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A new genus of Lophioneuridae (Thysanoptera s.l.) with elytrized forewings from mid-Cretaceous Burmese amber

Новый род Lophioneuridae (Thysanoptera s.l.) с элитризованными передними крыльями из среднемелового бирманского янтаря

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КЛЮЧЕВЫЕ СЛОВА: трипсы, Paraneoptera, миниатюризация, палинофагия.

ABSTRACT. A new genus and species of minute lophioneurids with elytrized forewings from mid-Cretaceous Burmese amber, *Iotacypha zherikhini* **gen.** et **sp.n.**, is separated along with *Burmacypha longicornis* Zherikhin, 2000 into the subfamily Iotacyphinae **subfam.n.**

РЕЗЮМЕ. Новый род и вид миниатюрных лофионеврид с элитризованными передними крыльями из среднемелового бирманского янтаря, *Iotacypha zherikhini* **gen.** et **sp.n.**, выделен вместе с *Burmacypha longicornis* Zherikhin, 2000 в подсемейство Iotacyphinae **subfam.n.**

Lophioneuridae were originally described in Homoptera, but later were transferred to Psocoptera [Tillyard, 1921, 1935]. Based on the forewing venation, Sharov [1972] demonstrated that lophioneurids are ancestral to thrips. Zherikhin [1980] and Vishniakova [1981] included Lophioneuridae in Thysanoptera s.l. as a primitive suborder Lophioneurina due to the similar structure of their mouthparts and tarsi. Zherikhin [2000] described a peculiar minute lophioneurid with elytrized forewings from mid-Cretaceous Burmese amber. Here we report a new Burmese amber genus with such forewings and establish a new subfamily for these two genera, comprising the smallest known lophioneurids with the forewing length less than 1 mm.

The Early Permian *Cyphoneura permiana* Carpenter, 1932 and *Cyphoneurodes patriciae* Beckemeyer, 2004 (both with forewing length 1.9 mm), the Middle Permian *Zoropsocus tomiensis* Becker-Midgisova, 1961, and the Late Permian *Z. stanleyi* Davis, 1942 (both with forewing length 1.5 mm or more) are the smallest winged insects known from the Paleozoic [Beckemeyer, 2004]. The Late Cretaceous *Jantardachus* spp. (forewing length 1.0 mm or more) and the mid-Cretaceous *Burmacypha* and *Iotacypha* **gen.n.** (forewing length 0.6–0.8 mm) are even smaller. The latter two genera are the smallest described lophioneurids, of the size of small living thrips (see e.g. Polilov, Shmakov [2016]), but more squat and broad-winged. The true thrips are well known as spore and pollen feeders [Ananthakrishnan, 1993; Heming, 1993] and have used this feeding mode since the Mesozoic [Peñalver *et al.*, 2012] and possibly since the Permian [Zherikhin, 2002]. The Thysanoptera s.l. is considered an ancient group of gymnosperm pollen feeders, as indicated by the possible consumption of Early Permian progymnosperm spores by Lophioneuridae [Wang *et al.*, 2009]. Palynophagy is also suggested for iotacyphines, whose beetle-like habit implies they may have dwelt inside male strobiles.

The type specimens are deposited at Borissiak Paleontological Institute, Russian Academy of Sciences, Moscow (PIN). Imaging was done using a Nikon E-800 compound microscope equipped with Olympus OM-D E-M10-II digital camera. Stacks of images, comprising multiple focal planes, were treated for color, digital noise and sharpness with Adobe Lightroom. Focus stacking was performed with Helicon Focus 7.6.2. Some photographs were taken using a Leica M165C stereomicroscope with a Leica DFC425 digital camera and a Zeiss Axioplan 2 microscope with a Zeiss Axiocam 105 digital camera. We are grateful to Dmitry Vorontsov (Koltzov Insti-

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tute of Developmental Biology RAS) for superb images and to Eugeny Karasev and Roman Rakitov (both PIN) for help with photography.

