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Morphological study of *Perileptus* larvae (Coleoptera Carabidae Trechitae)

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Abstract. Larvae of the genus *Perileptus* Schaum, 1860 are described or redescribed: *P. areolatus* (Creutzer, 1799) (all instars) and *P. mesasiaticus* Uéno, 1976 (first and second instars). Based on the larval morphology, the genus *Perileptus* is closely related to the genus *Thalassophilus* Wollaston, 1854. This relationship is supported with three synapomorphic character states: (1): Anterior claw bears a hyaline organ on its dorsal surface which extends to its apex; (2): Presence of a flat, ventrally curved, long seta attached between the clawes; (3): Seta UR_3 on urogomphi located near seta UR_4, not near UR_2. The presence of two claws is presumably a plesiomorphic character. Taxonomic position of the genera *Perileptus* and *Thalassophilus* within the supertribe Trechitae is unclear. Neither of these two genera posses any of the significant autapomorphic larval characters thought to be definitive for Trechitae. Some bionomics data of *Perileptus* larvae are shortly discussed.

Резюме. Описаны или переописаны личинки рода *Perileptus* Schaum, 1860: *P. areolatus* (Creutzer, 1799) (все возрасты) и *P. mesasiaticus* Uéno, 1976 (первый и второй возрасты). На основании морфологии личинок, род *Perileptus* наиболее близок роду *Thalassophilus* Wollaston, 1854. Их родственные связи подтверждаются тремя синапоморфными состояниями признаков: 1) Передний коготок несет на дорсальной поверхности гиалиновый орган, направленный вперед; 2) Присутствует плоская, изогнутая вентрально длинная хета, прикрепленная между коготками; 3) Хета UR_3 на урогомфах расположена рядом с хетой UR_4, а не UR_2. Присутствие двух коготков является, возможно, плезиоморфным признаком. Таксономическое положение родов *Perileptus* и *Thalassophilus* в надтрибе Trechitae остается неясным. Ни один из этих двух родов не обладает каким-либо важным аутапоморфным личиночным признаком, который считается определяющим для Trechitae. Кратко обсуждены некоторые данные по биологии личинок *Perileptus*.

Key words: larvae, morphology, taxonomy, phylogeny, Coleoptera, Carabidae, Trechini, *Perileptus*.

INTRODUCTION

The genus *Perileptus* Schaum, 1860, along with the Asiatic *Neoblemus* Jeannel, 1923 and *Apoplotrechus* Alluaud, 1915 from Madagascar, belongs to the subtribe Perileptina of the tribe Trechini. The subtribe is distributed in the Palaearctical, Afrotropic, Oriental, and Australian Regions with one species in Cuba (CASALE &LANEYRIE, 1982). According to these authors, the genus includes 42 species. Since then, BAEHR (1987) described 3 new species from Australia.

Very little is known about the larval morphology of *Perileptus*. BOLDORI (1936) described the larva of the European *Perileptus areolatus* (Creutzer, 1799). Almost a half of century later, LUFF (1985) redescribed this species based on Boldori's material. This genus was included several times in identification keys of carabid larvae (VAN EMDEN, 1942; SHAROVA, 1958, 1964; LARSSON, 1968; ARNDT, 1991; LUFF, 1993; MAKAROV, 1994). So, our knowledge about the larval morphology of *Perileptus* is based on the three specimens, collected by Leonida Boldori in July 21, 1935.

In 1996 the senior author reared *ex ovo* larvae of two species of the genus *Perileptus*: *P. areolatus* from Caucasus and *P. mesasiaticus* Uéno, 1976 from Kugitang Range (East Turkmenistan). This new material allows us to conduct a new study of the morphology, including larval chaetotaxy, of this genus. Additionally, larvae from five tribes and a number of genera of the supertribe Trechitae were part of this compartive study.

Material and methods

All studied larvae were reared *ex ovo* from the field collected females. Geographic data are provided below, under each studied species. The material is deposited in the collections of the authors, the British Museum of Natural History, London (BMNH) and the Canadian National Collection, Ottawa (CNC).

Some larvae of each species were mounted on permanent slides. A light stereo microscope MBS-1 was used at magnification 80 to 900 x. All drawings have been done with the aid of a camera lucida. Notation of the setae and pores follows Bousquet & Goulet (1984) and Bousquet (1985).

All measurements were made using a micrometer. The following abbreviations are used in the descriptions of species: HW – maximum width of head; HL – length of head along middle line. Symbols L_1, L_2, and L_3 mean the first, second, and third instar larvae respectively.

