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Immature stages of *Pseudorchestes abdurakhmanovi* Korotyaev, 1992 (Coleoptera: Curculionidae) with notes on biology and distribution

Преимагинальные стадии *Pseudorchestes abdurakhmanovi* Korotyaev, 1992 (Coleoptera: Curculionidae) с заметками по биологии и распространению

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KEY WORDS. Curculionidae, Rhamphini, *Pseudorchestes abdurakhmanovi*, *Artemisia tschernieviana*, larvae, pupae, biology, Sarykum barkhan.

КЛЮЧЕВЫЕ СЛОВА. Curculionidae, Rhamphini, *Pseudorchestes abdurakhmanovi*, *Artemisia tschernieviana*, личинки, куколки, биология, бархан Сарыкум.

ABSTRACT. The last instar larvae and pupae of the rare Pre-Caspian weevil *Pseudorchestes abdurakhmanovi* Korotyaev, 1992 are described and illustrated in detail for the first time. Its disjunctive range is confirmed, which includes two localities located approximately at the same latitude on both sides of the Caspian Sea — Sarykum barkhan (Dagestan, Russia) and Tuyesu sands near Senek village (Mangyshlak peninsula, Kazakhstan). For the first time, the host plant of this species *Artemisia tschernieviana* Besser was correctly recorded.

РЕЗЮМЕ. Впервые детально описаны и проиллюстрированы личинки последнего возраста и куколки редкого вида жука-долгоносика *Pseudorchestes abdurakhmanovi* Korotyaev, 1992. Подтвержден его дизъюнктивный ареал, включающий два локалитета, расположенных примерно на одной широте по обе стороны Каспийского моря — бархан Сарыкум (Дагестан, Россия) и пески Туйесу у посёлка Сенек (полуостров Мангышлак, Казахстан). Впервые достоверно установлено кормовое растение данного вида *Artemisia tschernieviana* Besser.

Introduction

The adult stage in insects with complete metamorphism, including beetles, is only one-fourth of the life cycle, while the other three-quarters are in the preimaginal stages — egg, larva, and pupa. In the family of Curculionidae, these stages have been studied rather poorly and unevenly. One such group, where no detailed descriptions of immature stages have been provided so far, is the genus *Pseudorchestes* Bedel, 1894.

The genus *Pseudorchestes* belongs to the tribe *Rhamphini* of the subfamily *Curculioninae* and currently includes 35 species, most of which occur in the arid and semiarid regions of the Western Palaearctic [Alonso-Zarazaga et al., 2023]. Almost all species of this genus are associated with herbaceous plants from the *Asteraceae* family, mainly with various *Centaurea* and *Artemisia*, only one species *P. astracanicus* Tournier, 1873 is associated with *Ceratocarpus arenarius* L. from the *Chenopodiaceae* family [Korotyaev, 1992]. The larvae of *Pseudorchestes* are leaf miners, form brownish to black swelling in which they develop and pupate [Dieckmann, 1963].

During my visit to the Sarykum barkhan (Dagestan Republic, Russia), I managed to collect a significant material, both on the adults and the immature stages of a rare and poorly studied species — *Pseudorchestes abdurakhmanovi* Korotyaev, 1992, which was described from this location and for long time was considered as its narrow endemic. This material formed the basis of this article and allowed for the first time to describe the larva and pupa of this peculiar species and clarify the host plant.

Materials and methods

Slide preparation of the larvae and pupae was followed according to the method described and applied earlier by the author for *Anthonomus* [Zabaluev, 2021]. The larvae were first cleared in a 10% solution of potas-

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sium hydroxide (KOH), then rinsed in ethanol and distilled water and finally dissected, wherein the head, mouthparts, thoracic and abdominal segments of the body were separated and mounted on the permanent microscope slides in Faure-Berlese fluid. Evans blue dye was used to stain the thoracic and abdominal segments of the larvae.

Images of the host plants and biotopes were made with a camera Canon EOS 650D and the habitus of adults and larvae with a camera Canon 5D Mark IV with MP-E 65 mm macro objective. The preparation was performed under an under an optical stereomicroscope Altami CM0745. Slides were examined under a microscope Micromed 2 with using USB-camera AmScope MU1000-CK.

A scanning electron microscope (SEM) TESCAN MIRA 3 LMH was used to study small details of the structure. Sample preparation of the larvae and pupae consisted of first dehydrated and treated by critical point drying on Leica EM CPD300, then mounted with double-sided carbon tape on SEM stubs and gold-sputtered using S150A Sputter Coater.

All drawings were made using the free vector editor Inkscape and finishing in Photoshop CS6. Measurements were performed with an ocular micrometer.

General terminology and abbreviations of the setae of the mature larva and pupa following Scherf [1964], May [1994] and Marvaldi [1997, 1999], with the antennae terminology following Zacharuk [1985]. Numbers for setae and sensory pores are given for one side of the body.

