ and CuA₂.

***Daohugoucossus parallelivenius* sp. nov. (Figures 2 and 5)**

Etymology: From the Latin ‘parallelus’ = parallel, indicating Rs parallel to R after departing from it.

Holotype: A well-preserved fore wing, No.: CNU-H-NN2006006.

Horizon and locality: Jiulongshan Formation, Middle Jurassic, Daohugou Village, Ningcheng County, Inner Mongolia in China.

Description: The new species is known from a single complete fore wing. Fore wings tegmina. CP present. Sc simple and without branches, united anteriorly with R, departing from R at the point of basal crossvein m-cua connected with M, and very closed to R, and then coalesced with R again at the same level of M branching into M_{1+2} and M_{3+4} , at last extending beyond the nodal line and terminating on R_1 . Rs simple and deriving from R little before Sc fused with R, and then paralleling from it; M_1 connect with Rs by a short crossvein r-m, a little far away from the point of M_{1+2} dividing into M_1 and M_2 . M four-branched, and departing into M_{1+2} and M_{3+4} beyond the nodal line, a little after the curved crossvein m-cua connected with M; M_{1+2} separating distad of

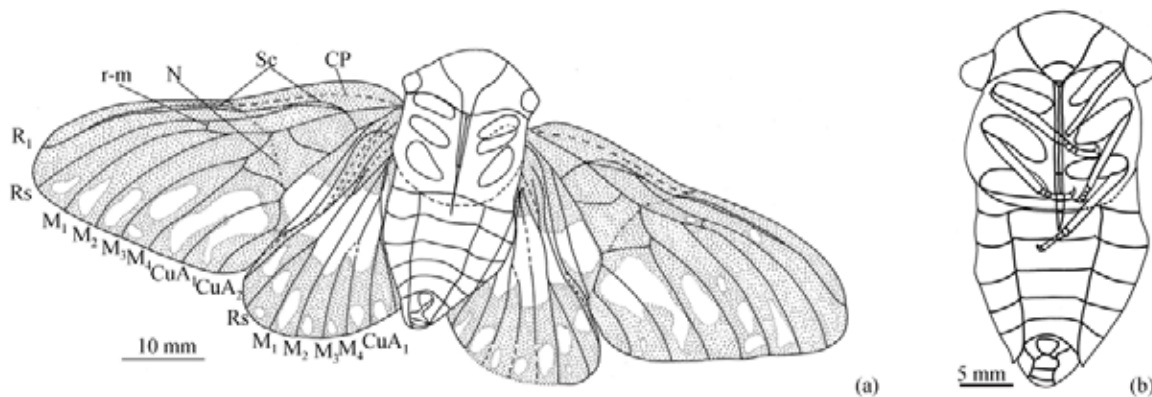


Figure 4 *Daohugoucoussus shii* gen. et sp. nov. holotype, No. CNU-H-NN2006005-1. (a) Line drawing of body with wings; (b) line drawing of body.

M_{3+4} . CuA curved, irregular and connected with M by two transverse veins, one is short near the base, and another one is curved beyond the nodal line. There is also a sinuate crossvein between M_4 and CuA. CuP departing from Cu near the wing basal and before the basal crossvein m-cua connected with CuA. A 2-branches, and A_2 with branches. Nodal line present. Tegmina elongated, narrow in the basal part. The forewing with distinct regular stripes at the posterior margin, and surface is also clothed with anomalistic patches.

Fore wing (preserved part) 39 mm long, 16 mm wide.

Comparison: The new species is similar to *D. shii* sp. nov., but it is different from the latter in the following characters on the fore wing: fore wings are smaller than the latter; Rs parallel to R after departing from it; the separating point of M is near the curved crossvein m-cua connected with M; r-m is little far away from the point of M_{1+2} bifurcating; the point of m_4 -cua connected with M_4 is later than the latter and A_2 branches near the basal.

***Daohugoucoussus lii* sp. nov. (Figures 3 and 6)**

Etymology: The specific name is dedicated to Mr. Li Yuezhao, Director of Sanya Palaeotological Museum, for his donating this fossil.

Holotype: A well-preserved fore wing, No.: CNU-H-NN2006010.

Horizon and locality: Jiulongshan Formation, Middle Jurassic, Daohugou Village, Ningcheng County, Inner Mongolia in China.

