

# FIRST FOSSIL PENTASTIRINI FROM EOCENE BALTIC AMBER (HEMIPTERA: FULGOROMORPHA: CIXIIDAE)

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**Abstract.**— *Perunus* gen. nov. with two new species – *Perunus bruziorum* sp. nov. and *P. sudoviorum* sp. nov. from Eocene Baltic amber is described. Characters of male and female are given and discussed on the basis of three specimens from various collections. Other fossil representatives of the family Cixiidae are discussed. Characters and composition of the tribe Pentastirini and its subdivision are also presented.



**Key words.**— *Perunus* gen. nov., *P. bruziorum* sp. nov., *P. sudoviorum* sp. nov., Hemiptera, Cixiidae, Pentastirini, fossil record, Eocene Baltic amber

## INTRODUCTION

The family Cixiidae is a group of planthoppers with over 1500 described species (which may be about 40 percent of the actual world fauna) and cosmopolitan distribution (Larivière 1999). Within the family three subfamilies: Bothriocerinae, Borystheninae and Cixiinae are recognized (Emeljanov 1987), but there is no universally adopted tribal classification of this group. The problem of the higher classification of Cixiidae was discussed by Emeljanov (1989).

Fossil representatives of the family Cixiidae have rarely been described. Supposed cixiids have been reported from Lower and Upper Triassic strata of Siberia (Becker–Migdisova 1955), but a true cixiid – a sole species, *Cixius petrinus* Fennah, have been found in the Jurassic of Dorset in England (Fennah 1961).

Cixiidae are quite common in Eocene Baltic amber inclusions (Szwedo and Kulicka 1999a, b). The first description of representatives of this family from Baltic amber comes from the second half of the 19th century (Germar and Berendt 1856). In this work nine species have been ascribed to the genus *Cixius* Latr., although some of them seem to represent Achilidae (Szwedo, work in progress). Another species — *Oliarus oligocenus*, ascribed by Cockerell (1910) to cixiids, also belong to Achilidae.

## SYSTEMATIC

The tribe Pentastirini (Cixiinae) was separated by Emeljanov (1971) and characterized by five longitudinal

carinae on mesonotum and ovipositor reduced, or if ovipositor elongated, gonapophysis VIII (valvula I) not corrugated and gonapophyses IX (valvulae II) not fused together. Van Stalle (1986c) added also the connection of aedeagus with the pygofer. Pentastirini were divided by Emeljanov (1971) into two subtribes: Oliarina with characters as follows: vertex with subapical keel forming a sharp angle, hind tarsi with a single row of teeth, and Pentastirina, characterized as follows: subapical keels of vertex fused together in a blunt angle, hind tarsi with a double row of teeth. Subsequently, Emeljanov (1992) added a new subtribe Mnemosynina with the combination of characters as follows: five keels on mesonotum, ovipositor reduced, direct articulation between anal tube and theca.

The fossil genus described below is without doubt a member of the tribe Pentastirini, subtribe Pentastirina.

*Perunus* gen. nov.

**Type species.** *Perunus bruziorum* sp. nov., here designated.

**Etymology.** ‘Perun’ — name of the main god in the pagan Balto-Slavonic mythology. Gender: masculine.

**Diagnosis.** *Perunus* gen. nov. is similar to the recent genus *Norialsus* Van Stalle, 1986 (Van Stalle 1986b) in the type of hind leg tarsomere chaetotaxy: 1 row on the first tarsomere, double row on the second tarsomere. It differs from *Norialsus* by the presence of five lateral spines on the hind tibia (three lateral spines in *Norialsus*), median keel of frons bifurcated in upper portion and two short keels connecting apical and subapical carinae of vertex. The other distinguishing characters are: post and anteclypeus with distinct median keel,