Results

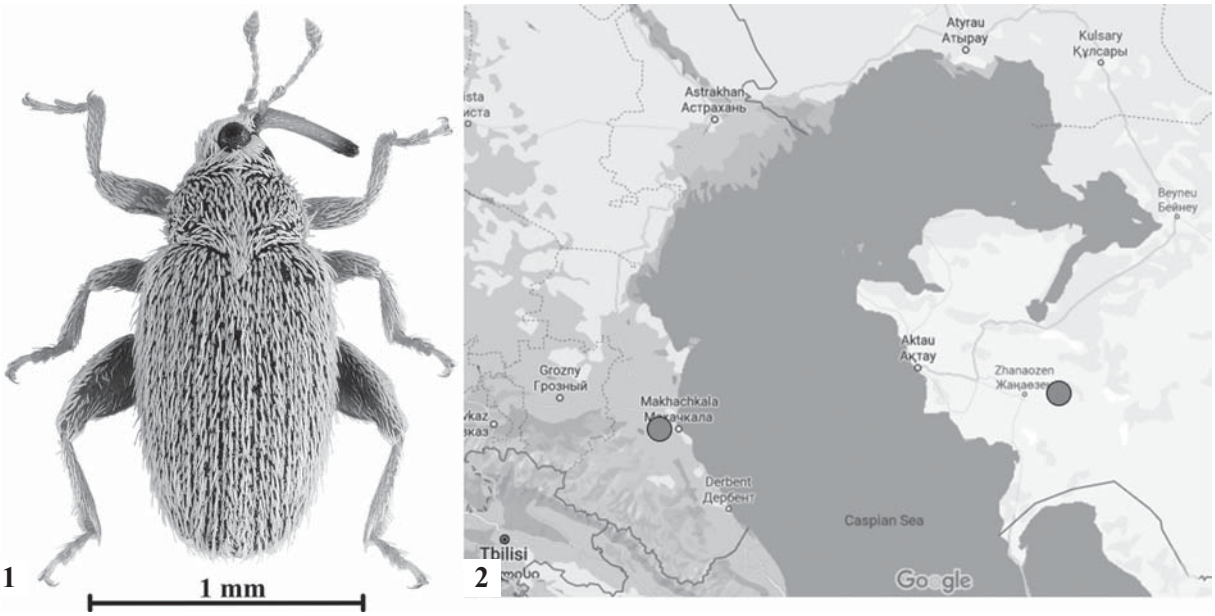
Distribution reasoning

MATERIAL. Kazakhstan: Mangystau region, Karakiya distr., 5 km NW from Senek vill., Tuyesu Sands, 43.390833°N 53.334833°E, 9–10.06.2017, D.V. Potanin leg., I.A. Zabaluev det. — 1 ex. (Fig. 1).

The type locality of *P. abdurakhmanovi* is the foot of the Sarykum barkhan [Korotyaev, 1992] and the species was considered its endemic for some time [Mukhtarova, 2009]. Later, it was also recorded from "the sands in the southwesternmost Kazakhstan" [Korotyaev, 2012], but without any specific data. A specimen in my collection (Fig. 1) from the Tuyesu Sands in the environs of the Senek village does not differ from those collected at Sarykum and additionally confirms this record.

Although it has been suggested that this species may be widespread either on the coastal sands of the Caspian Sea or in the sands of the Terek-Sulak interfluve [Korotyaev et al., 1993], it has not yet been found in these areas. Thus, the range of this species at the moment consists of two isolated areas located at about the same latitude on both sides of the Caspian Sea (Fig. 2).

It is interesting to note that at least two other beetle species are distributed in a similar way, these are the weevil *Macrotarrhus bartelsii* (Boheman, 1842) (Curculionidae: Hyperinae) [Korotyaev, Savitsky, 1998] and the darkling beetle *Leptodes boisduvalii* Zubkov, 1833 (Tenebrionidae: Pimeliinae) [Ilyina, 2013]. The first species is quite widespread in Kazakhstan and Uzbekistan in the Aral Sea region, and on the Mangyshlak peninsula and the Ustyurt plateau. The second species is found on the Ustyurt plateau and northern Turkmenistan. However, both of these species are flightless, little mobile and live on the surface of the soil or in cracks in the rock, moreover they are associated not with open sandy massifs, but with clay and petrophytic slopes. Their spread in Dagestan most likely occurred during the regression of the Caspian Sea [Ilyina, 2013]. *Pseudorchestes abdurakhmanovi*, on the contrary, is a very active, jumping and flying species, strictly confined to sandy massifs. Therefore, the reasons for its so narrow endemism are not entirely clear and require more thorough study. Nevertheless, the Pre-Caspian region is still



Figs 1–2. *P. abdurakhmanovi*: 1 — adult (West Kazakhstan); 2 — map of distribution.

Рис. 1–2. *P. abdurakhmanovi*: 1 — взрослая особь (Западный Казахстан); 2 — карта распространения.

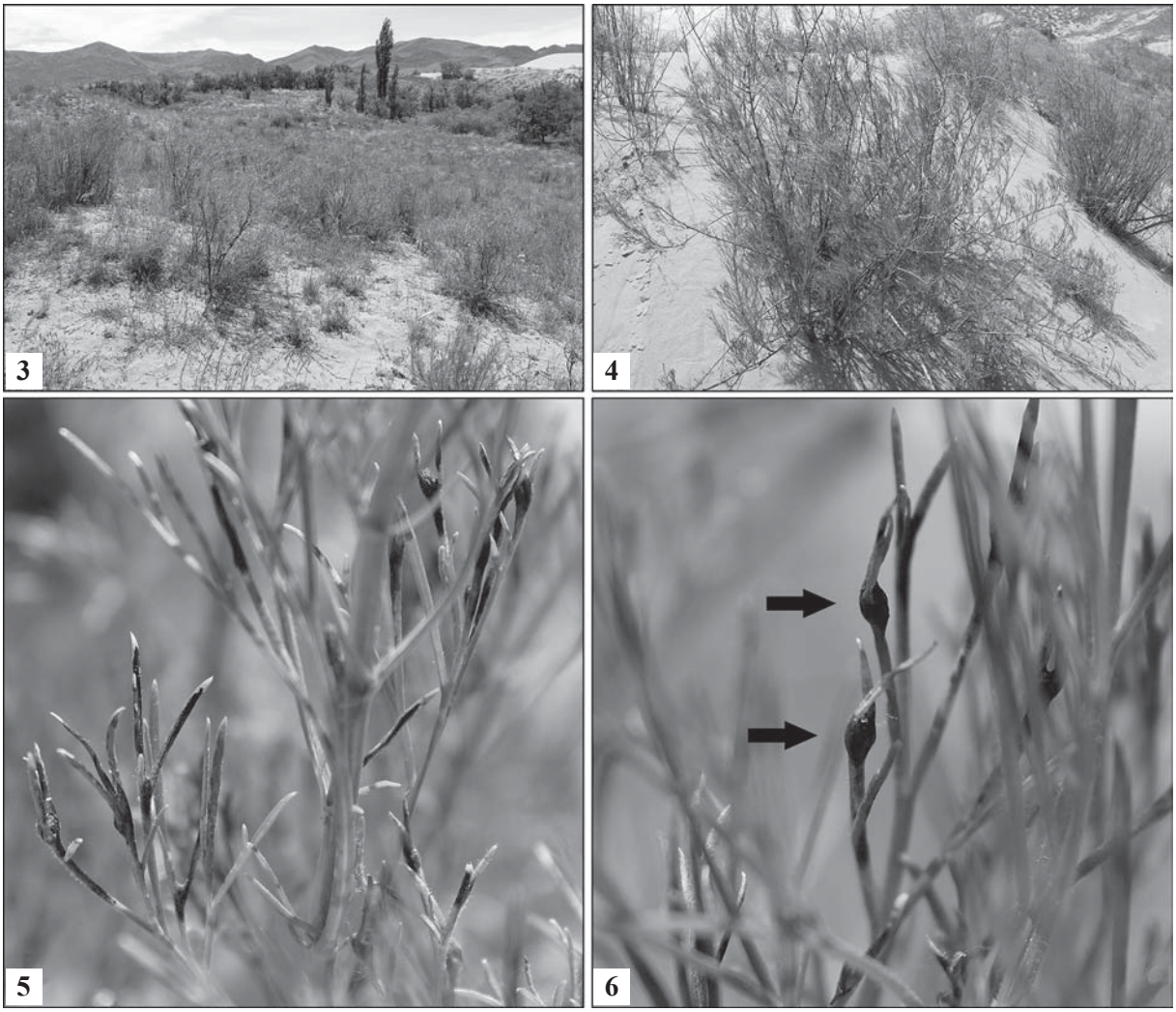
poorly studied and there is a possibility of finding *P. abdurakhmanovi* on other isolated sandy massifs.

