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A new species of *Proneuronema* (Neuroptera: Hemerobiidae) from late Eocene Rovno amber

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Abstract

Proneuronema sidorchukae **sp. nov.** (Neuroptera: Hemerobiidae: Drepanepteryginae) is described from the late Eocene Rovno amber, Ukraine. It is most similar to *P. minor* from Baltic amber, but easily distinguished from it by some crossveins in the third gradate series of the forewing broadly margined with dark brown, the proximal part of the costal space narrower, and proximal subcostal veinlets more oblique. The new species is the smallest known of the genus, with a forewing length of 5.9 mm. Rovno amber hemerobiids show a tendency to decrease in size compared to congeneric or conspecific specimens from Baltic amber. The morphology and terminology of the mesonotum in Hemerobiidae is discussed.

Key words: Neuroptera, Hemerobiidae, Rovno amber, Baltic amber, Eocene

Introduction

The family Hemerobiidae today consists of more than 520 extant species, distributed worldwide (Oswald 2018). It has a rich fossil record, especially from the Cenozoic, with 25–26 species described from the Late Jurassic to the Miocene (see a list in Yang *et al*. 2018a), and there are many undescribed specimens.

Nine extinct genera are known: The Late Jurassic *Promegalomus* Panfilov, 1980; the Cretaceous *Purbemerobius* Jepson *et al*., 2012, *Cretomerobius* Ponomarenko, 1992, *Hemeroberotha* Makarkin & Gröhn, 2019, and *Plesiorobius* Klimaszewski & Kevan, 1986; the Eocene *Prolachlanius* Krüger, 1923, *Prospadobius* Krüger, 1923, *Proneuronema* Makarkin *et al.,* 2016 and *Bothromicromus* Scudder, 1878 (but see remarks on this genus in Makarkin *et al.* 2016).

The genus *Proneuronema* includes three Eocene species: *P. wehri* (Makarkin *et al*., 2003) from the early Eocene of North America, and *P. minor* Makarkin *et al*., 2016 and *P. gradatum* Makarkin *et al*., 2016 from Baltic amber. Also, there are undescribed and unnamed species certainly belonging to this genus from the early Eocene of Denmark (the Fur Formation) (e.g., Henriksen 1922: Fig. 5; Larsson 1975: Fig. 6; Rust 1999: Fig. 81, Pl. 24b, c), and from Northern Germany, e.g., Havighorst (Illies 1941: Fig. 4) and Greifswalder Oie Island (Obst & Ansorge 2012: Fig. 10).

Here, we describe a new species of *Proneuronema* from Rovno amber. The well-preserved mesonotum of the new species allowed us to analyze and partly revise its terminology.

Material and methods

We describe the new species based on one specimen embedded in a relatively large piece of Rovno amber (233 x 74 x 59 mm) without sininclusions (except stellate hairs). It was collected 11 km NW from Voronki in the Vladimirets

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District of the Rovno Region, Ukraine. An overview of Rovno amber and its biota was provided by Perkovsky *et al.* (2010), Sokoloff *et al.* (2018) and Perkovsky & Makarkin (2019, and references therein). The latest data on the fauna and flora of amber from the Vladimirets District was reported by Ignatov *et al.* (2019) and Jałoszyński & Perkovsky (2019).

Venational terminology follows Makarkin *et al*. (2016).

Abbreviations: AA1–AA3, first to third anterior anal vein; CuA, Anterior Cubitus; CuP, Posterior Cubitus; hp, humeral plate; hv, humeral veinlet; MA and MP, anterior and posterior branches of Media; ORB1, ORB2, first and second oblique radial branches; RA, Anterior Radius; RP, Posterior Radius; RP1–RP3, first (proximal-most) to third branches of RP; ScP, Subcosta Posterior.

Institutional abbreviations: SIZK, Schmalhausen Institute of Zoology, National Academy of Sciences of Ukraine, Kiev, Ukraine.

Systematic paleontology

Order Neuroptera Linnaeus, 1758

Family Hemerobiidae Leach, 1915

Subfamily Drepanepteryginae Krüger, 1922

Genus *Proneuronema* Makarkin *et al*., 2016

Proneuronema sidorchukae sp. nov.

Figs 1–3

Type material. Holotype SIZK L-116, collected by Nikolai R. Khomich and currently deposited in his collection, but will be ultimately deposited in SIZK. A nearly complete specimen in the resting position, with wings folded steeply roof-like.

