C. R. Palevol 13 (2014) 1–8

Contents lists available at ScienceDirect

Comptes Rendus Palevol

www.sciencedirect.com

General palaeontology, systematics and evolution (Invertebrate palaeontology)

A new lasiosynid beetle from the Middle Jurassic of China with remarks on the systematic position of Lasiosynidae

Un nouveau coléoptère lasiosynidé du Jurassique moyen de Chine, avec des remarques sur la position systématique des Lasiosynidae

Evgeny V. Yan [a,b,*], Bo Wang [a], Haichun Zhang [a]

[a] *State Key Laboratory of Palaeobiology and Stratigraphy, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, 39 East Beijing Rd., Nanjing 210008, China*
[b] *Paleontological Institute, Russian Academy of Sciences, Profsoyuznaya ul. 123, Moscow 117997, Russia*

ARTICLE INFO

Article history:
Received 17 December 2011
Accepted after revision 3 June 2013
Available online 11 October 2013

Presented by Philippe Taquet

Keywords:
Lasiosynidae
Coleoptera
New species
Middle Jurassic
Daohugou
China

ABSTRACT

A new beetle species, *Lasiosyne laxa* n. sp., is described from the Jurassic Daohugou deposits in Inner Mongolia, China. Its morphological significance and systematic position within the genus *Lasiosyne* Kirejtshuk et al., 2010a, b and the family Lasiosynidae are discussed. The research history of Lasiosynidae is summarized for the first time. The affiliation of Lasiosynidae to the superfamily Byrrhoidea is discussed in detail.

Mots clés :
Lasiosynidae
Coleoptera
Nouvelles espèces
Jurassique moyen
Daohugou
Chine

RÉSUMÉ

Une nouvelle espèce de coléoptère, *Lasiosyne laxa* n. sp., est décrite dans les dépôts jurassiques de Daohugou, en Mongolie intérieure. Sa signification morphologique et sa position systématique au sein du genre *Lasiosyne* Kirejtshuk et al., 2010a, b et de la famille des Lasiosynidae sont discutées. L'histoire de la recherche sur les Lasiosynidae est en même temps résumée pour la première fois. L'affiliation des Lasiosynidae à la superfamille des Byyhoïdea est discutée en détail.

1. Introduction

The family Lasiosynidae is a group of fossil elateriform beetles which are abundant and diverse in numerous localities of Middle Jurassic-Early Cretaceous age in Russia (Siberia and Transbaikalia), Kazakhstan, China and Mongolia. In addition, some isolated elytra, most likely belonging

* Corresponding author. State Key Laboratory of Palaeobiology and Stratigraphy, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, 39 East Beijing Rd., Nanjing 210008, China.
E-mail addresses: yanevgeny@gmail.com, yan-e@mail.ru (E.V. Yan).

1631-0683/$ – see front matter
http://dx.doi.org/10.1016/j.crpv.2013.06.001

to Lasiosynidae, are also known from Switzerland, Spain, England and Australia. A whole, well preserved beetle with a clearly visible ventral surface is commonly needed to reliably decide its placement within Elateriformia (and within Polyphaga in general). Isolated elytra, abundant and frequently found beetle remains, usually have no "specific" (familial) structures and cannot be unambiguously attributed to Elateriformia, or even to Polyphaga (Ponomarenko, 1969). Therefore, description of fossil elateriform beetles is often restricted to certain groups, such as Elateridae, Byrrhidae, and Buprestidae, in which some characteristic morphological features can be easily recognized in the fossil state. Thus, our knowledge about the huge variety of other fossil Elateriformia is still fragmentary (Ponomarenko, 1983).

The earliest mention of lasiosynid-like beetles may be traced back to the middle of the 19th century when Heer (1852) found a few poorly-preserved buprestid-like beetles in the Lower Lias of Switzerland, which is considered to be upper Lower Jurassic (Toarcian) now (Ponomarenko, 1985b), and assigned them to the jewel beetles. In the worldwide catalogue of Buprestidae (Bellamy, 2008), one of these beetles, *Glaphyroptera insignis* Heer, 1852, was included in the subfamily Buprestinae. More than 100 years elapsed after the mention of probable fossil buprestids in Heer's paper before A.G. Ponomarenko (1983) suspected the existence of some high-level new taxa, probably at the family or even higher level, within Mesozoic elateriform beetles. During this period, the beetles similar to Lasiosynidae were included in several extant families such as Buprestidae by Heer (1852), Elateridae, to which Handlirsh (1906) transferred half of Heer's *Glaphyroptera* species, Dascillidae (Martynov, 1926), Polyphaga incertae sedis (Ponomarenko, 1977), and Nitidulidae (Hong, 1983). Since 1983, the genera *Dzeregia* Ponomarenko (1985a) and *Artematopodites* Ponomarenko (1990), which were known previously from the USSR, have been described as Elateriformia incertae sedis, and in other countries they have been placed in different families and even suborders: Elateridae (Zhang, 1997) and Ademosynidae (Tan et al., 2007). In the last few years, considerable progress has been made in our understanding of the fossil Coleoptera due to the discovery of numerous well-preserved beetles from the Daohugou beds (Kirejtshuk et al., 2010b; Tan et al., 2007; Wang et al., 2009; Yan and Wang, 2010), and some finds in a few other localities (Yan, 2009; Yan and Zhang, 2010). Finally, the new family Lasiosynidae was erected (Kirejtshuk et al., 2010a) on the basis of the new finds from Daohugou and redescription of some former "ademosynids" from the same locality (Tan et al., 2007).