Host plant and biology.

When describing this species, it was recorded that type series was collected on *Artemisia abrotanum* L. (as *A. procera* Willd.) [Korotyaev, 1992]. This data was repeated in subsequent work [Korotyaev et al., 1993] and the first edition of the Red Book of the Republic of Dagestan [Mukhtarova, 2009], however, in the new edition of Red Book was indicated only "on various *Artemisia* species" [Mukhtarova, Ismailova, 2020]. I also note that *A. abrotanum* is not recorded in the flora of Sarykum barkhan [Adjieva, 2015]. According to my observations, this species develops as leaf miner only on another *Artemisia* species — *A. tschernieviana* Besser (Fig. 4), which is the endemic of the Pre-Caspian sands and common on Sarykum. Obviously, this particular species of *Artemisia* was incorrectly identified in the original description as «*A. procera*».

The beetles are strictly restricted to open sandy areas with thickets of host plants and avoid heavily overgrown or disturbed habitats (Fig. 3). At the foot of Sarykum barkhan in May 2019 on individual infected plants it was found from 20 to 30 mines. On May 21, I collected mines with the full-grown larvae and placed them in Petri dishes, on May 27, I opened some of the mines and found pupae in them, and on May 30, young beetles began to hatch from the mines. No parasitoids were observed during this. In the first week of June, the largest abundance of this species on host plants in nature was observed while all the mines were empty.

According to the location of the postovipositor scar, oviposition seems to occur at the very margin in the apex of foliole, like in *P. pratensis* [Scherf, 1964], not in the midrib as in most *Orchestes*. The larva gradually moves to the base of the folioles, where it forms brownish to black oval swollen "bubble" filled with excrement (Fig. 5–6). The larva eats up the surrounding parenchyma and damages several (usually 2–3) folioles, so there can be



Figs 3–6. Biotopes and host plant: 3 — biotope on the foot of Sarykum barkhan; 4 — host plant, *A. tschernieviana*; 5–6 — leaf mines, black arrows mark bubble containing larva or pupa.

Рис. 3–6. Биотоп и кормовое растение: 3 — биотоп у подножия бархана Сарыкум; 4 — кормовое растение *A. tschernieviana*; 5–6 — листовые мины, чёрными стрелками отмечены вздутия, содержащие личинку или куколку.

several mines on one leaf. The full-grown larva pupates in a globular cocoon in the center of "bubble".

Description of the last instar larva
Figs 7–22.

MATERIAL. Russia: Dagestan, 20 km W from Makhachkala town, Sarykum barkhan, 43.003497°N 47.237421°E, I.A. Zabaluev leg. 36 larvae collected on 21.05.2019 ex leaf mines on *Artemisia tschernieviana*, and 6 pupae on 27.05.2019 in the same place.

Measurements (in mm). Body length: 2.64–3.49 (mean 2.97). Prothorax width: 0.49–0.60 (mean 0.55). Mesothorax width: 0.62–0.82 (mean 0.73). Metathorax width: 0.69–0.89 (mean 0.79). Abdominal segments I width: 0.73–0.91 (mean 0.83). Head width: 0.36–0.38 (mean 0.37). Head length: 0.22–0.31 (mean 0.25).

Body general (Figs 7–11) almost straight, elongated, slightly dorso-ventrally flattened. Body coloration mainly from light yellow to brownish yellow, sometimes with yellowish merged spots, which can be from imperceptible to very clear in different specimens. Head yellowish-brown, with dark brown lateral parts, endocarina and posterior margin of epicranium darkened. Pronotum with three brownish spots on each side. Ventral part of prothorax with large strongly sclerotized dark brown scutellum. Abdominal segments I–VII on the dorsal side along the middle with a transverse protruding cuticular callus-like fold. Segments VIII–IX without such a fold and gradually conically narrowed towards the apex. Epipleural lobe on abdominal segments I–VIII strongly convex and protrude noticeably laterally. Body cuticle densely covered with dentiform asperities (Fig. 12) forming short rows and bands, but they absent on head, pronotum, ventral scutellum of prothorax, pedal lobes, dorsal folds of abdominal segments, and in area around spiracles. Spiracles (Fig. 13) bicameral, not colored, placed on the prothorax and on abdominal segments I–VIII. Anus situated terminally.

Chaetotaxy of body. Pronotum (Figs 8–9) with long $prns_{2–4}$ and $prns_{6–8}$, short $prns_1$ and $prns_5$, very short $prns_9$. Meso- and metanotum with very short pds_1, long pds_2 and pds_3, short *as*. Pleural parts of prothorax with two long *ps*; pleural parts of meso- and metathorax with short *ss*, very long *eps* (the longest seta on the thorax) and long *ps*. Pedal area with two short and one very short *pda*. Ventral parts of each thoracic segments with one long and one short *eus*. Abdominal segments I–VIII (Figs 8–11) with short *prs*, two short and one long *pds*, very short and long *ss*, short and very long *eps*, very short and very long *ps* and two short *eus*. Abdominal segment IX (Fig. 11) with one minute, one medium and one long *ds*, minute and long *ps* and two long and one minute *sts*. Abdominal segment X (Fig. 11) with three short *ts*. In addition, along the anterior margin of meso- and metathorax there are four greatly reduced microscopic setae (one each next to *pds*, *ss*, *ps*, and *eus*), which are visible at 400x magnification; abdominal segments I–VIII bear three similar setae (next to *prs*, *ss*, and *eus*).