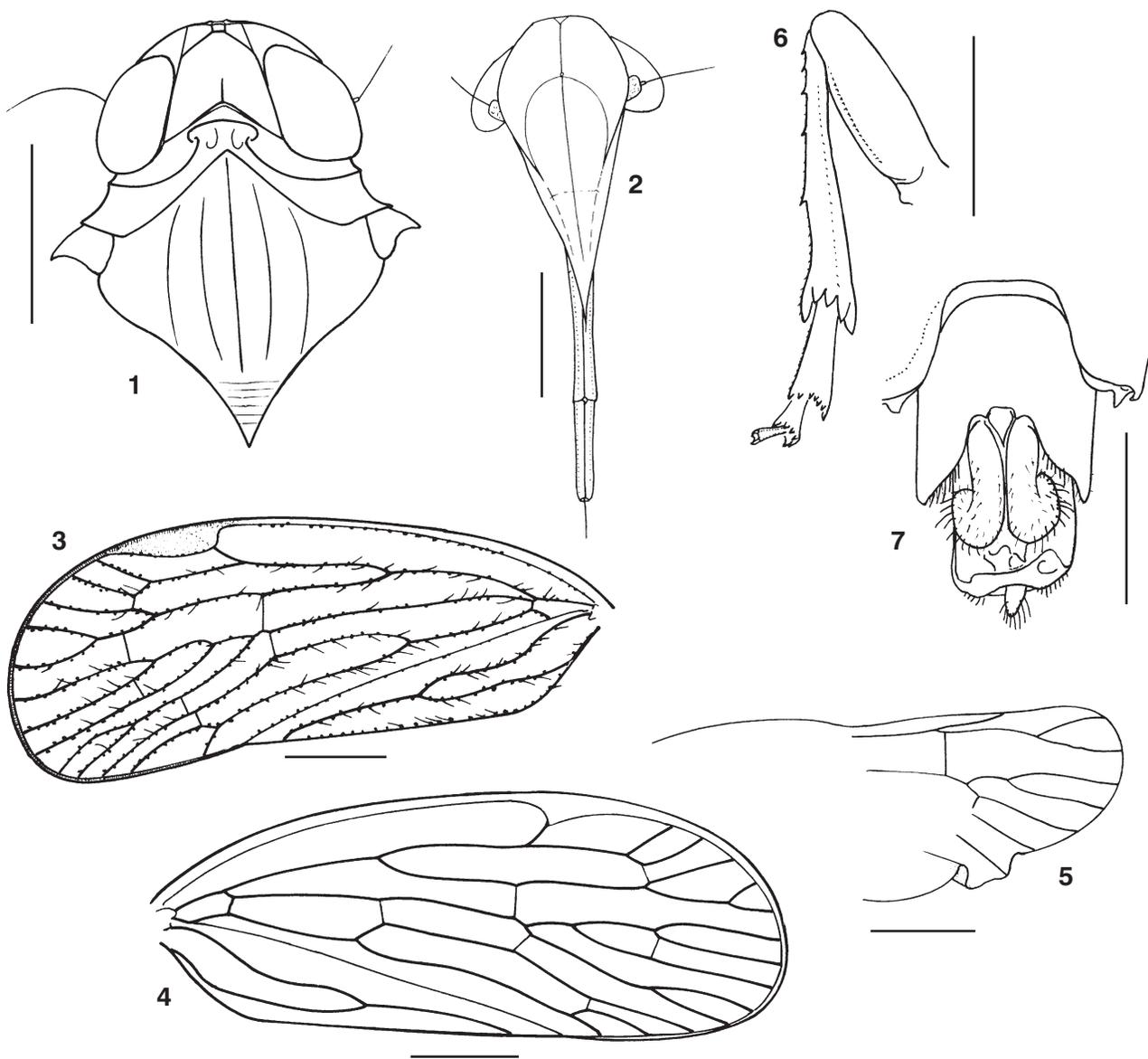
median ocellus well developed (small, obsolete or absent in *Noriatus*). Maculae on frons and muscular impressions on postclypeus absent. Male anal tube elongate and wide, slightly asymmetric. Female anal tube elongate, narrow. Ovipositor well developed, slightly longer than anal tube.

**Description.** Head with three ocelli distinctly visible, the median one, well developed, near frontoclypeal suture and two lateral ones on genae; with compound eyes narrower than pronotum.