Description: The new species is established on a single complete fore wing. Fore wing tegmina. CP and nodal line present. Sc simple and without branches, united anteriorly with R, departing from R at the same point of R arising from Sc+R+M, and then coalesced with R again little before the point of M branching into M_{1+2} and M_{3+4} , at last extending beyond the nodal line

and terminating on R_1 . R_1 little upwards before ending in the distal, Rs simple and deriving from R little before Sc fused with R; crossvein r-m short. M four-branched, and departing into M_{1+2} and M_{3+4} little before the nodal line; M_{1+2} forking after the dividing point of M_{3+4} . CuA curved, irregular and connected with M by two transverse veins, one is short near the base, and another one is slightly S-shaped. A slightly sinuate crossvein between M_4 and CuA. CuP departing from Cu near the wing basal and before the basal crossvein m-cua connected with CuA. A 2-branches, and A_2 with branches. Tegmina elongated, narrow in the basal part. The forewing surface is clothed with distinct irregular stripes.

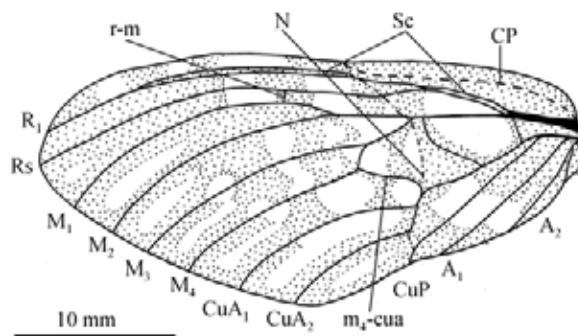


Figure 5 *Daohugoucoussus parallelevenius* gen. et sp. nov., line drawing of holotype, No. CNU-H-NN2006006.

Fore wing 51 mm long, 21 mm wide.

Comparison: The new species is closely related to *D. shii* sp. nov., but differs from the latter on the fore wing in Sc final fused with R before distal one-third; m_4 -cua connected with M_4 later than the latter; m-cua slightly sinuate and surface clothed with irregular stripes.

The new species is also similar to *D. parallelevenius* sp. nov., but differs from the latter in the following features on the fore wing: Sc final fused with R earlier than the latter; R_1 little upwards before ending in the distal; a

long crossvein m_4 -cua is slightly sinuate; A_2 branches late and surface clothed with irregular stripes.

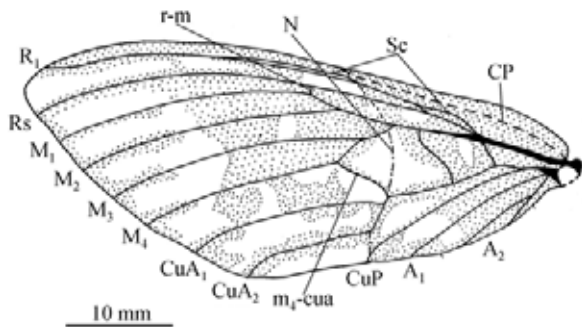


Figure 6 *Daohugoucossus lii* gen. et sp. nov., line drawing of holotype, No. CNU-H-NN2006010.

3 Discussion

The *Daohugoucossus* are closely related to two Jurassic Palaeontinids, *Palaeontinodes* Martynov, 1937^[15-17] from the Early Middle Jurassic of Shurab in Tadzhikistan, and *Ijacossus* Becker-Migdisova, 1950^[19,20] from the Middle Jurassic of Iya in Russia. However, the former differs from latter in the fore wing by the shape of Sc (joined with R at base, diverged near M separation, coalesced with R before the nodal line, extending be-

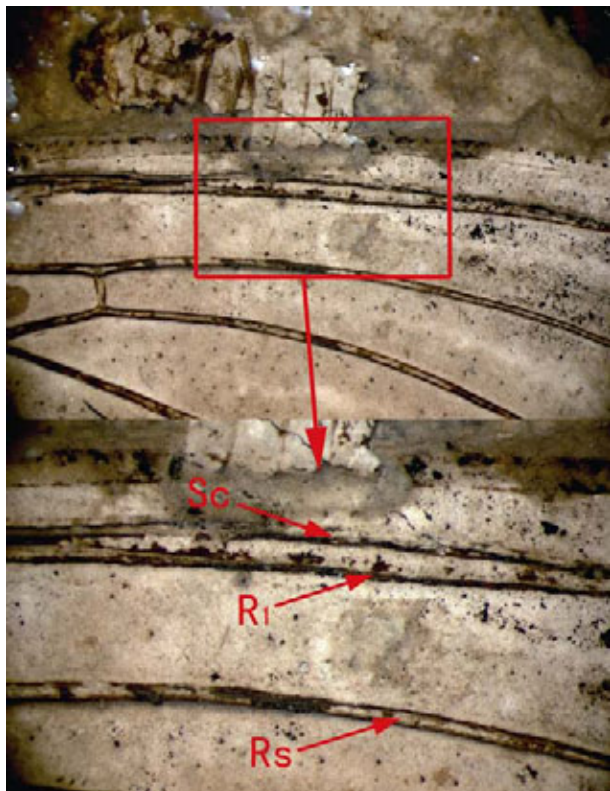


Figure 7 *Daohugoucossus shii* gen. et sp. nov., holotype, No. CNU-H-NN2006005-1 Photograph of subcosta (Sc) on forewing.

yond the nodal line and fused with R_1 before distal end) (Figure 7) and A_2 (with branches) (Figure 8).