Head capsule and antennae. Head (Figs 14–15) wide, 1.5x as wide as long, almost one-third retracted into prothorax, the posterior margin deeply and broadly emarginated, and strongly thickened. Frons triangular, about reaching occipital foramen, frontal sutures on head distinct, extended to antennae. Endocarinal line very obvious, thickened, prominent posteriorly, almost reaching the anterior margin of frons. One stemma (*st*) in the form of rounded dark bulge, located close to les_2. Hypopharyngeal bracon absent. Dorsal setae: des_1 and des_2 very short, located close to the central part of epicranium, des_3 short, located close to frontal suture, des_4 absent, des_5 — long, located anterolaterally. There are dorsal sensory pores between des_2 and des_5, and proximal to des_1. Frontal area with minute fs_2 and fs_4, long fs_5, lacking fs_1 and fs_2, and also with two sensory pores — between fs_2 and fs_4, and proximal to fs_2. Lateral setae: les_1 long, les_2 very short. Ventral setae: vcs_1 and vcs_2 very short. Posterior epicranial area with row of four minute *pes*. Antenna (Fig. 22) one-segmented, bearing a conspicuous elongated sensorium (*se*) and six sensilla: two ampullacea (*sa*), two styloconium (*ss*) and two basiconicum (*sb*).

Clypeus and mouthparts. Clypeus (Fig. 16) transverse, approximately 2x as wide as long, anterior margin deeply emarginated, the lateral parts of clypeus sclerotized, while the anterior margin and central part membranous; slightly anterior to the middle with two short clypeal setae (*cls*), cls_1 nearly half as long as cls_2, and with sensillum (*clss*) between them. Labrum (Fig. 16) approximately 1.6x as wide as long, anterior margin slightly protruding, with two short *lrs*. Epipharynx (Fig. 17) with three elongated *als*, equal in length, with three *ams* distinctly shorter and thinner than *als* and two noticeably

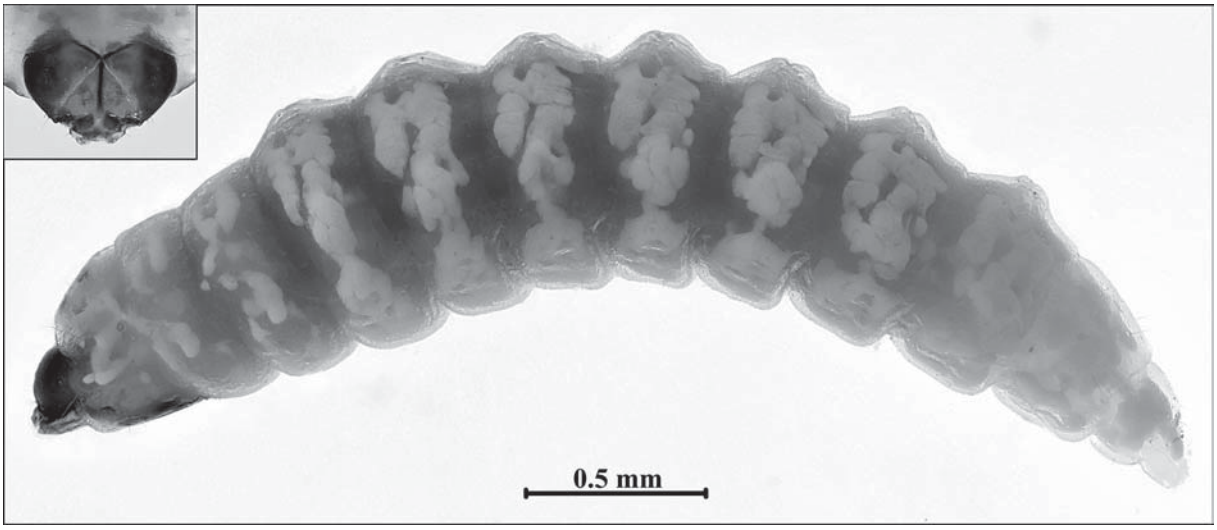
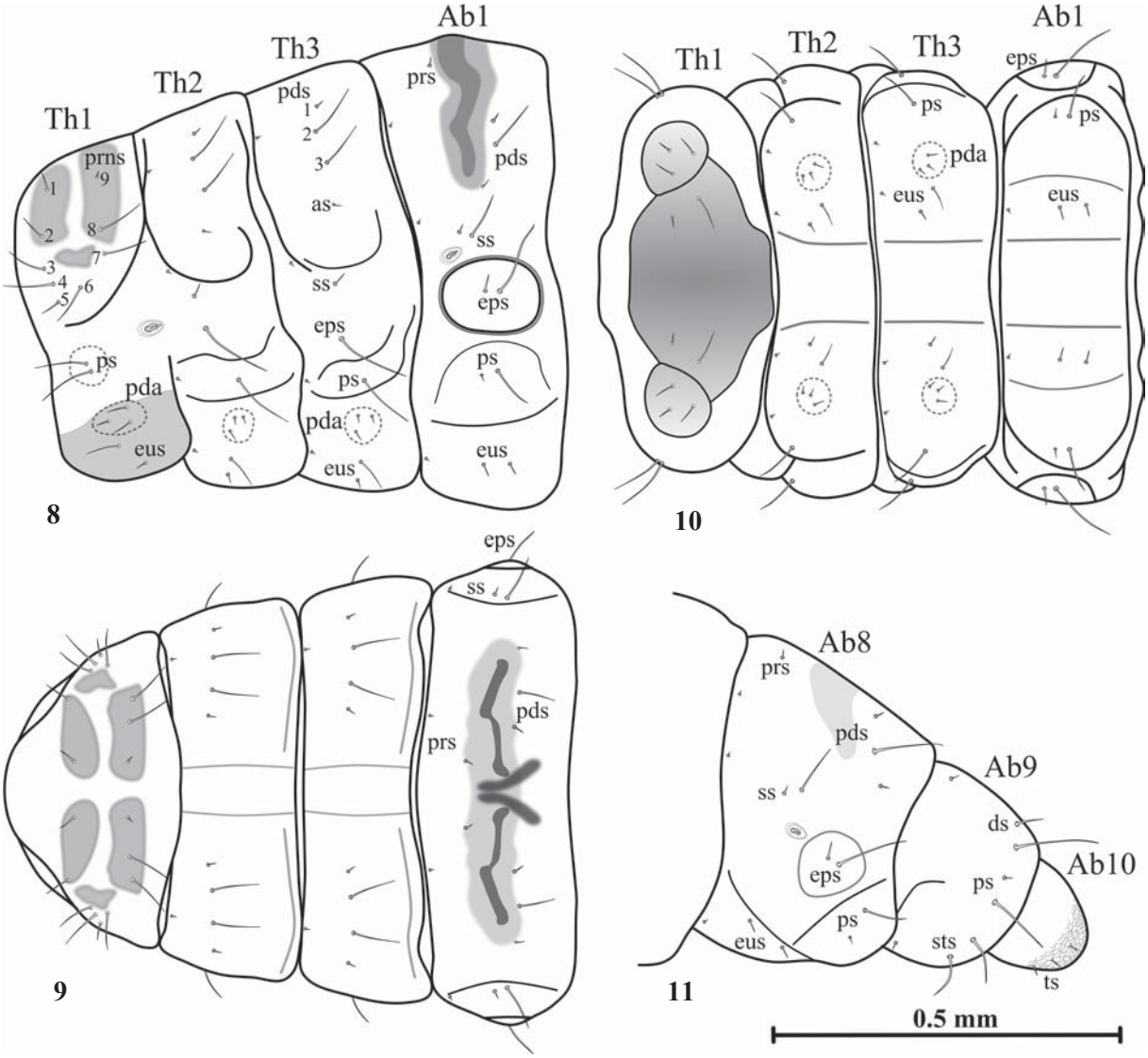
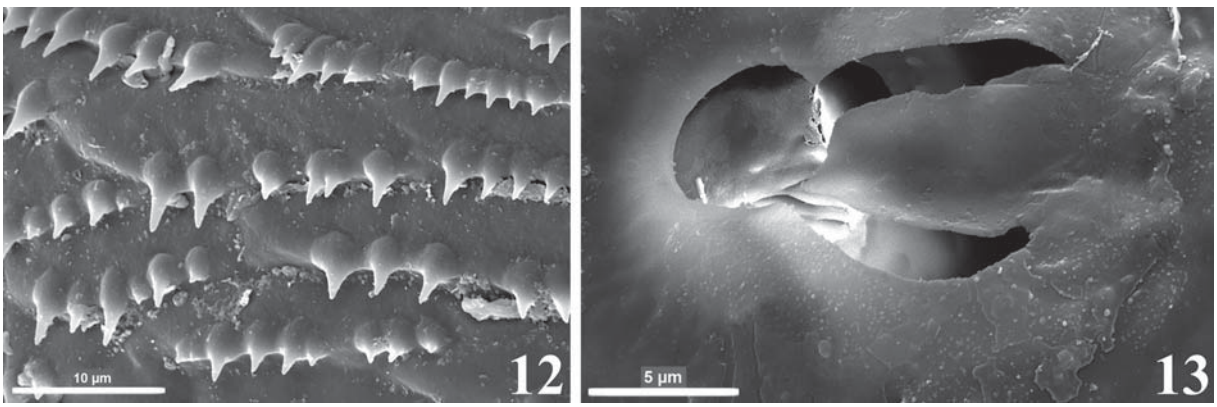