2. Material and methods

The specimen described herein comes from the Daohugou Lagerstätte, Ningcheng County, Inner Mongolia, China. The Daohugou fossil-bearing strata consist of mainly greyish white tuff, tuffaceous sandstone, tuffaceous siltstone and shale, and they are generally considered to be Middle Jurassic in age (Rasnitsyn and Zhang, 2004). The coleopteran assemblage is very diverse in the Daohugou fauna, and about 10 families have been described, and more fossils (especially Polyphaga) await description. The fossil insects are commonly preserved as carbonaceous compressions on the surface of grey tuffaceous siltstones, together with small freshwater conchostracans *Euestheria* sp. (Wang et al., 2009).

The specimen was examined dry and under alcohol, using a Nikon SMZ1000 stereomicroscope. Photographs were prepared using a digital camera (DXM1200) connected to the same stereomicroscope, and line drawings were readjusted on photographs using image-editing software (CorelDRAW X4, Adobe Photoshop CS and Helicon Focus). In the drawings, dotted lines indicate faintly seen parts and cleaved areas. Body length was measured along the midline from the mandibles to the elytral apices, and width was measured across the broadest part of the elytra. Pronotal length was measured along the midline; width was measured across the broadest part of the pronotum. In the present paper we refer to temples as the lateral regions of the head, starting from the posterior margins of the eyes and extending to the basal margin of the head. We tentatively followed the traditional terminologies summarized by Fedorenko (2009), and the venational terms by Kukalová-Peck and Lawrence (1993) are given in parentheses. The studied material is stored in the Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences (NIGPAS).

3. Systematic palaeontology

Order Coleoptera Linnaeus, 1758.
Superfamily Byrrhoidea Latreille, 1804
Family Lasiosynidae Kirejtshuk et al., 2010.
Genus *Lasiosyne* Tan et al., 2007.
Lasiosyne laxa n. sp. (Figs. 1–3).

3.1. Etymology

Species name from the Latin word "*Laxus*" – for "wide", referring to the stout body outline and transverse pronotum.

3.2. Material

Holotype NND04601. An almost complete beetle with right antenna and tarsi of a few legs missing.

3.3. Age and occurrence

Middle Jurassic; Daohugou Village, Chifeng City, Inner Mongolia, China.

3.4. Remarks

L. laxa differs from congeneric species in having the strongly transverse pronotum, antennae with distinctly heteromorphic antennomeres, and long, triangular and pointed abdominal ventrite 5.