Type locality and horizon. Rovno amber (11 km NW from Voronki in Vladimirets District of Rovno Region, Ukraine). Late Eocene.

Etymology. The species is named in memory of Ekaterina A. Sidorchuk (1981–2019), a Russian paleoentomologist.

Diagnosis. Easily distinguished from other species of the genus by forewing maculation: some crossveins in third gradate series broadly margined with dark brown.

Description. Head cuneiform in lateral view, but obscured by milky covering. Eyes relatively large. Postocular lobe narrow. Vertex covered with strong setae. Antennae moderately long. Scapus rather large; pedicellus slightly broader than first flagellomeres; flagellum 41-segmented (right antenna).

Pronotum, mesonotum covered with dense relatively long setae. Prothorax rather short. Mesothorax: prescutum narrow, slightly convex; anterior part of mesoscutum (anteriad parapsidal sutures) triangular, divided into two by longitudinal median suture; posterior part of mesoscutum consisting of two lateral rounded convex lobes, strongly constricted concave medial part; in middle of notum, transversal medial ridge well developed; mesoscutellum rather large, posteriorly rounded, convex.

Legs: Forecoxa very long. Forefemur, mesofemur relatively short, rather stout. Metatibia long (1.5 times longer than metafemora), slightly curved and thinner proximally, not especially swollen medially. Metatarsus relatively short, metabasitarsus longest.

Forewing oval, 5.9 mm long, 2.4 mm wide. Costal space broad, dilated approximately at basal quarter of wing length. Most subcostal veinlets forked once (except three basal veinlets, which are each forked twice in right wing), distal veinlets simple; humeral veinlet strongly recurrent, with five branches (four simple, one forked). One occasional crossvein (aberrant) between stems of two basal veinlets in right wing. Subcostal space moderately broad, with four (right wing) to five (left wing) crossveins: one basal, one intermediate, one to three distal (distal part of subcostal space poorly visible in right wing). RA with few branches distally: posterior trace of RA one forked with one once-forked veinlet in both right, left wings (plus one simple posterior branch in right wing, probably aberrant). RA space (in this genus between RA, ORB2) rather broad with two crossveins belonging to third, fourth gradate series. RP with two ORBs. ORB1 with two branches directed anteriorly, originating proximad third gradate series of crossveins (both branches forked one to three times distad fourth gradate series); posterior trace of ORB1 deeply dichotomously forked proximad fourth gradate series. ORB2 (RP proper) with four branches originating proximad fourth gradate series (of these, one deeply forked in right wing), most forked once. M basally not fused with R, forked distad origin of ORB1. MA deeply forked at third gradate series (right wing) or relatively shallowly forked distad fourth gradate series (left wing). MP deeply forked between third, fourth gradate series. CuA with five (left wings) or four (right wing) pectinate branches, mostly once forked. CuP deeply forked, both branches shallowly once forked, except simple posterior branch in right wing. AA1 rather deeply forked, somewhat distad mid-point; both branches shallowly forked. AA2 deeply forked, proximad mid-point; both branches shallowly forked (right wing). AA3 forked near its origin (anterior branch with two short branches, posterior branch simple). Four gradate series of crossveins present: First (basal) series consists of six crossveins, from M to AA3 (including basal crossvein between CuA, CuP); second series includes three–four crossveins from ORB1 to CuP (crossvein between ORB1, MA not discernible in right wing,); third ("inner") series consists of nine crossveins, from RA to CuA; fourth ("outer") series complete, consists of 21 (left wing), 22 (right wing) crossveins from RA to AA1. Two basal-most crossveins proximad first series in anal space: one between AA2, AA3, one between branches of AA3. Four folds clearly discernible: (1) between posterior trace of ORB1, M/MA longest (radiomedial flexion line or medial flexion line); (2) between M, Cu short (mediocubital flexion line); (3) between Cu/CuP, AA1 long (cubitoanal flexion line or claval flexion line); (4) between AA1, AA2 rather long (intraanal flexion line). Wing membrane fuscous with distinct color pattern consisting of broad dark brown bordering of some crossveins in third gradate series.

Hind wings mostly not visible (hidden by forewings), except apical part of right wing, narrow outer to posterior parts of left wing. ScP, RA not fused distally, with at least one distal subcostal crossvein. RA with two forked veinlets.