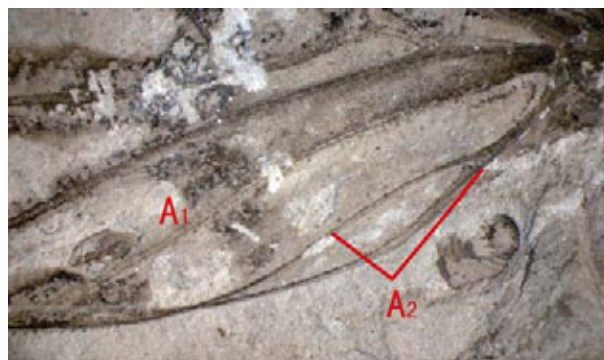


Figure 8 *Daohugoucossus lii* gen. et sp. nov., holotype, No. CNU-H-NN2006010 Photograph of anal vein (A) on forewing.

This shape of Sc in *Daohugoucossus* resembles *Liaocossus* Ren, Yin et Dou, 1998^[18] (Figure 9), known from the Late Jurassic of Liaoning and Hebei Provinces in China. Sc is completely fused with R in *Fletcheriana* Evans, 1956 from the Upper Triassic of Ipswich in Australia and Bird's River in South Africa^[21,22]; or terminated at the margin near fore wing indentation in *Pseudocossus* Martynov, 1931 from the Early Middle Jurassic of Ust-Baley in Russia, Turgay in Kazakhstan and Xinjiang and Inner Mongolia in China^[2,17,20,23,24]. Thus we assume the Sc form of both *Daohugoucossus* and *Liaocossus* Ren, Yin et Dou, 1998 may be transitional between those two forms.

Menon, Heads and Martil attributed *Liaocossus* Ren,

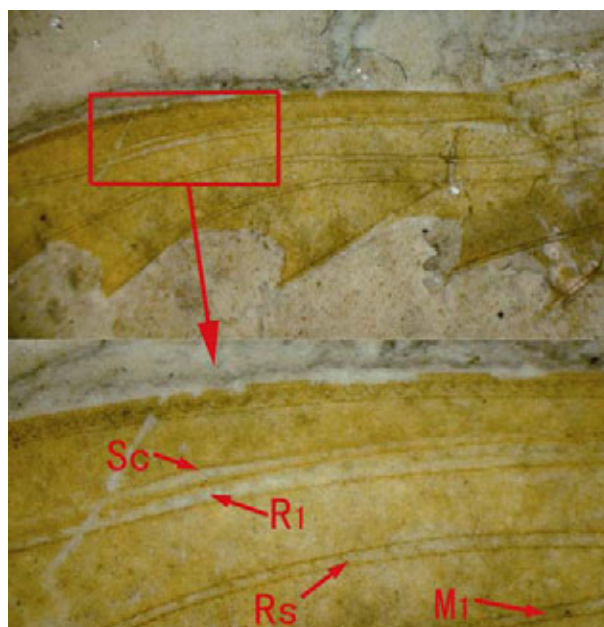


Figure 9 *Liaocossus hui* Ren, Yin et Dou, 1998 holotype, No. LB97105 Photograph of subcosta (Sc) on forewing.

Yin et Dou, 1998 into “*Ilerdocossus*-complex”^[1]. However, the shape of Sc, extending beyond the nodal line and terminating on R₁ is a conservative diagnostic character.

This transitional shape of Sc might have been appeared induced by heritable mutation as evidenced by

insects from the Jurassic/Cretaceous boundary, but the cause of these forms of Sc is obscure. During unstable Middle Jurassic periods, changeable environment mainly caused by multi-volcanism might result in mass mutations, premising some evolutionary processes which eventually resulted in self-organization^[25].