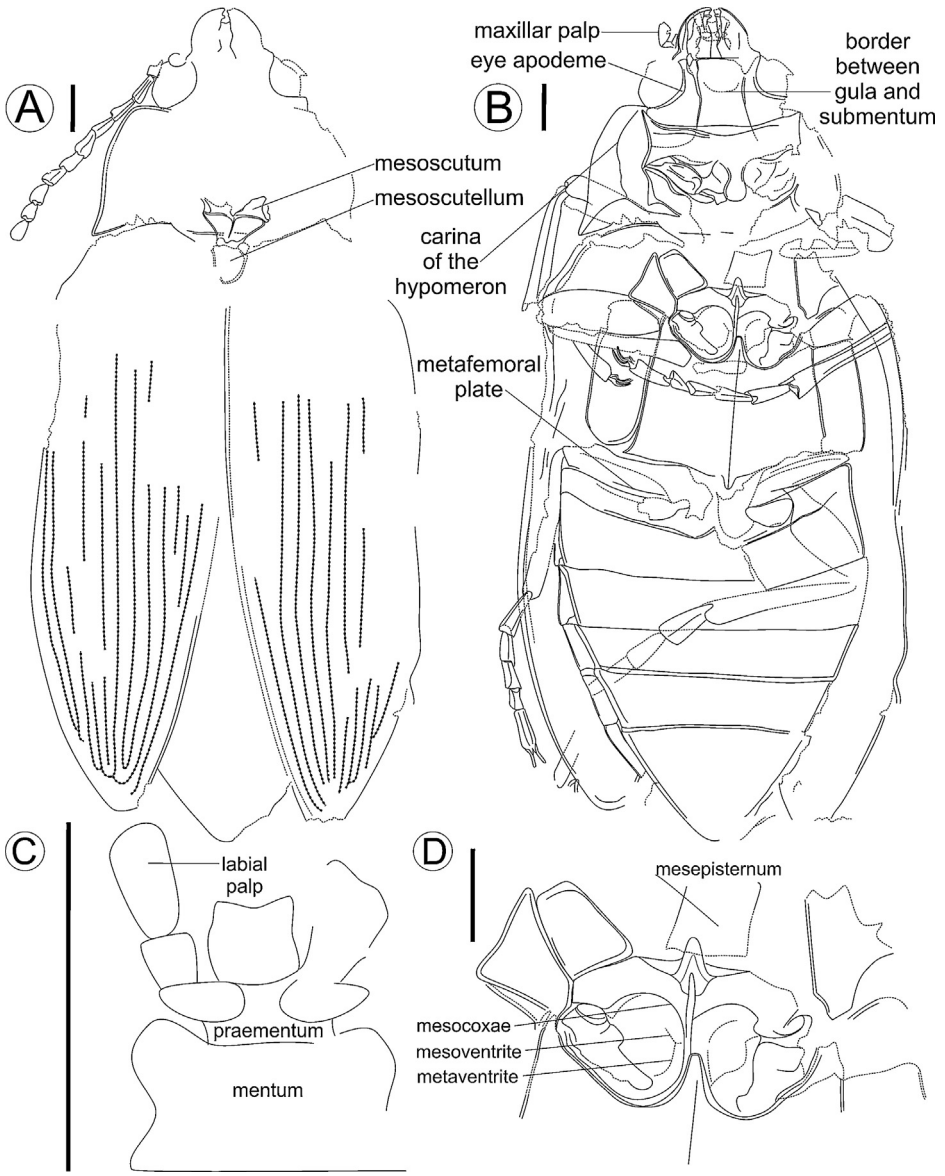

Fig. 1. *Lasiosyne laxa* n. sp. Line drawings of the holotype. **A**. Dorsal side. **B**. Ventral side. **C**. Detail of labium. **D**. Mesoventrite. Scale bars represent 1 mm.
Fig. 1. *Lasiosyne laxa* n. sp. Dessin au trait de l'holotype. **A**. Face dorsale. **B**. Face ventrale. **C**. Détail du labium. **D**. Mésoventrite. Les barres d'échelle représentent 1 mm.

3.5. Diagnosis

Antennae consisting of different types of antennomeres with 3–5 subtrapezoidal, elongated; 6–11 of sub-oval shape, stout and short; and distal half of antennae moniliform. Pronotum strongly transverse, twice as wide as long, slightly narrower anteriorly, with maximal width at hind margin, its anterior angles absent, and posterior ones notably projecting postero-laterally. Fifth abdominal ventrite triangular, and twice longer than each of the previous ventrites.

3.6. Description

Large beetle with broad, elongate body, maximal width at mid-length. Mandibles long, equal in length to eyes, triangular, distance between them less than ⅓ of the mandibular basal width. Outer margins of mandibles weakly curved, inner almost straight, apices blunt, each mandible with a small denticle in apical one third of its length. Antennae twice as long as pronotum. Scape oval-shaped, its maximal width only slightly exceeding width of the anterior margin of antennomeres 3–11. Pedicel long,

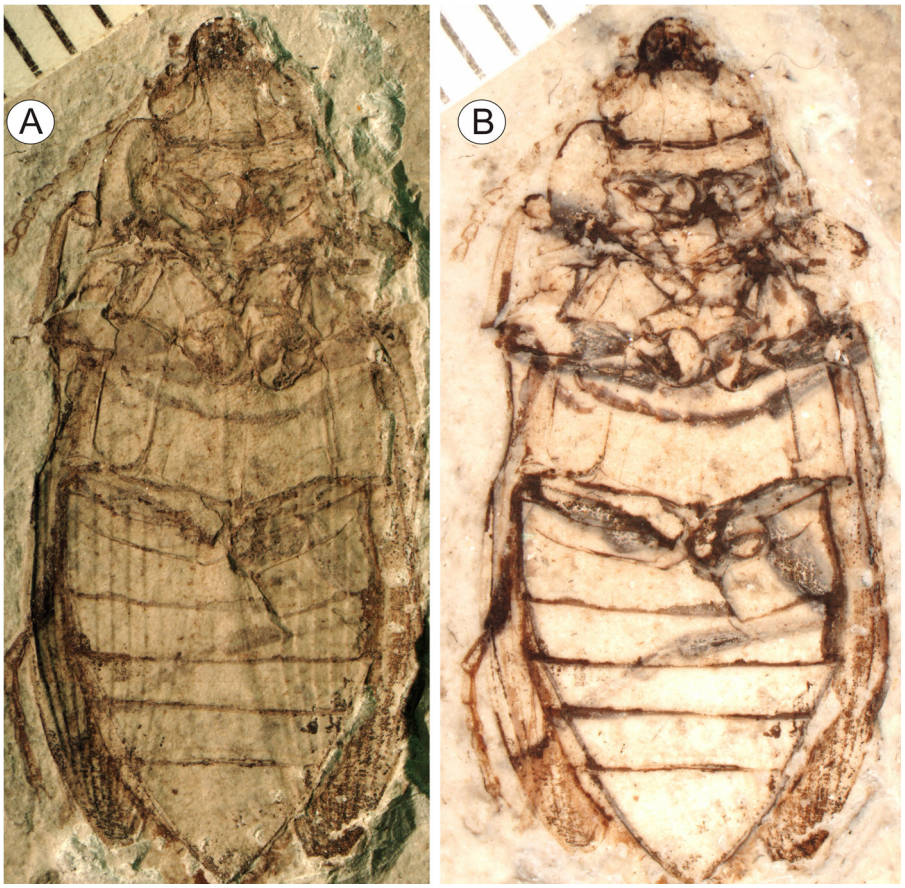

Fig. 2. *Lasiosyne laxa* n. sp. Photograph of the holotype. **A**. Dry. **B**. Under alcohol. Color available online.
Fig. 2. *Lasiosyne laxa* n. sp. Photographie de l'holotype. **A**. À sec. **B**. Dans l'alcool.