Abdomen not visible, wholly hidden between wings.

Remarks. *Proneuronema sidorchukae* **sp. nov.** is most similar to *P. minor* in size, number of flagellomeres and wing venation. These species however are easily distinguished by forewing color pattern, by the shape of the costal space, and by the configuration of their subcostal veinlets. Some crossveins in the third gradate series are broadly margined with dark brown in *P. sidorchukae* **sp. nov.** (i.e., dark coloration extending broadly on the membrane surrounding the vein, see Fig. 2), but this dark bordering is absent in *P. minor* (its forewing membrane is slightly fuscous almost throughout, lacking distinct maculation). The proximal part of the costal space of *P. sidorchukae* **sp. nov.** is markedly narrower with its subcostal veinlets more oblique than those of *P. minor*.

The two other described species of the genus (*P. gradatum* and *P. wehri*) differ from *P. sidorchukae* **sp. nov.** (and from *P. minor*) by many features of forewing venation, e.g., by the dichotomously branched M and the presence of crossveins in the costal space, and by larger size.

Discussion

Diversity and distribution of *Proneuronema*. Four species of *Proneuronema* have been described from the Eocene of Europe and North America (including the new species), however the genus was apparently distributed more widely then. *Proneuronema wehri* from the early Eocene of North America and an undescribed species from the presumed early Eocene of the Tadushi Formation (Russian Fast East) are more similar to each other than both are to any European Eocene species. Some features of these two species are shared, e.g., the dichotomously branched M (three or more long branches originating proximad third gradate series) and the presence of crossveins between the branches of CuP in the forewing. *Proneuronema gradatum* from late Eocene Baltic amber is the single European species more or less similar to these. *P. gradatum*, however, possesses no crossvein between its branches of CuP, and its M has only two long branches originating proximad third gradate series (but it possesses crossveins in its costal space like *P. wehri*).

The majority of undescribed specimens from the early Eocene of Europe (i.e., from the Fur Formation from Denmark, and from Havighorst and Greifswalder Oie Island in northern Germany) have wing venation similar to that of *P. sidorchukae* **sp. nov.** and *P. minor*. In both, M is forked once (two long branches originating proximad third gradate series) and there are no crossveins in the costal space and between branches of CuP. However, most of the early Eocene European specimens are much larger than these two late Eocene species (i.e., the former range from 9 to 11.5 mm: Rust 1999; pers. obs.).

Proneuronema minor is relatively common in Baltic amber. We know of ten specimens in private collections and museums that may belong to this species. *P. sidorchukae* **sp. nov**. from contemporaneous, but more southern Rovno amber, is not yet known from Baltic amber. Therefore, we suspect that *P. sidorchukae* **sp. nov**. is a thermophilic element in the Rovno fauna, and this occurrence may represent the northern limit of its range. This has been assumed for many other thermophilic taxa in Rovno amber fauna (Perkovsky 2018, Legalov *et al*. 2018 and references therein).