Anterior margin of head arcuate, about 0.6 times as wide as posterior margin of vertex, length of vertex in mid line about 0.6 times of total length of vertex measured to the posterior angles and slightly longer than

half of width of vertex in posterior angles. Median keel weakly visible, reaching  $1/3$  of vertex length in mid line. Lateral keels converging anteriorly, subapical keel arcuate, connected with anterior margin by two narrow ridges (keels). Areolets trapezoid, not elongate. Subapical keel connected to lateral keel at the level of  $1/3$  of its total length anteriorly. Posterior margin of vertex distinctly V-shaped incised, with incision obtusely angulate, with highly elevated borders, about half as wide as width of head with compound eyes (Figs 1, 8, 19–20, 22).

Frons about 2.5 times as wide as in upper margin, with median keel forked near vertex. Frontoclypeal suture strongly convex. Disc of frons slightly concave, maculae and fenestrae absent from the frons near frontoclypeal



Figures 1–8. *Perunus bruziorum* sp. nov., holotype: (1) Anterior part of body; (2) face; (3) left tegmen; (4) right tegmen; (5) visible part of left wing; (6) hind leg; (7) male genital bloc. Scale bar: 1 mm

suture. Clypeus inflated, with its upper portion distinctly embedded into frons. Anteclypeus elongate with median keel, lacking lateral keels (Figs 2, 9, 20, 23). Rostrum reaching the level of the end of trochanters of hind leg, with subapical segment 1.1 times as long as apical one.

Pronotum with distinct postocular carinae, connected medially, posterior margin wide angled, with margins almost straight; in lateral portion bent anteriad. Mesonotum diamond-shaped, slightly longer than wide, with five longitudinal keels. Median keel almost reaching pronotum, mediolateral and lateral keels distinctly shorter, subparallel, mediolateral not reaching margins of mesonotum, lateral ones reaching almost posterior margin of mesonotum. Scutellum transversely wrinkled (Figs 1, 8, 19–20, 22).

Tegulae longer than wide.

Tegmina (Figs 3–4, 10, 12–13, 19, 22–23) about 2.8 times as long as wide. Costal margin granulate between base and stigma, almost straight in median portion to the level of stigma; stigma triangularly elongate. Clavus long, exceeding 2/3 of tegmen length. Longitudinal veins densely granulate, setose, hairs quite long. Sc+R and M started from common point, Sc+R forked basad of M forking, at the level, or slightly posteriad of Cu forking. Sc+RA1 reaching stigma near its basal margin. Veins RA2 and RA3 reaching the margin of tegmen well before its apex. Vein RP with three branches, forked at level of vein RA second forking, vein RP3 reaching margin of tegmen almost at apex. RA3 and RP1 connected by apical transverse veinlet. Vein M with five terminal branches, connected with RP by transverse r–m veinlet slightly basad of M first forking; other more apical veinlets connect RP and MA1, MA2 and MA3, MA3 and MP. Vein CuA with three terminal branches, first forking of CuA at the level, or slightly basad of Sc+R forking, at the same level as connection of claval veins. Clavus closed, CuP (claval suture) straight, exceeding 2/3 of tegmen length. Claval veins PCu and A1 united at the level of vein midpoint and in the middle of PCu length.

Wing hyaline, vein Sc+R finishes before the apex, vein ScRA finishes distinctly above the apex, vein RP1 connected with margin above the apex, vein RP2 just below the apex. MA with two branches, MP not bifurcate, Cu with two branches. Transverse veinlet r–m long, placed basad of bifurcations of ScRA and M. Transverse veinlet m–cu relatively short (Figs 5, 11, 22–23).

Legs relatively long. Fore and mid femora with ventral double row of short and stout spinules (Figs 14–15). Fore and mid tibiae quadrangular in cross section, without lateral spines, but with rows of short spinules and a few apical spinules. First and second tarsomeres of fore and mid legs subequal in length, with a pair of apical chaetae, apical tarsomere slightly longer, tarsal claws and arolium small. Hind tibia with five lateral spines, with three large, and two distinctly smaller spines near the base of tibia (Figs 6, 16).

First tarsomere about 1.6 times as long as mid tarsomere, about 2.5 times as long as apical tarsomere;

with row of 7 apical spines. Second tarsomere about 1.6 times as long as apical one with row of 6 apical spines and another row of a few platellae (macrochaetae) (2 visible in *P. bruziorum* sp. nov., 4 in the male holotype of *P. sudoviorum* sp. nov.). Apical tarsomere with rows of short chaetae on plantar margin, tarsal claws and arolium small (Figs 6, 16–17).