rectangular, equal in length to antennomeres 9–11. Antennomeres 3–5 subtrapezoidal, uniform, their length three times greater than width, anterior margins two times wide than base. Starting from the sixth, antennomeres become more of suboval shape with rounded anterior margins. Antennomeres 3–6 and 8 with gentle longitudinal keels (antennomere 3 with double keel). Eyes have maximal width in basal half, gradually narrowing anteriorly, their inner margins armed with wide eye apodemes. Temples are very long, not shorter than eyes, completely inserted into pronotum. Gular plate trapezoidal, long, not shorter, or a little longer than mandibles, its width at base one third of head width, its anterior angles somewhat protruded forward enveloping base of submentum. There is no demarcation between gular plate and submentum, their delimitation is possible only seen in difference in surface sculpture: deep transverse wrinkles with punctures on the gular plate (on the counterpart punctures look like big tubercles) and very big sparse punctures on the submentum. Gular sutures clearly visible and rather wide. Submentum quadrangular, its anterior margin thickened, width 1.5 times greater than length, sides with clearly visible incisions for receiving cardos. Only three apical palpomeres of maxillar palp visible, first two equal in length, 2.0 times shorter than drop-shaped apical palpomere. Mentum 1.5 times shorter than submentum, with rounded anterior angles projecting forward, its sides distinctly concave. Prementum 2.5 times narrower than mentum, labial palps three-segmented, ligula only slightly incised medially. First palpomere is drop-shaped, 1.6 times longer than the second which is square-shaped, apical palpomere of elongate-oval shape, twice as long as the previous palpomere. Postgenae densely covered with numerous deep, oblique furrows with punctures between them.

Pronotum with thick carinae all along its perimeter except the posterior margin where it becomes half as thick. Posterior margin of pronotum bisinuate. Proventrite rather short, 2.5 times shorter than pronotum (excluding intercoxal process), pronotal process long, equal in length to proventrite, fully dividing procoxae, its sides strongly concave, widened posteriorly to the broad, round apex. Proventrite with thickened anterior margin and sides, which lack sculpture, intercoxal process of proventrite also edged with thick margin. Procoxal cavities partially closed posteriorly with postcoxal projections. Hypomeron reinforced with carina, which extends from anterior angles of pronotum to its posterior angles and postcoxal projections. Proventrite surface entirely covered with deep, transverse wrinkles. Anterior mesoscutal arms well developed, their length equal to length of mesoscutum, median suture with