Fig. 7. Larva of *P. abdurakhmanovi*, habitus (front view of head is shown in the left corner).
Рис. 7. Личинка *P. abdurakhmanovi*, общий вид (в левом углу показана голова спереди).



Figs 8–11. *P. abdurakhmanovi*, larva: 8 — chaetotaxy of thorax and abdominal segment I, lateral view; 9 — same, dorsal view; 10 — same, ventral view; 11 — chaetotaxy of abdominal segments VIII–X, lateral view.

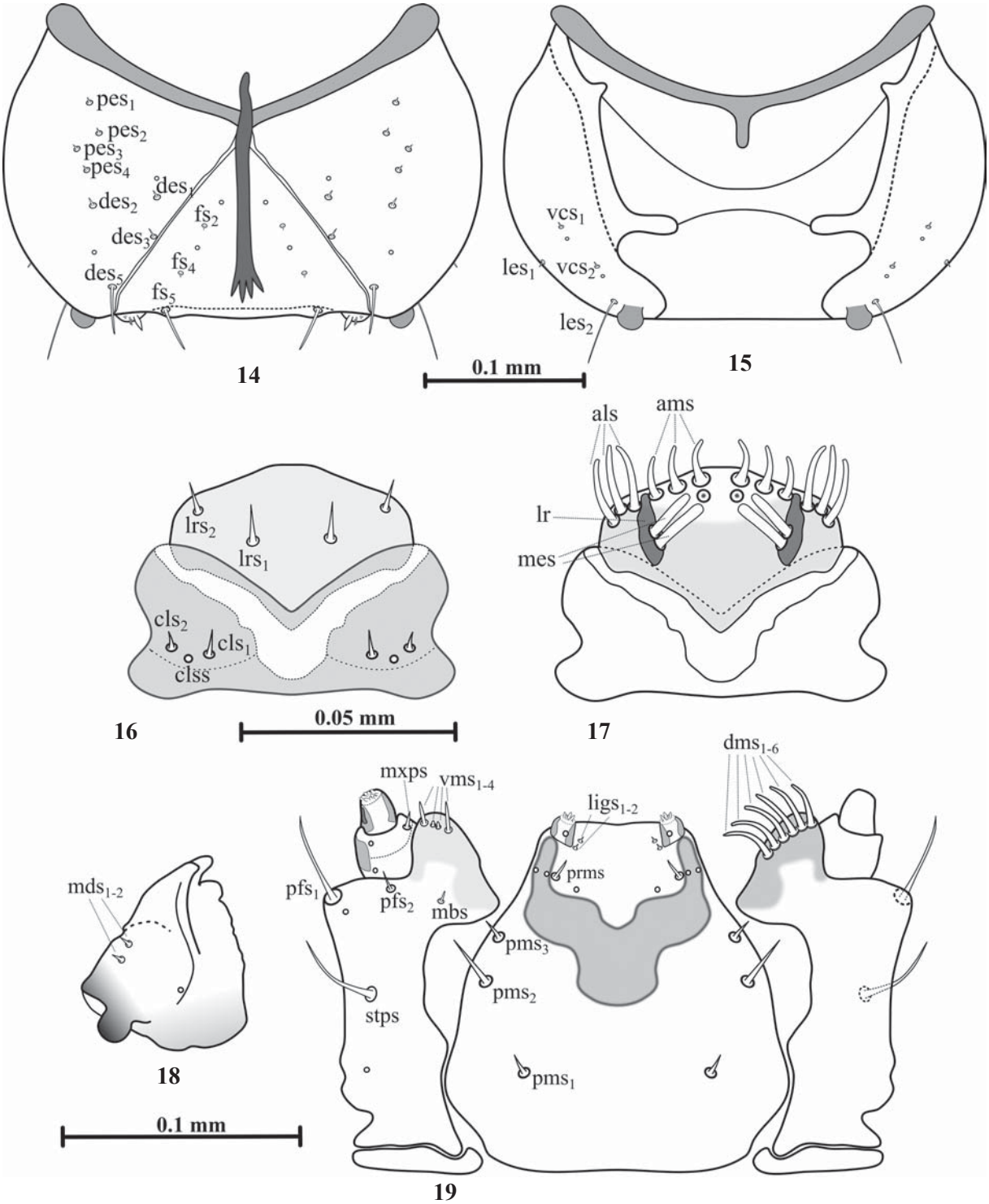
Рис. 8–11. *P. abdurakhmanovi*, личинка: 8 — хетотаксия груди и I сегмента брюшка, сбоку; 9 — тоже, сверху; 10 — тоже, снизу; 11 — хетотаксия VIII–X сегментов брюшка, сбоку.