Male genitalia: Anal tube slightly asymmetric, wide and elongate, apically with ventrad slightly asymmetric protrusion, without additional processes; with left side (in dorsal view) slightly more developed, but right angle of ventral protrusion with indistinct protuberance.

Female genitalia: Pygofer with apical margin straight in lateral view, pregenital segment not visible. Anal tube quite long, narrow, round in cross section. Ovipositor well developed, with two pairs of valvulae visible (gonapophyses VIII and IX), not fused together.

*Perunus bruziorum* sp. nov.

(Figs 1–8, 19–21)

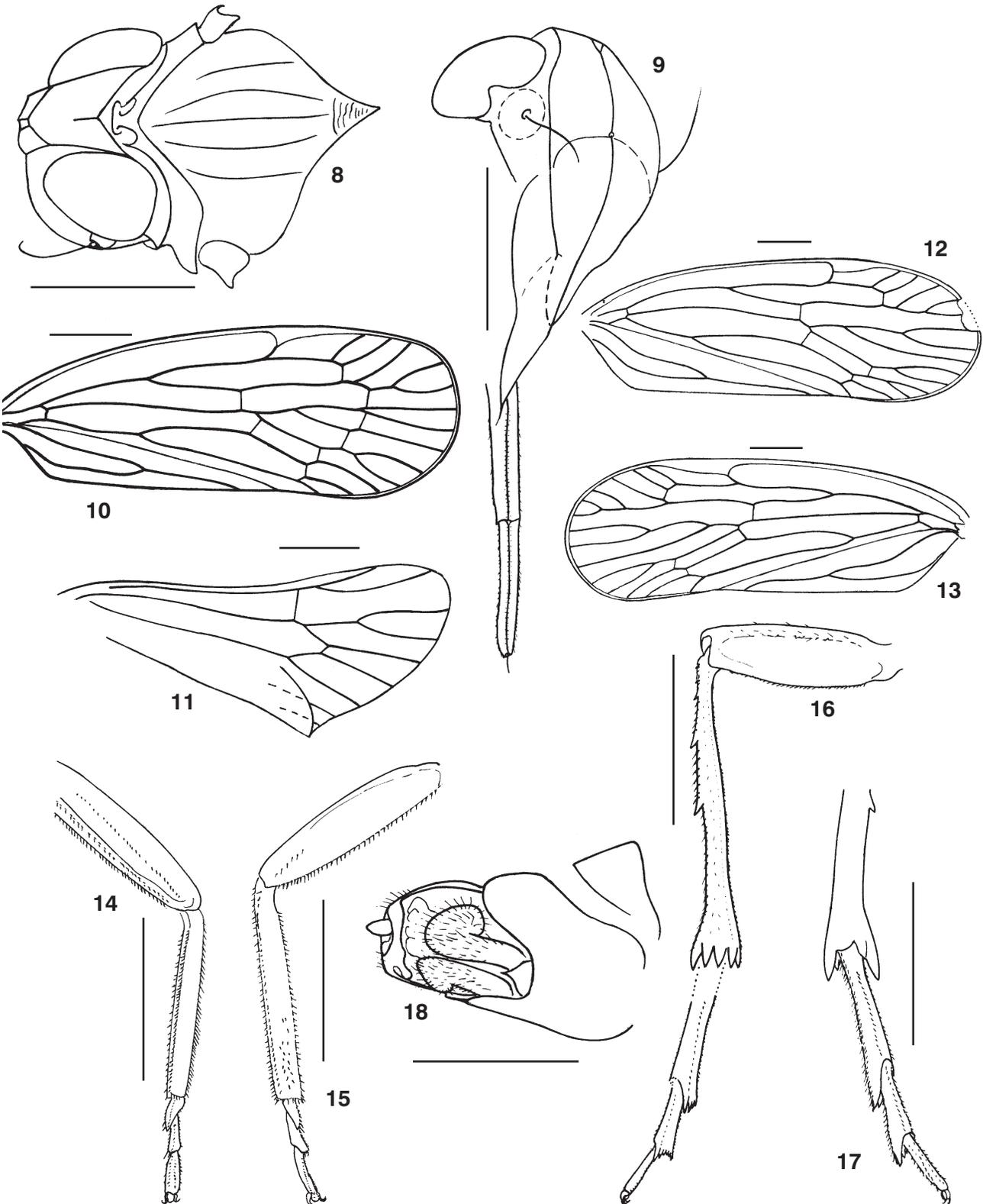
**Etymology.** ‘Bruzi’ — name of the indigenous people living between Vistula and Niemen rivers in the Antiquity and Medieval times.