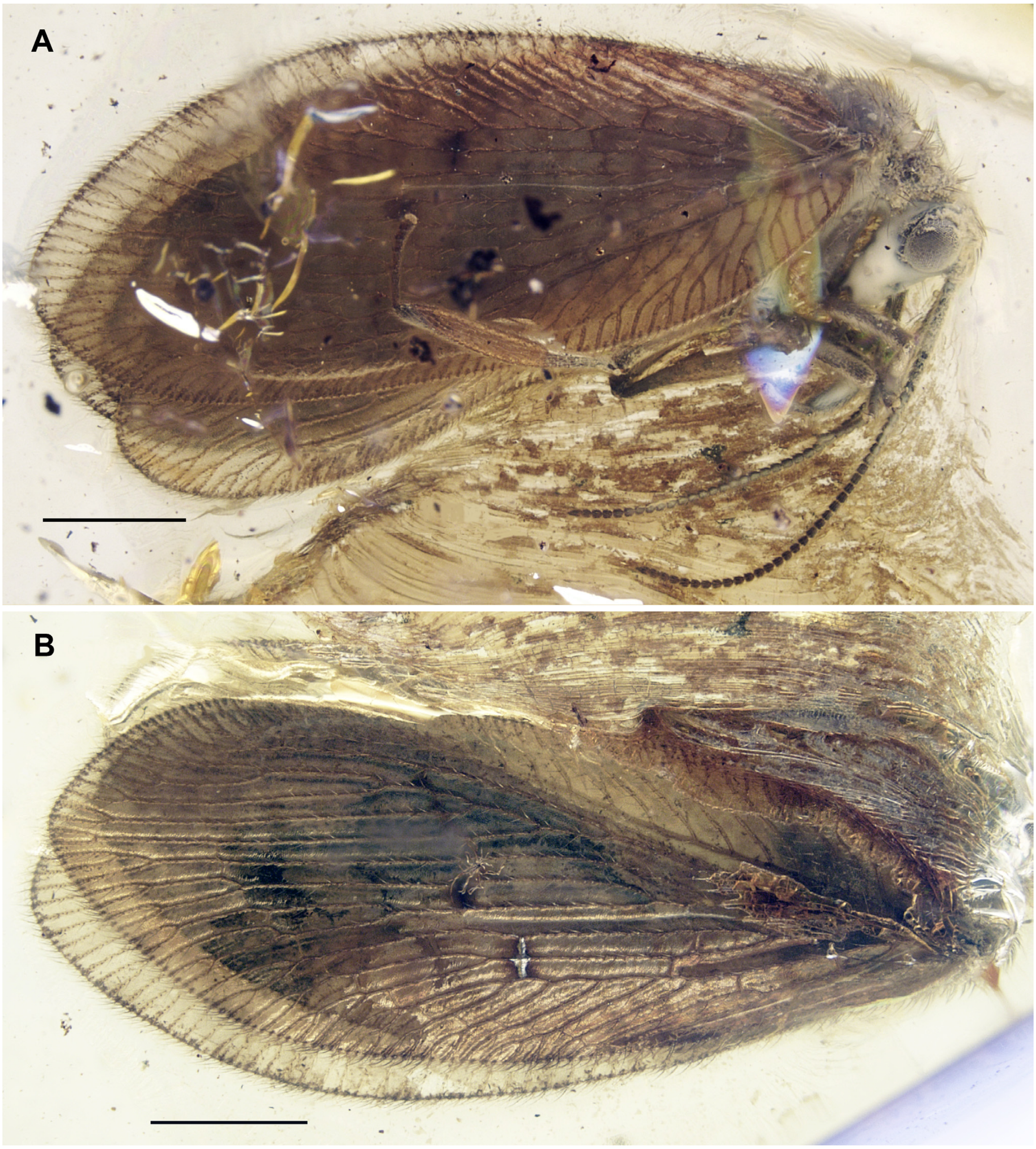

FIGURE 1. *Proneuronema sidorchukae* **sp. nov.**, holotype SIZK L-116. A, right side; B, left side. Scale bars = 1 mm.

Size of the Rovno amber Hemerobiidae. *Proneuronema sidorchukae* **sp. nov.** is the smallest known species of the genus, with a forewing length of 5.9 mm. The forewings of other species of the genus are 6.3–6.9 mm long (*P. minor*), 7.9–9.5 mm (*P. gradatum*), and ca. 9 mm (*P. wehri*) (Makarkin *et al*. 2003, 2016). The majority of undescribed specimens from the early Eocene of Europe are also much larger (see above). Two other species of Hemerobiidae have been reported in Rovno amber. *Prolachlanius resinatus* (Hagen in Pictet et Hagen, 1856) is known in both Baltic and Rovno ambers. The Rovno specimen of this species is smaller than most Baltic amber specimens (Makarkin *et al*. 2019). The forewing of an undescribed species of *Sympherobius* Banks, 1904 from Rovno amber (5.4 mm long) is slightly shorter than that of two species from Baltic amber, i.e., 5.5 mm long in *S. completus* Makarkin & Wedmann, 2009, and 5.9 mm in *S. siriae* Jepson *et al.,* 2010.

Therefore, all known hemerobiids from Rovno amber show a clear tendency toward smaller size compared to congeneric or conspecific specimens from Baltic amber. This could result from decreased access to aphids, their major prey. Aphids comprise 4–6.5% of all insects (excluding Entognatha) in representative collections of Baltic amber from the Sambia Peninsula (Kaliningrad Oblast of Russia), but only 2.8% in the Rovno amber collection of SIZK (Perkovsky & Wegierek 2018). Furthermore, most aphids from Rovno amber have a long rostrum and were ant-attended (Perkovsky *et al*. 2012 and references therein), and so would have been better able to defend themselves from hemerobiids.