Figs 12–13. *P. abdurakhmanovi*, structure details (SEM micrographs): 12 — cuticle surface with asperities; 13 — thoracic spiracle.

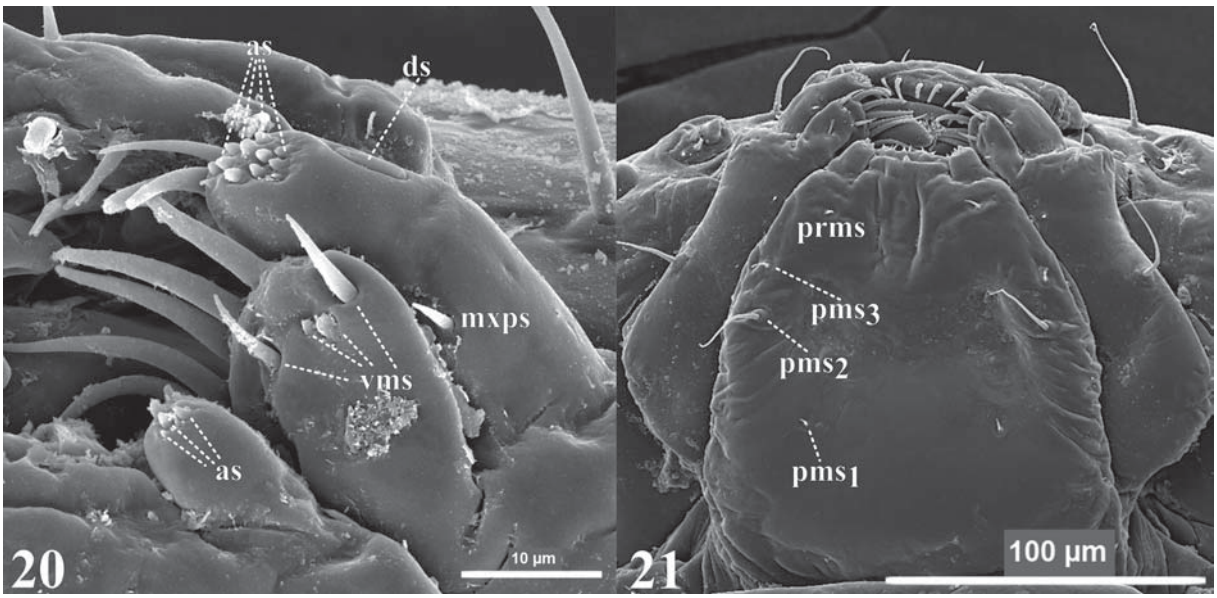
Рис. 12–13. *P. abdurakhmanovi*, детали строения (микрофотографии СЭМ): 12 — участок поверхности кутикулы с асперитами; 13 — дыхальце груди.

elongated finger-like *mes*. Labral rods (*lr*) elongated, slightly wider towards base, not converging posteriorly. There is a rather large sensory pore on each side of epipharynx, which located anteromedially. Mandibles (Fig. 18) relatively small, triangular, with two apical teeth. Both mandibular setae (mds_{1-2}) very short, equal in length. Maxilla (Fig. 19) with one long *stps*, long pfs_1, short pfs_2, very short *mbs* and two sensory pores (one near the base of pfs_1, other distal to *stps*). Mala on dorsal



Figs 16–19. *P. abdurakhmanovi*, head and mouthparts: 14 — head, dorsal view; 15 — head, ventral view; 16 — clypeus and labrum; 17 — epipharynx; 18 — left mandible; 19 — maxillolabial complex (left maxilla in ventral aspect, right maxilla in dorsal aspect).

Рис. 16–19. *P. abdurakhmanovi*, голова и ротовые органы: 14 — голова, сверху; 15 — голова, снизу; 16 — наличник и верхняя губа; 17 — эпифаринкс; 18 — левая мандибула; 19 — максиллолабиальный комплекс (левая максилла показана с вентральной стороны, правая максилла — с дорсальной стороны).



Figs 20–21. *P. abdurakhmanovi*, details of mouthparts (SEM micrographs): 20 — maxilla and labial palpomere, ventral view; 21 — prementum, ventral view.

Рис. 20–21. *P. abdurakhmanovi*, детали строения ротовых органов (микрофотографии СЭМ): 20 — максилла и губные щупики, снизу; 21 — прементум, снизу.

side with a row of six curved, almost equally-sized *dms*, and on ventral side with four *vms* (two medium and two very short). Maxillary palpi (Fig. 20) consist of two palpomeres: basal palpomere slightly wider than distal one, with one short *mxps* and two sensory pores; distal palpomere with one sensory pore, one digitiform sensillum (*ds*) laterally, and a group of an eleven apical sensillae on terminal receptive area (*tra*). Prelabium wide, cup-like, distinctly dilated laterally and especially posteriorly, with three small sensory pores and one short *prms*. Ligula with two minute *ligs*. Labial palpi widely separated, one-segmented; palpomere (Fig. 20) with one sensory pore and a group of seven apical sensillae on terminal receptive area (*tra*). Postlabium (Fig. 21) rather elongated, with three *pms*: pms_1 and pms_3 short (pms_3 slightly longer than pms_1), pms_2 medium length, approximately 2x as long as pms_3.