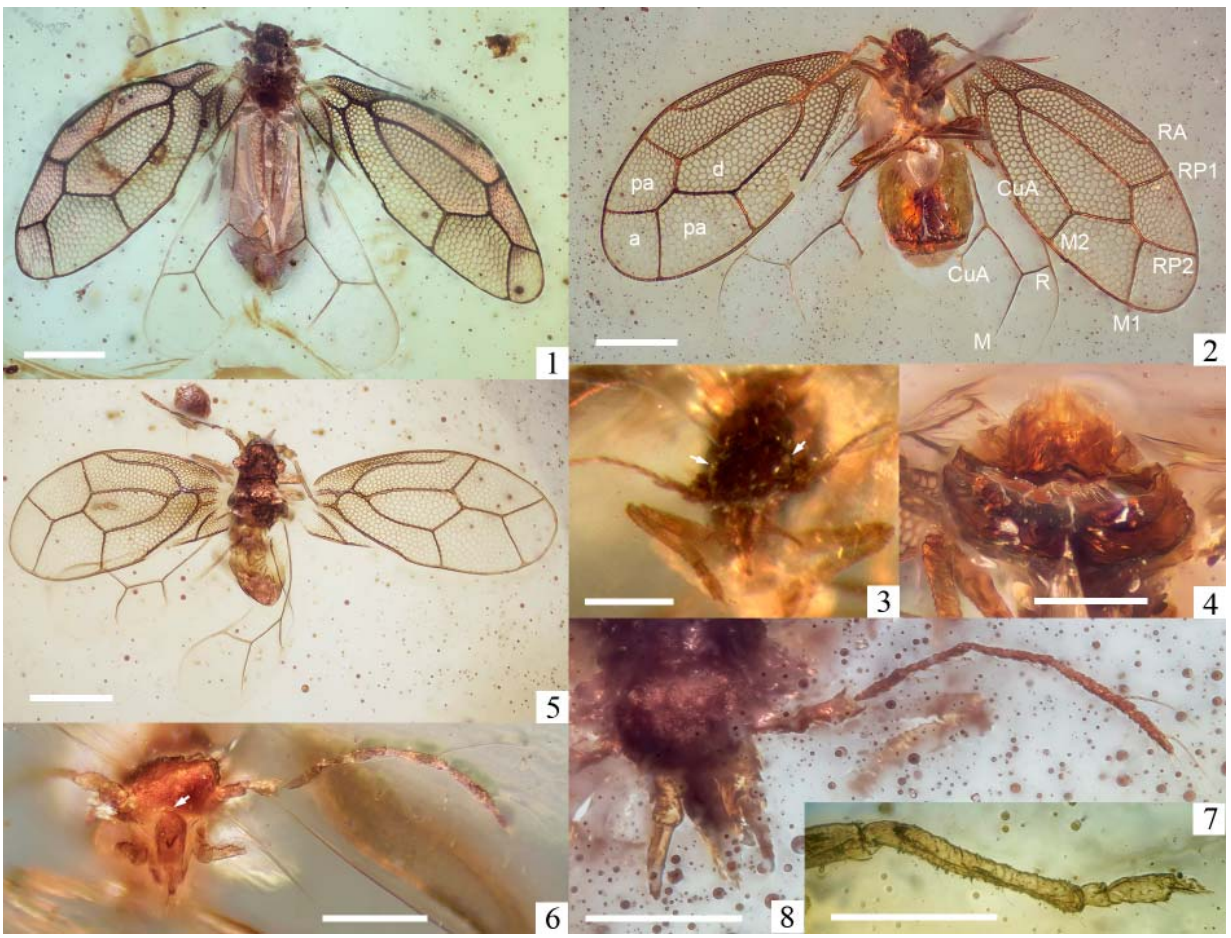
Order Thysanoptera Haliday, 1836, s.l.
Suborder Lophioneurina Zherikhin, 1980
Family Lophioneuridae Tillyard, 1921
Subfamily Iotacyphinae Shcherbakov, Bashkuev et Shmakov, **subfam.n.**

TYPE GENUS. *Iotacypha* Shcherbakov, Bashkuev et Shmakov, **gen.n.**

DIAGNOSIS. Distinct from remaining Lophioneuridae in elytrized, convex, finely areolate forewings and a very small ovipositor. In other lophioneurids the forewings are flat, somewhat more sclerotized than the hind wings, lacking areolate microsculpture, and the ovipositor is well developed, with cutting valvulae.