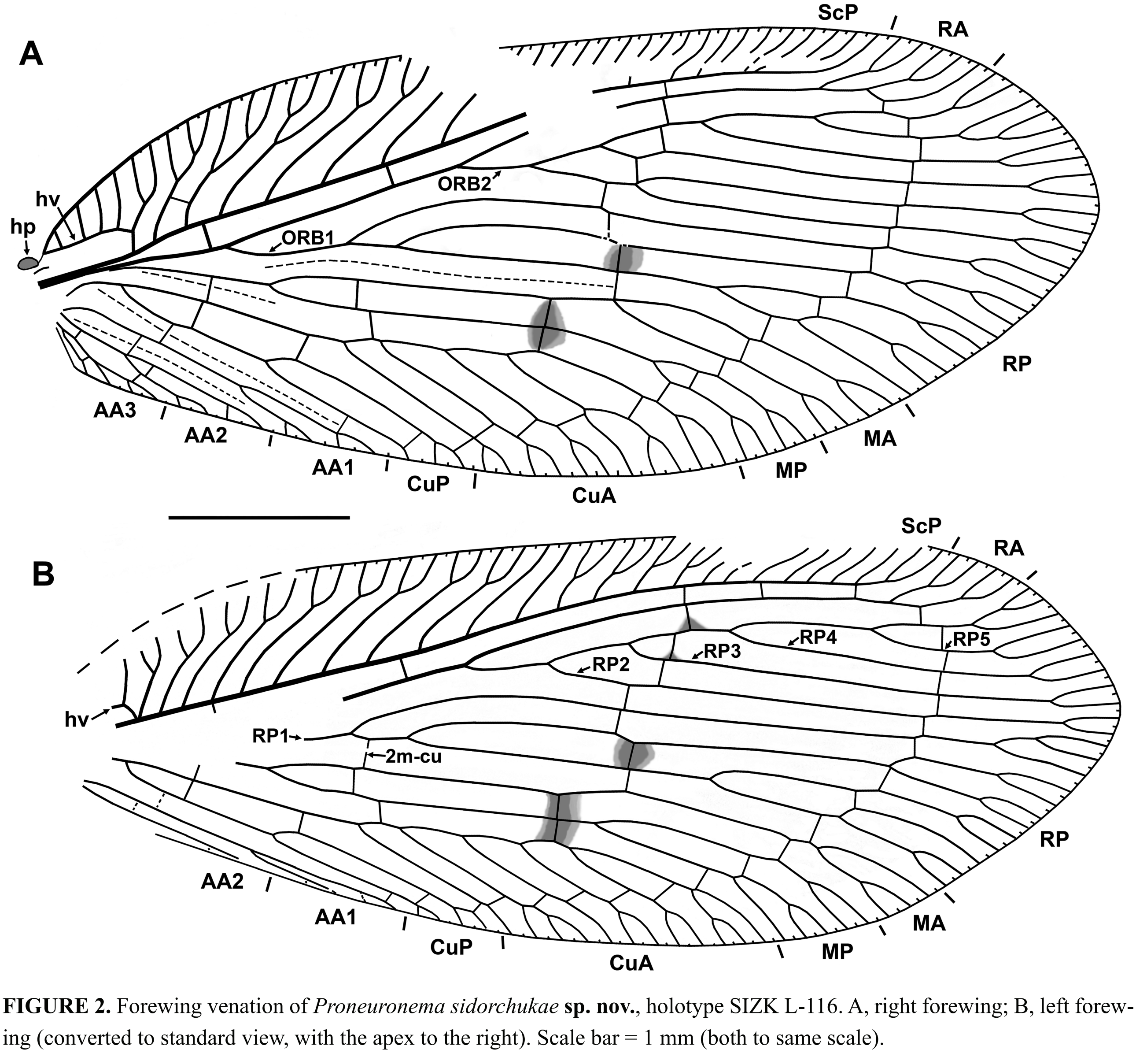

FIGURE 2. Forewing venation of *Proneuronema sidorchukae* **sp. nov.**, holotype SIZK L-116. A, right forewing; B, left forewing (converted to standard view, with the apex to the right). Scale bar = 1 mm (both to same scale).