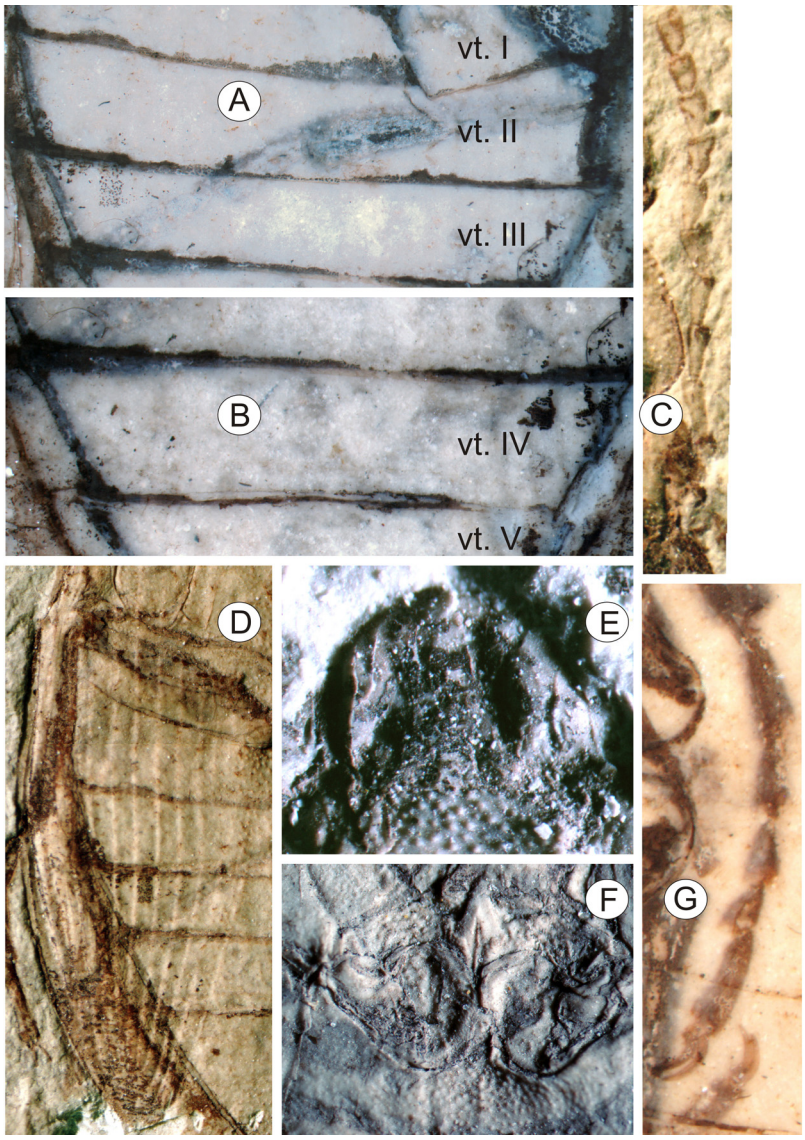

Fig. 3. *Lasiosyne laxa* n. sp. Photograph of the holotype. **A**. First three abdominal ventrites. **B**. Apical and preapical abdominal ventrites. **C**. Details of antennal structure. **D**. Details of elytral striation. **E**. Details of mentum and praementum. **F**. Meso-metaventral joint. **G**. Midtarsus (above), apical tarsomere of pretarsus (below). Color available online.
Fig. 3. *Lasiosyne laxa* n. sp. Photographie de l'holotype. **A**. Les trois premières ventrites abdominales. **B**. Ventrites abdominales pré-apicales et apicales. **C**. Détails de la structure de l'antenne. **D**. Détails de la striation de l'élytre. **E**. Détails du mentum et du pré-mentum. **F**. Articulation méso-métaventrale. **G**. Tarse médian (en haut) et tarsomère apical du pré-tarse (en bas).

two fully developed lateral arms, mesoscutellum semioval, rather big, 1.2 times longer than mesoscutum. Elytra have 12 deep striae with punctures, distance between two punctures equal to diameter of one puncture. Stria 2 (counting from the sutural margin) distinctly longer than the next one, apices of some striae merging near the elytral tip, enclosing other striae: 4 and 7 also surround merged apices of striae 5 and 6; 7 and 9 surround apex of 8th, apices of striae from 10 to 12 consequently merging with the previous stria posteriorly. Mesoventrite with long anterior process, short procoxal rests, deep cavity for receiving intercoxal process of proventrite and distinct, thick discrimen. Basal half of mesoventrite looks very narrow, only little wider than discrimen. In fact, this character seems to be a peculiarity of preservation, when prominent mesocoxae partially overlap the mesoventrite and latter becomes a "groove" on their surface (Fig. 1D). Mesoventral surface densely covered with big, deep punctures. Mesepisternum trapezoidal, mesepimeron triangular, both of them with thickened edges, densely covered with shallow punctures. Metaventrite with apices of its anterior angles slightly anterior of anterior intercoxal process, Anterior and lateral margins of metaventrite and also metepisterna are narrow edged. Posterior angles of metaventrite only slightly protruding laterally, not extending around posterior edges of metepisterna. Katepisternal

suture absent. Metaventral posterior process very narrow and short, with rounded apex. Surfaces of metaventrite and metepisterna densely covered with very deep punctures. Abdomen with slightly curved sides and pointed apex. Ventrites 1–4 equal in length, apical ventrite two times longer than each of the previous ones, triangular. Sides of ventrites and laterosternites thickened, their surfaces covered with dense, deep punctures. Metatrochanters big, their length about ⅓ of femoral length, Tibias of fore- and midlegs with longitudinal keels, double on midlegs. Tarsi with pair of long curved claws; claws longer than half-length of apical tarsomeres, their bases expanded. At least mid- and hindtarsi with longitudinal keels.

Measurements of holotype in mm: body length 17.7, width 7; elytra length 12.5, width 4.2; head length 3, width with eyes approximately 3.3; antennal length 5.5; prothoracic length 2.8, maximal width 5.6, abdominal length 7.5, width 6.3.

4. Discussion

The exact systematic position of Lasiosynidae remains open in the currently unstable elateriformian classification. In the original description (Kirejtshuk et al., 2010a), it was noted that lasiosynids possess characters encountered in several superfamilies of Elateriformia, which allows comparison with Dascilloidea, Buprestoidea, Elateroidea, or Byrrhoidea, without more precise attribution. In fact, most of the used characters, such as transverse coxae with exposed trochantins, retained sutures on meta- and, in some forms, also mesoventrites, and head of the prognathous type, appear to be just a complex of plesiomorphies (Lawrence et al., 2011) and could not be reliable evidence of the lasiosynid's close relationship with any of these superfamilies.