COMPOSITION. Type genus and *Burmacypha* Zherikhin, 2000, both from mid-Cretaceous Burmese amber.

REMARKS. The families Lophioneuridae and Cyphoneuridae were described from the Permian as Homoptera by Tillyard [1921] and Carpenter [1932], respectively. Tillyard [1935] merged these families, described the allied Permian family Zoropsocidae and placed it along with Lophioneuridae in Psocoptera. Becker-Migdisova described the genus *Lophioneurodes* Becker-Midgisova, 1953, bridging the gap between Lophioneuridae and Zoropsocidae, and united these two families [Becker-Midgisova, 1961]. Vishniakova [1981] retained Lophioneurinae and Zoropsocinae as subfamilies and for the first time described Mesozoic Lophioneuridae, including two species from Late Cretaceous Taimyr amber. Jell and Duncan [1986] described the monotypic family Edgariekiidae



Figs 1–8. *Iotacypha zherikhini* Shcherbakov, Bashkuev et Shmakov, **gen.** et **sp.n.** (photographs by Dmitry Vorontsov, except 3): 1 — female paratype PIN 5608/281, habitus, dorsal; 2–4 —female holotype PIN 5608/173: 2 — habitus, ventral (a, apical cell; d, discal cell; pa, preapical cell); 3 — head, frontal (arrows, lateral ocelli); 4 — apex of abdomen, caudal; 5–7 — male paratype PIN 5608/280: 5 — habitus, dorsal; 6 — head and antenna, frontal (arrow, median ocellus); 7 — hind tibia and tarsus; 8 — female paratype PIN 5608/279, head and antenna, frontal. Scale bars: 1, 2, 5 — 0.2 mm; 3, 4, 6–8 — 0.1 mm.

Рис. 1–8. *Iotacypha zherikhini* Shcherbakov, Bashkuev et Shmakov, **gen.** et **sp.n.** (фото Дмитрия Воронцова, кроме 3): 1 — паратип ПИН 5608/281, самка, общий вид сверху; 2–4 — голотип ПИН 5608/173, самка: 2 — общий вид снизу (a – апикальная, d – дискальная, pa – преапикальная ячейки); 3 — голова спереди (стрелки – боковые глазки); 4 — вершина брюшка сзади; 5–7 —паратип ПИН 5608/280, самец: 5 — общий вид сверху; 6 — голова и усик спереди (стрелка – срединный глазок); 7 — задняя голень и лапка; 8 —паратип ПИН 5608/279, самка, голова и усик спереди. Длина масштабных линеек: 1, 2, 5 — 0,2 мм; 3, 4, 6–8 — 0,1 мм.

from the Lower Cretaceous in Psocoptera, but Ansorge [1996] synonymized it under Lophioneuridae. Our observations confirm that there is no reason to distinguish between Lophioneurinae and Zoropsocinae even at the subfamily level.

Genus *Iotacypha* Shcherbakov, Bashkuev et Shmakov, **gen.n.**

TYPE SPECIES. *Iotacypha zherikhini* Shcherbakov, Bashkuev et Shmakov, **sp.n.**

DIAGNOSIS. Minute subbrachypterous lophioneurids. Forewings weakly elongated, strongly sclerotized, deeply convex; veins carinate, beset with strong curved setae; membrane finely areolate; Sc absent; RA long sigmoidal, leaving short R+M stem before separation of M (short RP+M stem developed); arculus (basal *m-cu* crossvein) between R+M and CuA; veins at wing apex Y-shaped (apical cell petiolate); discal cell bordered by 4 cells; clavus short and broad. Hind wings narrow, with long R+M+CuA stem, R and M separating distally; R, M and CuA subtransverse; clavus areolate. Antennae 7-segmented, at most 1/2 as long as forewing, scape and pedicel stout, flagellum moderately slender. Ocelli far apart, lateral ocelli close to eyes, median ocellus near clypeus. Pronotum short, saddle-shaped. Hind coxae enlarged. Tibiae with rows of setae. Tarsi 2-segmented; two slender curved claws. Genitalia very small.

COMPOSITION. Monobasic.