Structure and terminology of the mesonotum in Hemerobiidae. The structure of the mesonotum is clearly preserved in *Proneuronema sidorchukae* **sp. nov.** (Fig. 3). However, we find that there is disagreement in its terminology in Neuroptera, particularly concerning the prescutum. Crampton (1919) believed that the anterior triangular area of the notum of some insects (e.g., Neuroptera; Hymenoptera: Tenthredinidae) is the prescutum (our anterior part of the mesoscutum), and the narrow sclerite anterior to it is the pretergite (our prescutum). This terminology was accepted by many subsequent authors and applied to many families, including Hemerobiidae (e.g., Morse 1931; Killington 1936; Parfin & Gurney 1956; Tjeder 1967, 1992).

Other authors considered the 'prescutum' of previous authors to be a part of the mesoscutum, and the prescutum is their pretergite (Snodgrass 1927, 1935; Matsuda 1970; Headrick & Gordh 2009). This terminology was applied to Mantispidae and Myrmeleontidae (e.g., Ferris 1940; Lambkin 1986; Krivokhatsky 2011). Here, we follow this, which seems much more reasonable. In Hemerobiidae, there is no suture in the medial part of the mesoscutum between its anterior (i.e., the 'anterior triangular area' of Crampton (1919)) and posterior parts (i.e., the 'mesonotum' of Crampton (1919)). In Mantispidae, the boundary between these parts is even lesser clear (see Lambkin 1986: Figs 17–20).

Proneuronema sidorchukae **sp. nov.** distinctly shows the structure of the mesonotum of Hemerobiidae, and so helps to clarify this issue. This terminology is partially new here, as some details were hitherto not named. We propose here the new term 'transversal medial ridge'.