**Diagnosis.** Posterior margin of pygofer with relatively shallow, slightly asymmetric median incision, the angles of incision create slightly asymmetric processes (lack of such processes in *P. sudoviorum* sp. nov.); with medioventral process about twice as long as wide (medioventral process as long as wide in *P. sudoviorum* sp. nov.). Basal spines on hind tibia present, placed at a distance longer than width of tibia at base from each other (in *P. sudoviorum* sp. nov. basad lateral spines of hind tibia placed close each other at a distance shorter than width of tibia at base); apical lateral spine of hind tibia placed in the middle of tibial length (slightly basad of the middle of tibial length in *P. sudoviorum* sp. nov.).

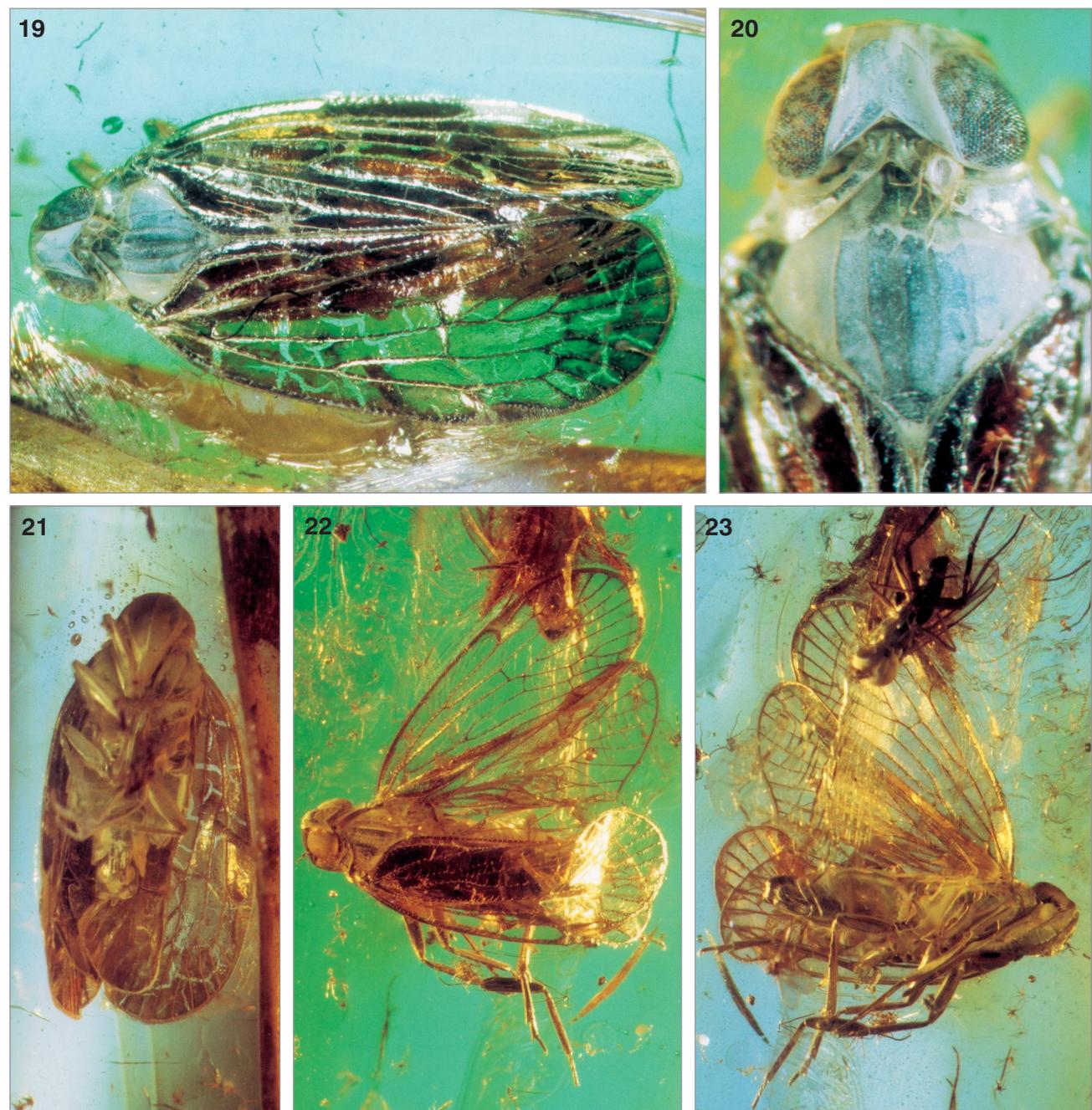
**Description.** Body robust, total length about 7.1 mm.