REMARKS. Similar to *Burmacypha* Zherikhin, 2000 in very small size, convex areolate forewings and the hindwing venation, but in the latter genus the veins at the forewing apex are H-shaped (apical cell is not petiolate), the discal cell is bordered by 7 cells, and the antennae are at least 2/3 forewing length with a filiform flagellum. Similar to *Jantardachus* Vishniakova, 1981 from Late Cretaceous Taimyr amber in very small size, 7-segmented antennae, absence of Sc and short CuA in forewings, but in the latter genus forewings are non-areolate, RA leaves the R stem after separation of M, tarsi and claws are shorter.

ETYMOLOGY. From Greek *iota* (smallest letter of Greek alphabet; anything very small) and genus *Burmacypha*; gender feminine.

Iotacypha zherikhini Shcherbakov, Bashkuev et Shmakov, **sp.n.**
Figs 1–8.

MATERIAL. Holotype PIN 5608/173, female; paratypes PIN 5608/279, 281, females, 280, male, 19b, female mesonotum with forewings, 128f, pair of isolated male forewings — Burmese amber, Hukawng Valley, Kachin State, Myanmar; mid-Cretaceous (Albian–Cenomanian).

DESCRIPTION. Smallest lophioneurids: body length 0.4–0.65 mm (as preserved). Subbrachypterous. Forewings 0.6–0.8 mm long, weakly elongated (2.1–2.3:1), deeply convex, strongly sclerotized (especially proximally), shallowly tectiform in repose; wing base pale; membrane translucent, covered with stub-like microtrichia and fine dark hexagonal areolation, cellules increase and somewhat fade towards apex; veins dark, raised, beset with strong curved setae (including distal C). C not carinate, Sc absent. RA sigmoidal, as long as wing width, leaving short R+M stem about its midlength (short RP+M stem developed). Arculus (basal *m-cu* crossvein) between R+M and CuA closing broad basal cell. RP and M both forked about 2/3 wing length, RP1 and M2 transverse, oblique RP2 and M1 fused for a short distance, forming petiole of cell enclosing wing apex. Discal cell bordered by 4 cells. Clavus short and broad, with two anal veins. Hind wings narrow, broadly rounded at apex; veins dark; R+M+CuA stem dividing distal to 1/2 wing length, R and M separating distal to 1/3 wing length; R, M and CuA subtransverse; claval furrow distinct; clavus with areolation, more pronounced posteriorly along thick marginal vein.

Antennae 7-segmented, at most 1/2 as long as forewing; scape and pedicel stout; flagellum moderately slender; first and last flagellomeres shortest, at least two terminal flagellomeres with very long curved setae. Eyes protruding, rounded; ommatidia few in number, loosely arranged. Cranium in anterior aspect transverse with lower margin trapezoidal; lateral ocelli near eyes; median ocellus near base of clypeus; clypeus oblong-ovate. Mouth cone elongated with dark apex; maxillary palps moderately long, stout, 2-segmented, 2nd segment long, with very long falcate fleshy seta near base; labial palps short, unsegmented, each with short fleshy seta beyond midlength. Pronotum transverse, saddle-shaped; mesoscutum subtriangular. Legs rather short, hind tibia less than 1/4 forewing length. Hind coxae largest. Tibiae with rows of setae. Tarsi 2-segmented, basitarsus about 1/2 distitarsus length; two slender curved claws. Female and male genitalia very small, directed dorsally as preserved. Ovipositor as long as hind tarsus, concealed between last tergite and sternite, valvulae not cutting.

Sexually dimorphic. Females larger than males: body length 0.6–0.65 vs 0.4 mm (as preserved). Female forewings larger (about 0.8 mm long), more narrowly rounded at apex, RP1 apex more distant from RA, discal cell longer than each of two preapical cells, areolation coarser and darker; male forewings smaller (0.6–0.7 mm long), more broadly rounded at apex, RP1 apex nearer to RA, discal cell about as long as each of two preapical cells, areolation finer and paler. Very long curved setae on two terminal flagellomeres in females, on all flagellomeres in males. Female abdomen longer and wider than head + thorax, pregenital segments sclerotized, dark; male abdomen about as long and wide as head + thorax, pregenital segments translucent.

ETYMOLOGY. In memory of paleoentomologist Vladimir Zherikhin, who made a great contribution to our knowledge of lophioneurids.

Competing interests. The authors declare no competing interests.

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