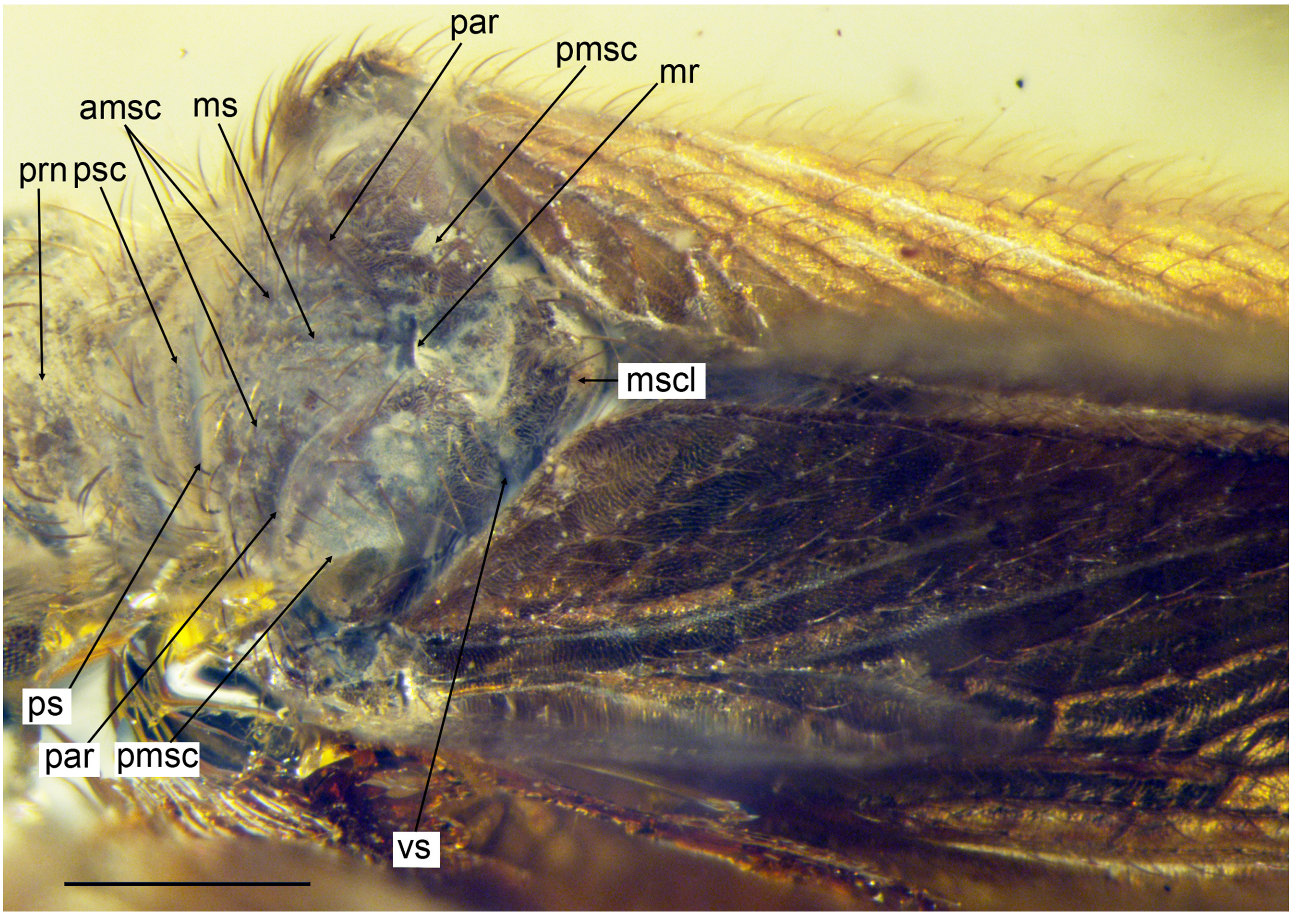

FIGURE 3. *Proneuronema sidorchukae* **sp. nov.**, holotype SIZK L-116. Thorax and anal areas of the forewings (dorsal view). amsc, anterior part of mesoscutum; mr, transversal medial ridge; ms, longitudinal medial suture; mscl, mesoscutellum; par, parapsidal suture; pmsc, posterior part of mesoscutum; prn, pronotum; psc, prescutum; ps, prescuto-scutal suture; vs, scuto-scutellar suture. Scale bar = 0.5 mm.

The prescutum is clearly seen in this species as a narrow transverse sclerite (Fig. 3, psc). It is separated from the mesoscutum by the prescuto-scutal suture [= prescutal suture of Headrick & Gordh 2009] (Fig. 3, ps). The mesoscutum is the largest part of the notum. In Hemerobiidae (as in many other Neuroptera) it consists of two distinct parts. The anterior part of the mesoscutum is triangular, divided into two (Fig. 3, amsc) by a longitudinal medial suture [= middorsal suture of Crampton 1919] (Fig. 3, ms). It is separated from the posterior part of the mesoscutum by the parapsidal sutures of Snodgrass (1927) [= convergent furrows of Ferris (1940); scutal furrows of Lambkin (1986)] (Fig. 3, par). These sutures are not connected medially, being replaced there by a depression. The posterior part of the mesoscutum is shaped like an eight, i.e., consists of two large lateral convex lobes and has a strongly constricted concave medial part (Fig. 3, pmsc). In the medial part of the posterior mesoscutum there is a narrow convex fold (the transversal medial ridge; Fig. 3, mr), which is located anteriad the middle part of the scuto-scutellar suture. The mesoscutellum is in general rhomboid and convex posteriorly. It is separated from the mesoscutum by a distinct scuto-scutellar suture (Fig. 3, vs).

The structure of the mesonotum of *Proneuronema sidorchukae* **sp. nov.** is very similar to that of the extant *Neuronema* McLachlan, 1869 and other Palearctic Hemerobiidae. Killington (1936) believed that the separation of the lateral parts of the mesoscutum (our posterior mesoscutum) of *Drepanepteryx* Leach, 1815 is complete. He considered the mesoscutum (our posterior mesoscutum) of other genera of Hemerobiidae to be entire (but medially constricted in a greater or lesser degree) (see Killington 1936: Fig. 9). However, detailed examination of extant species shows that there are no principal differences in the structure of the mesonotum in such hemerobiid genera as *Drepanepteryx* (at least in *D. punctata* (Okamoto, 1905)), *Neuronema*, *Hemerobius* Linnaeus, 1758, *Wesmaelius* Krüger, 1922, *Micromus* Rambur, 1842 and *Sympherobius*. In particular, the parapsidal suture was shown by Killington (1936: Fig. 9) to be entire, non-interrupted medially in *Wesmaelius nervosus* (Fabricius, 1793). However, in this species there are a pair of lateral parapsidal sutures which are medially missing, being replaced there by a depression. The transversal medial ridge is developed to varying degrees in all these genera.

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