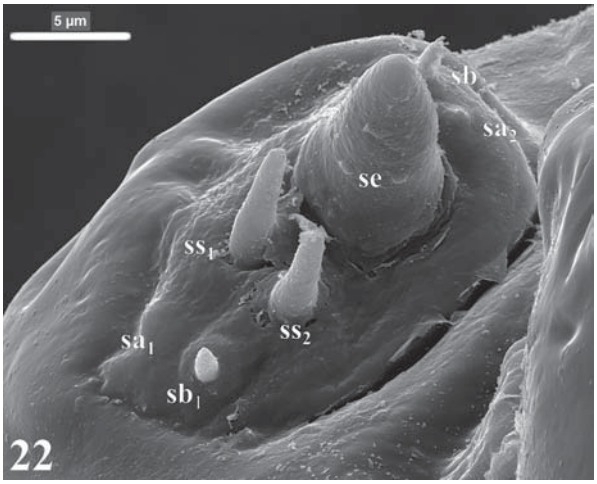


Fig. 22. *P. abdurakhmanovi*, antenna (SEM micrograph).

Рис. 22. *P. abdurakhmanovi*, усик (микрофотография СЭМ).

Description of pupa
Figs 23–26.

MATERIAL. 6 pupae collected on 27.05.2019 in the same place as larvae.

Measurements (in mm). Body length: 1.68–2.34 (mean 2.03). Body width: 0.78–0.84 (mean 0.81). Head width: 0.37–0.39 (mean 0.38).

General habitus. Body elongated, yellowish-green, urogomphi, setae and tubercles on which they are located are brown. In specimens ready to hatch, eyes, mandibles, margins of the rostrum, apical part of the wings and elytra, and apex of femora, are also darkened. Rostrum slender, 2.32–2.46x as long as wide, reaching mesocoxae. Antennae attached at the very base of the rostrum. Pronotum rounded-trapeziform, 1.24–1.30x wider than long. Spiracles placed dorso-laterally on abdominal segments I–VI. Urogomphi (Fig. 26) paired, converging, bear a stout acute spine at the apex. Surface of cuticle of sides of rostrum, antennae, abdomen, except for median areas of tergites between dorsal setae and urogomphi, as well as inner margin of elytra, outer surfaces of femora, tibiae, and tarsi covered with the same dentiform asperities as in larvae.

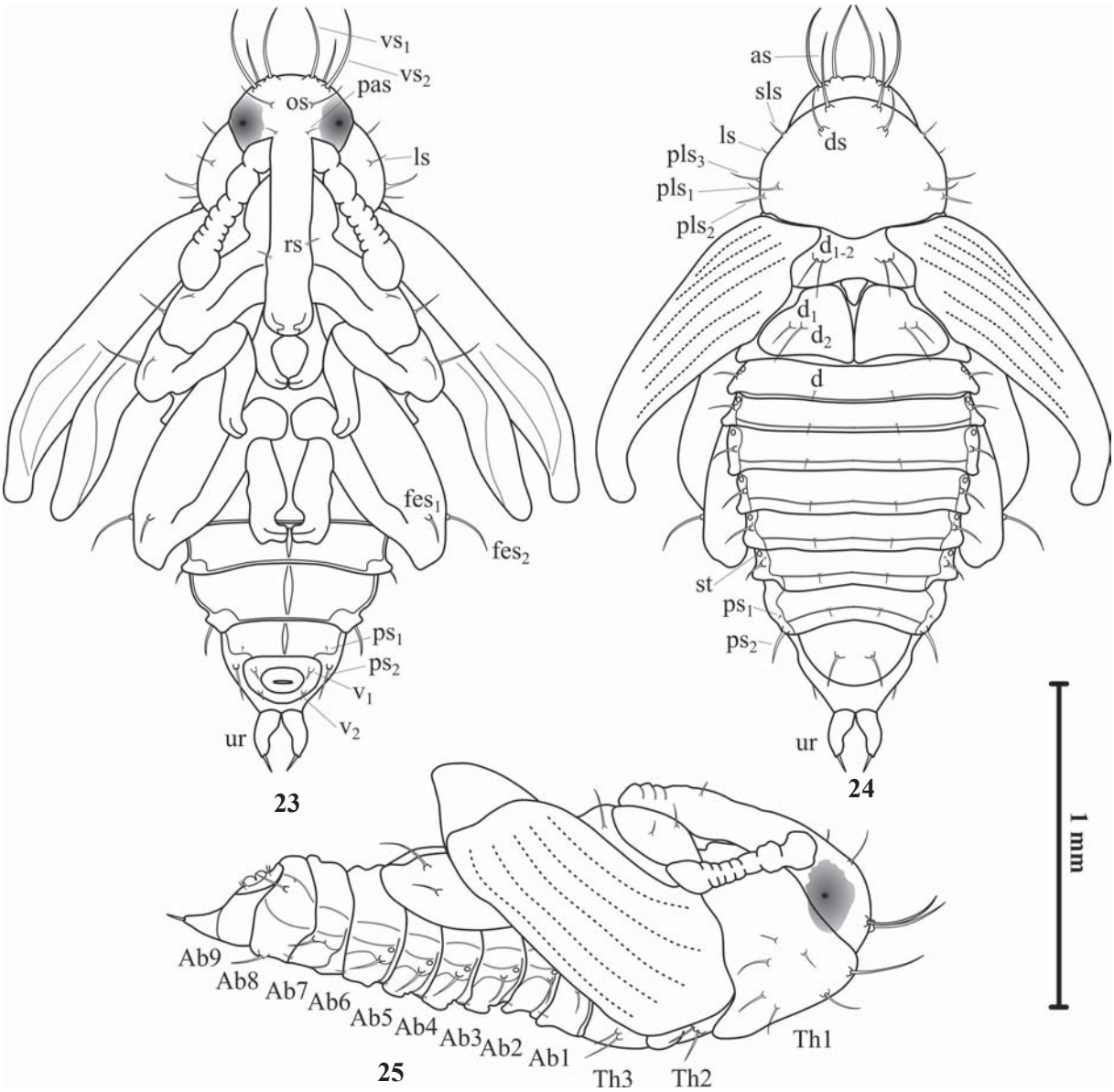
Chaetotaxy. Setae from yellowish to brownish, predominantly fine and hair-like, variable in size, located on apices of low, rounded tubercles. Head with one short *pas*, one long *os* (ca 3x as long as *pas*) and two exceptionally long and robust *vs* equal in length. Rostrum with one short *rs*, slightly more than $^1/_3$ of the width of the rostrum and placed posterior to its middle. Pronotum with one *as*, one *ds*, one *ls*, one *sls* and three *pls*. *As* very long, approximately equal to length of *vs*, *ds* about ½ as long as *as*, *ls* and *sls* short and fine, $pls_{1\text{-}3}$ approximately equal in length, slightly longer than *ls* or *sls*. Mesonotum with two long *d*, both are placed on the same convex base. Metanotum with two *d*, such as those on mesonotum, but located on separate convex tubercles. Each of abdominal segments I–VIII on dorsal parts with one *d*, short on I–VII and very long and located on a convex strong