The wing of *Lasiosyne fedorenkoi* Kirejtshuk et al. (2010a, b) is rather helpful and excludes the possibility of placing Lasiosynidae in Dascilloidea with a short radial cell (some undescribed species from the Upper Jurassic of Shar-Teg in Mongolia and Lower Cretaceous of Baissa in Transbaikalia have an rc whose length is five times greater than its width), normally developed MP3 + 4 (but without base), and CuP (MP3) with free base. Such wing venation resembles primitive buprestids in the subfamily Schizopodinae. However, according to Fedorenko's (2009) scheme of beetle wing evolution, this resemblance reflects derivation of the buprestoid venation pattern from a more primitive byrrhoid one and could be found in some byrrhoid families, such as Elmidae, Lutrochidae (Crowson, 1982), Callirhipidae (Forbes, 1926), and Ptilodactylidae (Crowson, 1978). This also supports Crowson's hypothesis of the close connection of Buprestoidea and Byrrhoidea (Crowson, 1982). *L. fedorenkoi* clearly differs from Schizopodinae in having a simple, not bilobed, fourth tarsomere, and from all Buprestoidea in having a much less developed interlocking mechanism which never extends to the mesoventral cavity and transverse coxae. Within Byrrhoidea, Lasiosynidae were compared with the four families of the psephenoid stem: Eulichadidae, Cneoglossidae, Ptylodactylidae and Callirhipidae (Kirejtshuk et al., 2010a). Unlike most byrrhoids, *L. fedorenkoi* has wings with an elongate rather than oblique radial cell and a short apical field, which brings Lasiosynidae closer to Callirhipidae and Eulichadidae. Callirhipidae are similar to lasiosynids in general appearance, but differ in a strongly declined head, narrowly separated antennal insertions, absence of the frontoclypeal suture and type of antennae–pectinate or flabellate.

Significant morphological similarity can be observed between Lasiosynidae and the small, primarily Asian family Eulichadidae (lasiosynid remains are mainly known from central and eastern Asia). The external appearance of Lasiosynidae, especially the type genus *Lasiosyne*, makes this family very similar to eulichadids, with large fusiform bodies, prognathous heads and big hemispherical eyes. Lasiosynidae, however, are strongly sclerotized, usually have only 11–12 deep elytral striae with punctures and mandibles without scoop-like apices. In addition, they have a number of primitive character states such as a distinct frontoclypeal suture, while in eulihadids it is replaced with just a transverse depression (Hájek, 2007; Ivie, 2005). The discovery of *L. laxa* seems very important in understanding the place of lasiosynids within Byrrhoidea, because being a typical lasiosynid beetle, it possesses a few characters of the intermediate state. *L. laxa* is easily defined as a member of Lasiosynidae due to its big prognathous head with large, protruding mandibles and big eyes, fully divided procoxae, acute and protruded posterior pronotal angles, transverse coxae, elytra with shortened striae near the sutural margin, and meso- and metaventrites with longitudinal sutures. It definitely belongs to the genus *Lasiosyne* because of the coarse body sculpture, laterally protruding eyes, long temples, short proventrite, shortened second and third striae, and almost parallel-sided metaventrite. However, modern eulichadids and callirhipids have a transverse and trapeziform pronotum, and a katepisternal suture on the metaventrite, which is clearly visible on the metaventrite's basal third in the lasiosynid genera *Anacapitis* Yan (2009) and *Parelateriformius* Yan and Wang (2010), but is strongly shifted to the posterior margin in *Lasiosyne* Tan et al. (2007), and is completely absent in *L. laxa*. Moreover, all known Lasiosynidae are characterized by unfused abdominal ventrites, which distinguish lasiosynids from Eulichadidae with three connate basal ventrites. However, the discovery of a well-preserved abdomen in *L. laxa* n. sp. shows that the borders between these three ventrites are somewhat "thinner", without intersegmental membranes (Figs. 1B and 3A), which probably indicates their fusion. Before the discovery of Lasiosynidae, Crowson predicted that Eulichadidae, which he placed at the base of the trichotomy with Dryopoidea (which currently forms the Byrrhoidea) and the rest of the Elateriformia, should appear in the Lower Jurassic (Crowson, 1978; Ivie, 2005). Nevertheless, it seems reasonable to retain Lasiosynidae as a separate family, at least until the rich collections from Daohugou have been studied in detail.

In their original description, the family Lasiosynidae included four genera: *Lasiosyne*, *Anacapitis*, *Tarsomegamerus* Zhang, 2005 and *Bupredactyla*. In the present paper, the genus *Bupredactyla* is excluded from this family, Kirejtshuk et al. (2010a, b, fig. 51) showing normal pentamerous rather than "pseudotetramerous"

Table 1
Characters of the genera included in Lasiosynidae Kirejtshuk et al., 2010a, b.
Tableau 1
Caractères des genres inclus dans les Lasiosynidae Kirejtshuk et al., 2010a, b.

Characters	1	2	3	4	5	6	7	8
Anacapitis	0	0	0	0	0	0	0	0
Lasiosyne	1	1	1	1	2	1	0	1
Parelateriformius	0	0	0	1	1	0	1	1
Tarsomegamerus	0	0	0	1	0	0	1	1

tarsi, with small setal brushes on the ventral surface, and tarsomeres of subcylindrical but not of "moderately lobed" shape. The tarsomeres appear lobed because the tarsus is anteriorly orientated. Differences between *Bupredactyla* and *Lasiosyne* in habitus, shape of metepisterna and pronotum, occur only because *Bupredactyla* was preserved in lateral aspect, therefore it should be placed in *Lasiosyne*. The genus *Tarsomegamerus* shares some habitual similarities with *Parelateriformius*; however it differs from the rest of Lasiosynidae in having an elevated median portion of the prosternum as in some Elateridae and Byrrhidae; abdominal sternites with curved margins; very short first visible abdominal sternite; and third and fourth visible abdominal sternites separated by a wide membranous connection. In addition, *Tarsomegamerus* differs from *Parelateriformius* in having a long rc cell on the hind wings. *Tarsomegamerus* also lacks pseudotetramerous tarsi, five tarsomeres being seen in fig. 1e of Zhang, 2005 and also, but less clearly, in fig. 1d. Flattened portions of tarsomeres 2–4 overlapping each other make it difficult to define the shape of the tarsomeres, but this character could be seen in fig. 1f.