Head with compound eyes 1.28 mm wide in dorsal view, narrower than pronotum. Vertex 0.38 mm long in mid line; with total length measured to posterolateral angles 0.68 mm; with lateral carinae measured to the level of connection with frontolateral carinae 0.50 mm long. Face at widest point, at the level of antennae 0.88 mm wide. Frons in median line about 0.7 mm long, 1.2 mm long in lateral line measured to the lower angle. Clypeus 0.58 mm wide at widest point, 1.42 mm long in mid line. Subapical segment of rostrum 0.84 mm long, slightly longer than apical one, 0.76 mm long (Figs 1–2, 19–20).

Pronotum in mid line 0.17 mm long, about 0.44 times as long as vertex in mid line, narrower in the middle than in lateral portions. Mesonotum 1.47 mm long, slightly longer than wide (1.40 mm), with five longitudinal keels; with median keel reaching almost to posterior margin of pronotum, mediolateral and lateral keels distinctly shorter, subparallel, mediolateral not reaching margins of mesonotum, lateral ones reaching almost to posterior



Figures 8–18. *Perunus sudoviorum* sp. nov.: (8) Anterior part of body, male; (9) face, male; (10) male right tegmen; (11) visible part of male right wing; (12) female left tegmen; (13) female right tegmen; (14) fore leg, male; (15) mid leg, male; (16) hind leg, male; (17) hind tarsus, male; (18) male genital bloc. Scale bar: 1 mm



Figures 19–23. (19–21) *Perunus braziorum* sp. nov., holotype, coll. Carsten Gröhn, Glinde, No. 1712; (22–23) *Perunus sudoviorum* sp. nov., holotype, coll. Christel and Hans Werner Hoffeins, No. 936. (19) Dorsal view; (20) anterior part of the body with a parasitic tick visible; (21) ventral view; (22) laterodorsal view; (23) lateroventral view.

margin of mesonotum. Scutellum transversely wrinkled (Figs 1–2, 19–20).

The holotype is marked by dissymmetry of veinlets connecting veins M and CuA; left tegmen: first transverse veinlet placed at the level of claval angle, second at the level of connection of CuA3 with commissural border; right tegmen: first transverse veinlet placed at the level of Sc+R first bifurcation, second transverse veinlet at the point of bifurcation of M (Figs 3–4).

Apical spine of hind tibia placed just behind middle of tibia, most basal two lateral spines grouped close each other, at the distance longer than width of tibia at base (Fig. 6).

Male genitalia: pygofer with relatively shallow, slightly asymmetric median incision, the angles of incision create slightly asymmetric processes; small medioventral process present, about twice as long in mid line as wide. In lateral view, posterior margin of pygofer without

protruding lateral lobes, only angulately elongate, in ventral portion covered with a few long setae. Genital styles symmetric, with big roundly widened apical portion, covered with few long setae (Figs 7, 21).

Coloration in amber: anterior part of body — head, pronotum and mesonotum light, tegmina uniformly brownish, wings light brownish (Figs 19–20).