tubercle on VIII; on pleural parts with two *ps*: ps_2 long, ps_1 minute and clearly visible only on segments V–VIII; $ps_{1\text{-}2}$ on segment VIII strongly displaced to the ventral side. Ventral part of abdominal segment IX (Fig. 26) with two short and stout *v*. Apex of femora with very long fes_2 and 2 times shorter fes_1. Urogomphi without setae.

Discussion

The larvae of the tribe Ramphini, including the genus *Pseudorchestes*, are very recognizable and are well distinguished from the larvae of other weevils by the following characters: head is retracted into the prothorax with deeply and broadly emarginated at the posterior margin, frons is pointed and about reaching occipital foramen, bearing minute fs_2 and fs_4, and long fs_5, endocarina is prominent posteriorly, hypopharyngeal bracon is absent, labial palpi are widely separated, abdominal segments on the dorsal side with cuticular fold, body is almost straight and usually flattened dorsoventrally [Morimoto, 1984; Lee, Morimoto, 1996]. Many of these characters arose as an adaptation to living between the leaf epidermis, i.e. miner lifestyle and are convergently similar to other miner, for example, Buprestidae of the genus *Trachys* [Bíl□, 1992].

There are very few descriptions of the larvae of Rhamphini in the literature, and those that do exist [Laboulbéne, 1858; Trägårdh, 1911; Oldham, 1928; Scherf, 1964; Lee, Morimoto, 1996] are very incomplete, superficial, and lack many important details of chaetotaxy. Therefore, it is very difficult to recognize



Figs 23–25. *P. abdurakhmanovi*, pupa habitus and chaetotaxy. 23 — ventral view, 24 — dorsal view, 25 — lateral view.
Рис. 23–25. *P. abdurakhmanovi*, общий вид куколки и хетотаксия. 23 — вид снизу, 24 — сверху, 25 — сбоку.

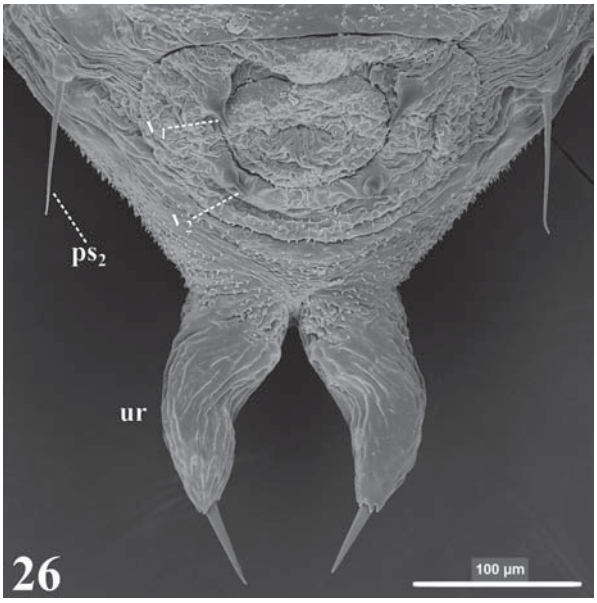


Fig. 26. *P. abdurakhmanovi*, abdominal segments IX and urogomphi of pupa, ventral view (SEM micrograph).

Рис. 26. *P. abdurakhmanovi*, IX сегмент брюшка и урогомфы куколки, снизу (микрофотография РЭМ).

the characters by which the genera of this tribe differ from each other. Apparently, the larvae of *Pseudorchestes* are closest to the larvae of *Orchestes*. Thus, the larvae of *O. quercus* (Linnaeus, 1758) [Trägårdh, 1911] and *O. testaceus* (O.F. Mueller, 1776) [Oldham, 1928, as *O. alni*] are distinguished by dark-colored spiracles and the presence of des_3, and the first species is also distinguished by a darkened the abdominal segment X. *Orchestes fagi* (Linnaeus, 1758) [Trägårdh, 1911] larvae are similar to *Pseudorchestes* larvae in that they have uncolored spiracles and abdominal segment X, but differ in long pms_1 and pms_3, which are not shorter than pms_2. Finally, the undescribed larvae of the eastern palearctic species *O. lateritius* (Morimoto, 1984) that I have at my disposal also differ from *Pseudorchestes* in very long *pms* and the presence of very short des_3.

Only for three species of *Pseudorchestes* (as *Rhynchaenus*) there are descriptions of larvae — *P. cinereus* (Fåhraeus, 1843), *P. pratensis* (Germar, 1821) [Scherf, 1964] and *P. smreczynskii* (Dieckmann, 1958) [Wanat, 1987]. However, these descriptions are very brief and are not accompanied by any figures or are accompanied by very schematic figures, which makes it impossible to compare them with the larva of *P. abdurakhmanovi* described in this work.

The pupae of representatives of the tribe Ramphini are described in the literature [Laboulbéne, 1858; Oldham, 1928; Scherf, 1964] even more briefly and more fragmentarily than larvae. As far as it is possible to establish from the available data, pupae of *Pseudorchestes* are also closest to *Orchestes*, but differ in that they have two *vs* located on small convex tubercles separately from each other, while in *Orchestes* two or three *vs* are located in a cluster on one very large tubercle. In addition, *P. abdurakhmanovi* pupae have two ventral setae (*v*) on abdominal segment IX, while at least *O. testaceus* has three *v*. In *Pseudorchestes*, only for *P. smreczynskii* there is a very brief description of the pupa [Wanat, 1987] with a schematic figure. It differs from *P. abdurakhmanovi* pupa in the presence of only one very long *fes*. However, it cannot be ruled out that fes_2 is also present in this species, but it is very short and, therefore, was not shown in the figure.

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