Here we propose the following four genera as belonging to the Lasiosynidae: *Anacapitis, Lasiosyne*, *Parelateriformius*, and *Tarsomegamerus*, with *Anacapitis* representing the least modified organization (Table 1), with all characters in the initial state, and *Lasiosyne* as the most derived; the genus *Parelateriformius* takes a somewhat intermediate position between them. The list of used characters is given below:

- eyes: (0) eyes do not protrude from the outline of the head; (1) eyes strongly protuberant;
- temples: (0) temples shorter than eyes; (1) temples equal, or slightly exceed length of eyes;
- prosternum: (0) length of prosternum two times greater than the length of its intercoxal process; (1) length of prosternum and its intercoxal process almost equal;
- punctures: (0) shallow grooves without punctures; (1) elytra with deep punctures in striae;
- elytral striae: (0) elytra without shortened striae; (1) second stria shortened (2) second and third striae shortened;
- metaventrites: (0) trapezoidal, with katepisternal suture fully exposed; (1) metaventrite rectangular with katepisternal suture strongly shifted to its posterior margin;
- lobes on tarsomeres: (0) absent; (1) tarsomeres 2–4 with short undivided lobes underneath;
- body sculpture: (0) body glabrous, with only sparse short hairs; (1) whole body roughly sculptured with dense punctures and tubercles.

All the above-mentioned genera were described on the basis of wholly preserved beetle material, but in many localities isolated elytra are most common without any bodies; thus here we place three additional genera within Lasiosynidae: *Artematopodites*, *Dzeregia* and *Glaphyroptrodes* Handlirsch, 1906. Initially, these genera had the status of "Polyphaga incertae sedis" and could not be associated with any beetle taxa because polyphagan elytra usually have "non-specific" systematic structures. With the recent finds of completely preserved beetles with the elytra of the same structure in the Chinese locality of Daohugou (Tan et al., 2007), it is possible to place these genera within Lasiosynidae.

Elytra of lasiosynid beetles are morphologically highly diverse, but rather easily divided into two morphotypes. Representatives of the genus *Dzeregia* have broad elytra without a median incision on the outer margin, deep, punctate striae and shortened stria 2. In *Dzeregia* small, strongly convex elytra probably belong to some forms of Byrrhidae, but bigger elytra look very similar to the elytra of *Parelateriformius* in Lasiosynidae. The majority of described isolated elytra, however, belong to the genus *Artematopodites*, which differs from *Dzeregia* in having a somewhat more elongated shape, two shortened striae and an incision on the outer elytral margin. The genus *Glaphyropterodes* differs from the previous two in having striae formed only by deep punctures.

Here, we therefore propose six genera for the family Lasiosynidae: *Anacapitis* (3 species), *Lasiosyne* (6 species), *Parelateriformius* (4 species), *Artematopodites* (9 species), *Dzeregia* (7 species) and *Glaphyropterodes* (2 species), with 31 species in total.

Acknowledgements

The authors are deeply grateful to A.G. Ponomarenko (PIN), J. F. Lawrence (CSIRO) and A.G. Kerjtshuk (ZIN) for their assistance in the preparation of this paper. Many thanks go to reviewers for reviewing the manuscript and providing some constructive suggestions and to Ed. Jarzembowski for checking the English language of the manuscript. This research was financially supported by the China Postdoctoral Science Foundation, the National Natural Science Foundation of China (Grant Nos. 40872015, 41002006, J093000) and National Basic Research Program of China (Grant No. 2012CB821900).

References

Bellamy, C.L., (volumes 1–5, No. 76–80) 2008/2009. A world catalogue and bibliography of the jewel beetles (Coleoptera: Buprestoidea). Pensoft Series Faunistica, Sofia-Moscow, pp. 1–3264.
Crowson, R.A., 1978. Problems of phylogenetic relationships in Dryopoidea (Coleoptera). Entomol. Germ. 4, 250–257.
Crowson, R.A., 1982. On the dryopoid affinities of Buprestidae. Coleopterists Bull. 36, 22–25.
Fedorenko, D.N., 2009. Evolution of the beetle hind wing with special reference to folding (Insecta, Coleoptera). Pensoft, Sofia-Moscow, pp. 1–336.
Forbes, W.T.M., 1926. The wing folding pattern of Coleoptera. J. N. Y. Entomol. Soc. 34, 42–68 (91–139).
Handlirsh, A., 1906/1908. Die fossilen Insecten und die Phylogenie der rezenten Formen. Wilhelm Engelmann, Leipzig, pp. 1–1430 (in German).

Hájek, J., 2007. Revision of the genus *Eulichas* Jacobson, 1913 (Coleoptera, Eulichadidae) I. Introduction, morphology of adults, key to subgenera and species groups, and taxonomy of E. funebris species group. Zootaxa 1620, 1–35.