**Type.** Holotype, male, Baltic amber, coll. Carsten Gröhn, Glinde, Germany, Nr. 1712. Labelled [1712 / Zikade / m. Milben – / Parasitismus]. Syninklusions: Acari, placed between posterior margin of head and anterior margin of pronotum; phoretic or parasitic; Diptera – damaged specimen, particles of detritus, stellate hairs. The specimen will be deposited in the Natural History Museum, University of Hamburg, Germany.

*Perunus sudoviorum* sp. nov.

(Figs 8–18, 22–23)

**Etymology.** ‘Sudovi’ — name of the indigenous Western Baltic tribe inhabiting the north–eastern parts of Poland in the Antiquity and Medieval times.

**Diagnosis.** Slightly bigger species; median incision of pygofer without lateral lobes or processes (lateral processes in angles of the median incision present in *P. bruziorum*); medioventral process of pygofer as long as wide (twice as long as wide in *P. bruziorum*); basal lateral spines of hind tibia placed close each other at a distance shorter than width of tibia at base (in *P. bruziorum* basad spines of hind tibia placed at a distance longer than width of tibia at base from each other); apical spine of hind tibia placed slightly basad of middle of tibia (in *P. bruziorum* placed in the middle of tibia length).

**Description.** Body robust, length 7.1–8.0 mm, female bigger than male.

Head with compound eyes 1.18 mm wide (male), 1.35 mm (female). Vertex 0.4 mm long in mid line; total length measured to posterolateral angles 0.69 (male), 0.74 mm (female); with lateral carinae measured to the level of connection with frontolateral carinae 0.47 mm (male), 0.52 mm (female) long. Frons (male) in median line about 0.7 mm long, about 1.12 mm in lateral line measured to the lower angle. Clypeus about 0.56 mm wide at widest point, 1.39 mm long in mid line. Subapical segment of rostrum 0.7 mm long, apical segment shorter, 0.68 mm long (Figs 8–9, 22–23).

Pronotum in mid line 0.12 (male), 0.14 mm (female) long, about 0.3 times as long as vertex in mid line. Mesonotum of male 1.37 mm long, slightly longer than wide (1.26 mm), in female 1.59 mm long and 1.54 mm wide. Median keel reaching almost to posterior margin of pronotum, mediolateral and lateral keels distinctly shorter, subparallel, mediolateral not reaching margins of mesonotum, lateral ones reaching almost to posterior margin of mesonotum. Scutellum transversely wrinkled (Figs 8, 22).

The paratype female is marked by dissymmetry of RP terminals, 4 in left and 3 in right tegmen (Figs 12–13).

Apical spine of hind tibia placed slightly basad of the middle of tibia length, more basad lateral spines grouped relatively closer to each other at a distance shorter than width of tibia at base (Fig. 16).

Male genitalia. Pygofer with relatively shallow, median incision, with angles smooth, without processes or lobes; small medioventral process present, about as long as wide. In lateral view, posterior margin of pygofer without protruding lateral lobes, only angulately elongate, with ventral portion covered with a few long setae. Genital styles symmetric, with big roundly widened apical portion, covered with few long, long setae (Figs. 18, 23).

Female genitalia: Pygofer with apical margin straight in lateral view, pregenital segment not visible. Anal tube quite long, narrow, round in cross section, ovipositor well developed, with two pairs of valvulae visible (gonapophyses VIII and IX), not fused together.

Coloration in amber: anterior part of body – head, pronotum and mesonotum light, tegmina uniformly brownish, only subapical transverse veinlets slightly darker, wings light brownish (Figs 22, 23).

**Types.** Holotype, male, Baltic amber inclusion, coll. Christel and Hans Werner Hoffeins, Hamburg, Germany, Nr. 936. Syninklusions: Diptera 10 specimens, some disarticulated, Hymenoptera – single specimen, Arachnida – damaged specimen, particles of detritus, stellate hairs. The specimen will be deposited in the Natural History Museum, University of Hamburg, Germany.

Paratype, female, Baltic amber inclusion, coll. Jacek Serafin, AUF09JS. Syninklusions: Hymenoptera: Chalcidoidea; Formicidae: single, very big – Formicinae: *Formica* sp., two (one partly damaged) – Dolichoderinae: *Liometopum* sp., Hemiptera: Aphidodea, Archaeognatha, particles of detritus, stellate hairs. Specimen stored in the Natural History Museum, Institute of Systematics and Evolution of Animals, Polish Academy of Sciences, Kraków, Poland.