- 1 Menon F, Heads S W, Martil D M. New Palaeontinidae (Insecta: Cicadomorpha) from the lower Cretaceous Crato Formation of Brazil. *Cret Res*, 2005, 26: 837–844
- 2 Wang Y, Ren D. Middle Jurassic *Pseudocossus* Fossils from Daohugou, Inner Mongolia in China (Homoptera, Palaeontinidae). *Acta Zootax Sin* (in Chinese, English abstract), 2006, 31(2): 289–293
- 3 Wang B, Zhang H C, Fang Y. *Gansucossus*, a replacement name for *Yumenia* Hong, 1982 (Insecta, Hemiptera, Palaeontinidae), with description of a new genus. *Zootaxa*, 2006, 1268: 59–68
- 4 Shen Y B, Chen P J, Huang D Y. Age of the fossil conchostracans from Daohugou of Ningcheng, Inner Mongolia. *J Strati*, 2003, 27(4): 311–313
- 5 Chen W, Ji Q, Liu D Y, et al. Isotope geochronology of the fossil-bearing beds in the Daohugou area, Ningcheng, Inner Mongolia. *Geol Bull China* (in Chinese), 2004, 23(12): 1165–1169
- 6 Liu Y Q, Liu Y X, Li P X, et al. Daohugou biota-bearing lithostratigraphic succession on the southeastern margin of the Ningcheng basin, Inner Mongolia, and its geochronology. *Geol Bull China* (in Chinese), 2004, 23(12): 1180–1185
- 7 Ren D, Lu L W, Guo Z G, et al. Fauna and Stratigraphy of Jurassic-Cretaceous in Beijing and the Adjacent Areas (in Chinese). Beijing: Seismic Press, 1995. 64–73
- 8 Ren D, Gao K Q, Guo Z G, et al. Stratigraphic division of the Jurassic in the Daohugou area, Ningcheng, Inner Mongolia. *Geol Bull China* (in Chinese), 2002, 21(8-9): 584–591
- 9 Ren D, Krzemiski M. Eoptychopterridae (Diptera) from the Middle Jurassic of China. *Ann Zool*, 2002, 52(2): 207–210
- 10 Ji Q, Luo Z X, Yuan C X, et al. A swimming mammaliaform from the Middle Jurassic and ecomorphological diversification of early mammals. *Science*, 2006, 311: 1123–1127
- 11 Huang D Y, Nel A, Shen Y B, et al. Discussions on the age of the Daohugou fauna—evidence from invertebrates. *Prog Nat Sci*, 2006, 16: 308–312
- 12 Zhang J F. Discovery of Daohugou biota (pre-jehol biota) with a discussion on its geological age. *J Strati* (in Chinese), 2002, 26(3): 173–177, 215
- 13 Wang X L, Zhou Z H, He H Y, et al. Stratigraphic relation and age discussion of the Daohugou area, Ningcheng, Inner Mongolia. *Chin Sci Bull* (in Chinese), 2005, 50(19): 2127–2135
- 14 Gao K, Ren D. Radiometric Dating of Ignimbrite from Inner Mongolia Provides no Indication of a Post-Middle Jurassic Age for the Daohugou Beds. *Acta Geol Sin*, 2006, 80(1): 42–45
- 15 Becker -Migdisova E E. Mesozoic Homoptera of Middle Asia. *Trudy Paleont Inst Acad Nauk SSSR* (in Russian), 1949, 22: 1–68
- 16 Martynov A V. Liassic Insects from Shurab and Kyzyl-Kiya. *Trudy Paleontol Inst Acad Nauk SSSR*, 1937, 7 (1), Moscow-Leningrad: 166–167
- 17 Becker -Migdisova E E, Wootton R J. New paleontinoids of Asia. *Palaent J* (in Russian), 1965, 2: 69–79
- 18 Ren D, Yin J C, Dou W X. Late Jurassic Palaeontinids (Homoptera: Auchenorrhyncha) From Heibei and Liaoning Provinces in China. *Entomol Sin*, 1998, 5(3): 222–232
- 19 Becker -Migdisova E E. Jurassic Palaeontinidae from a new locality on the Ii River. *Dok Acad Nauk SSSR* (in Russian), 1950, 71(6): 1105–1108
- 20 Kolosnitsyna G R. Organic World of East Siberia in the Phanerozoic. *Acad Sci SSSR* (in Russian), 1982, Institute of Earth Crust. 13–25
- 21 Evans J W. Palaeozoic and Mesozoic Hemiptera (Insecta). *Austral J Zool*, 1956, 4: 165–258
- 22 Riek E F. A new collection of insects from the Upper Triassic of South Africa. *Ann Natal Mus*, 1976, 22 (3): 791–820
- 23 Martynov A V. Morphology and systematic position of the family Palaeontinidae Handl, with a description of a new genus from Ust-baley, Siberia. *Ann Soc Palaent Russ* (in Russian), 1931, 9: 93–122
- 24 Zhang H C. Jurassic palaeontinids from Karamai, Xinjiang, with a discussion of Palaeontinidae (Homoptera: Palaeontinidae) in China. *Entomol Sin*, 1997, 4(4): 312–323
- 25 Vršanský P. Mass mutations of insects at the Jurassic/Cretaceous boundary? *Geol Carpathica*, 2005, 56, 6, 473–481