Heer, O., 1852. Die Lias Insel in Aagrau mit einen Tafel Lias-Insecten. E. Kiesling, Zurich, pp. 1–15 (in German).

Hong, Y., 1983. Middle Jurassic fossil insects in North China. Geological Publishing, Beijing, pp. 1–223.

Ivie, M.A., 2005. 18.11. Eulichadidae Crowson, 1973. In: Beutel, R.G., Leschen, R.A.B. (Eds.), Handbuch der Zoologie/Handbook of zoology. Band/Volume IV Arthropoda: Insecta Teilband/Part 38. Coleoptera, Beetles. Volume 1. Morphology and systematics (Archostemata, Adephaga, Myxophaga, Polyphaga partim). W. DeGruyter, Berlin, pp. 547–551.

Kirejtshuk, A.G., Chang, H., Ren, D., Shin, C.K., 2010a. Family Lasiosynidae n. fam., new palaeoendemic Mesozoic family from the infraorder Elateriformia (Coleoptera, Polyphaga). Ann. Soc. Entomol. Fr. 46, 231–247.

Kirejtshuk, A.G., Ponomarenko, A.G., Prokin, A.A., Chang Huali, Nikolajev, G.V., Ren, D., 2010b. Current knowledge of Mesozoic Coleoptera from Daohugou and Liaoning (Northeast China). Acta Geol. Sin. 84, 783–792.

Kukalová-Peck, J., Lawrence, J.F., 1993. Evolution of the hind wing in Coleoptera. Can. Entomol. 125, 181–258.

Lawrence, J.F., Ślipiński, A., Seago, A.E., Thayer, M.K., Newton, A.F., Marvaldi, A.E., 2011. Phylogeny of the Coleoptera based on morphological characters of adults and larvae. Ann. Zool. Warszawa 61, 1–217.

Martynov, A.V., 1926. A contribution to the knowledge of fossil insects from Jurassic shales in Turkistan. On some forms of beetles (Coleoptera). Ezhegod. Russk. Paleontol. Ob-va 5, 1–38 (in Russian).

Ponomarenko, A.G., 1969. The historical development of archostema beetles. Tr. Paleontol. Inst. Akad. Ski. USSR 125, 1–239 (in Russian).

Ponomarenko, A.G., 1977. Composition and ecological characteristics of Mesozoic coleopterans. In: Arnoldy, L.V., Zherikhin, V.V., Nikritin, L.M., Ponomarenko, A.G. (Eds.), Mesozoic Coleoptera. Proc. Acad. Sci. USSR. Nauka, Moscow, pp. 1–117 (in Russian).

Ponomarenko, A.G., 1983. The historical development of Coleoptera. Extended abstracts of doctoral dissertation in biology. Paleontol. Inst. Akad. Ski. USSR, 1–47 (in Russian).

Ponomarenko, A.G., 1985a. Beetles from the Jurassic of Siberia and western Mongolia. In: Rasnitsyn, A.P. (Ed.), Jurassic insects of Siberia and Mongolia. Tr. Paleontol. Inst. Akad. Sci. USSR. Nauka, Moscow, pp. 47–87 (in Russian).

Ponomarenko, A.G., 1985b. Fossil insects from the Tithonian "Solnhofener Plattenkalke". Ann. Naturhist. Mus. Wien 87, 135–144.

Ponomarenko, A.G., 1990. Beetles. In: Rasnitsyn, A.P. (Ed.), Late Mesozoic insects of eastern Transbaikalia. Tr. Paleontol. Inst. Akad. Sci. USSR. Nauka, Moscow, pp. 39–87 (in Russian).

Rasnitsyn, A.P., Zhang, H., 2004. Composition and age of the Daohugou Hymenopteran assemblage from Inner Mongolia, China. Palaeontology 47, 1507–1517.

Tan, J., Ren, D., Shin, C., 2007. New beetles (Insecta, Coleoptera, Archostemata) from the late Mesozoic of North China. Ann. Zool. 57, 231–247.

Wang, B., Li, J., Zhang, H., Fang, Y., 2009. Preliminary elemental analysis of fossil insects from the middle Jurassic of Daohugou, Inner Mongolia and its taphonomical implications. Chin. Sci. Bull. 54, 783–787.

Yan, E.V., 2009. A new genus of elateriform beetles (Coleoptera. Paleontol. Zh. 3, 51–56.

Yan, E.V., Wang, B., 2010. A new genus of elateriform beetles (Coleoptera, Polyphaga) from the Jurassic of Daohugou, China. Paleontol. Zh. 1, 71–75.

Yan, E.V., Zhang, H., 2010. New beetle species of the formal genus Artematopodites (Coleoptera, Polyphaga), with remarks on the taxonomic position of the genera Ovivagina and Sinonitidulina. Paleontol. Zh. 4, 88–93.

Zhang, H., 1997. A new genus of Elateridae (Insecta, Coleoptera) from lower-middle Jurassic of Jungar Basin, Xinjiang, China. Acta Micropalaeontol. Sin. 1, 71–77.

Zhang, J., 2005. The first find of chrysomelids (Insecta: Coleoptera: Chrysomeloidea) from Callovian-Oxfordian Daohugou biota of China. Geobios. 38 (6), 865–871.