## DISCUSSION

The subtribe Pentastirina comprises 24 recent genera. The genus *Perunus* belongs to the group of genera marked by a single row of teeth on the first hind leg tarsomere and double row of teeth on the second hind leg tarsomere. This group comprises recent genera: *Helenolius* Van Stalle, 1986 – endemic to St Helena Island, *Norialsus* – restricted to Cape region and Drakensberg Mts in South Africa and the Palaearctic *Reptalus* Emeljanov, 1971. Also other external characters relate *Perunus* with these genera. It is noteworthy that *Perunus* displays many characters regarded as plesiomorphic for Pentastirini (Van Stalle 1986c). The main plesiomorphic characters of the head are as follows: the presence of the median keel and lack of muscular impressions on postclypeus; a well developed median ocellus; the subapical transverse keel of vertex connected to the

apical keel by two transverse keels; frons without maculae; and normally developed compound eyes. All of these characters are to be found in *Perunus* gen. nov.

Another complex of characters regarded as plesiomorphic is to be found in the tegmina. Fully developed tegmina and wings, with triangular stigmata, and veins covered by granules are present in *Helenolius* and *Perunus*. By contrast, in *Norialsus* tegmina are often reduced (Van Stalle 1986b, c), but the protruding granules are present.

The pygofer and anal segment without distinct lobes and structurally simple genital styles are also considered as the plesiomorphic condition (Van Stalle 1986c). The male anal segment with flat ventral margin, devoid of ventral lobes or processes is present in *Helenolius*. In *Perunus* the male anal segment is more derived — wide and elongated, with asymmetric lobe; species of the genus *Norialsus* are marked by symmetric or asymmetrical male anal segment (Van Stalle 1986b). The anal tube in the female of *Helenolius* is small, shorter than ovipositor; it is slightly longer or shorter than ovipositor in *Norialsus* and the anal tube of the fossil genus *Perunus* is almost as long as the ovipositor. There are also some important features on the pygofer. In males of *Helenolius*, the pygofer is symmetrical or nearly so (Van Stalle 1986a) provided with a blunt lobe, which is the more derived condition. A pygofer with lateral lobes or spines is characteristic of *Norialsus* (Van Stalle 1986b), but in *Perunus* the posterior margin of the male pygofer is without protruding lateral lobes, only angulately elongate. Regarding the structure of the ovipositor, the plesiomorphic state with three pairs of valvulae (gonapophyses VIII and IX) is present in *Helenolius* (Van Stalle 1986a), while in *Norialsus* as well as in *Perunus* only the two pairs of valvulae (III and II, i.e. gonapophyses VIII) are to be observed, which is the more derived state (Van Stalle 1986c).

The chaetotaxy of the hind legs is also an important feature. The presence of lateral spines on the hind tibiae is a plesiomorphic condition (Van Stalle 1986c), and such condition is present in *Perunus* with five spines; a more reduced number of lateral hind tibial spines (three, but one or more spine obsolete) are present in *Norialsus* (Van Stalle 1986b), which is considered a more derived state. Another important feature is the chaetotaxy of apical portion of the first and second tarsomeres. The condition considered as plesiomorphic is the double row of variable number of teeth on the first and second tarsomeres (Van Stalle 1986c). A more derived state: the first tarsomere with a single row, and second tarsomere with a double row is characteristic for *Norialsus*, *Helenolius* as well as for *Perunus*. The function of the macrochaetae (platellae) present in tarsomeres of many

Fulgoromorpha, and Cicadomorpha as well, is not thoroughly investigated (Dlabola 1988). These structures are frequent in herbicolous taxa, and it has been postulated that platellae act as an organ of the sense of hearing during communication through the substrate of vibrations by drumming (Dlabola 1988). To prove this hypothesis, further research is necessary. It is interesting that platellae are also present in the fossil *Perunus*., which may suggest that this planthopper lived on herbs rather than on a still mysterious amber producing gymnosperm tree.

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