For comparison larvae of 25 genera, representing 5 tribes of the supertribe Trechitae (sensu Kryzhanovskij, 1976, 1983; Kryzhanovskij et all, 1995) have been studied: the tribe Trechini (genera *Aepopsis* Jeannel, 1992, *Thalassophilus* Wollaston, 1854, *Temnostega* Enderlein, 1905, *Amblystogenium* Enderlein, 1905, *Trechus* Clairville, 1806, *Epaphius* Stephens, 1827 and *Trechimorphus* Jeannel, 1927); the tribe Bembidiini (genera *Bembidion* Latreille, 1802, *Asaphidion* Des Gozis, 1886, *Ocys* Stephens, 1829 and *Phrypeus* Casey, 1924); the tribe Tachyini (genera *Tachys* Stephens, 1829, *Paratachys* Casey, 1918, *Sphaerotachys* J. Müller, 1926, *Elaphropus* Motschulsky, 1839, *Porotachys* Netolitzky, 1914, *Tachyta* Kirby, 1837, *Mioptachys* Bates, 1882 and *Polyderis* Motschulsky, 1862); the tribe Pogonini (genera *Pogonus* Nicolai, 1822, *Pogonistes* Chaudoir, 1870, *Cardioderus* Dejean, 1829 and *Thalassotrechus* Van Dyke, 1918); the tribe Zolini (genera *Oopterus* Guérin-Méneville, 1841 and *Idacarabus* Lea, 1910).

Genus *Perileptus* Schaum, 1860

Diagnosis

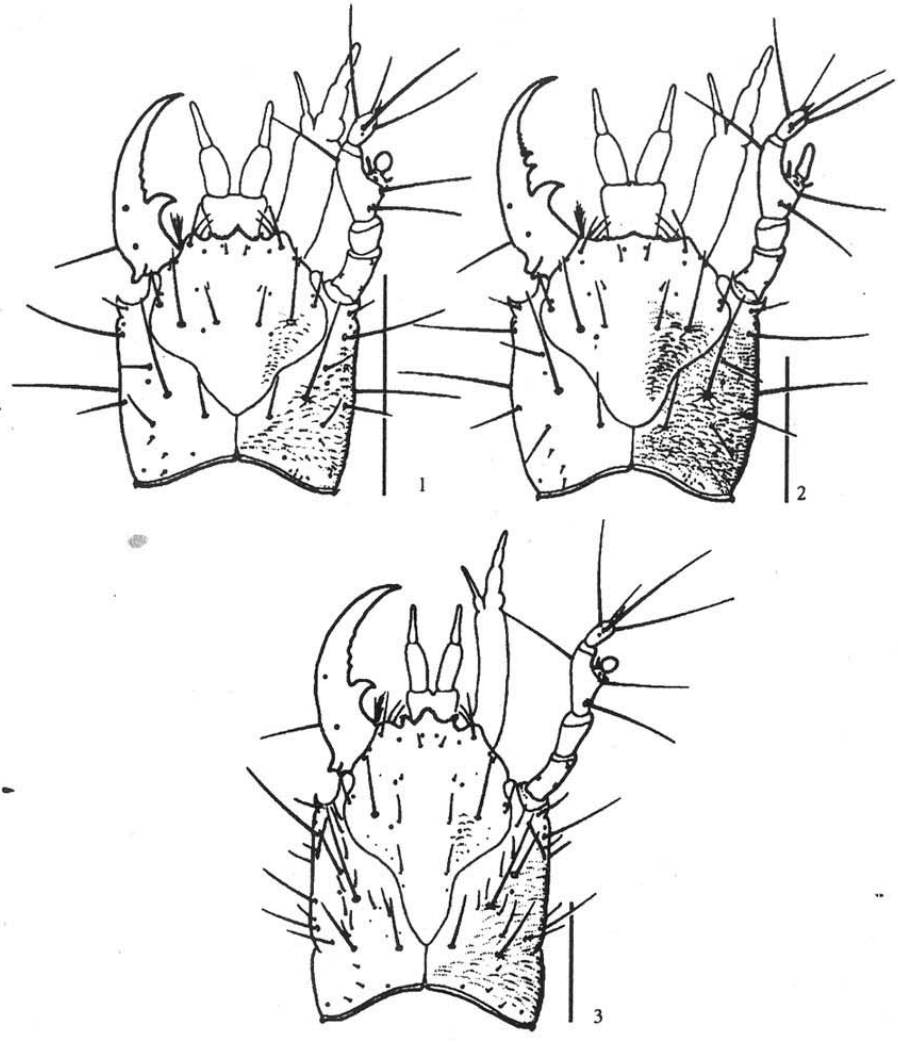
Within the supertribe Trechitae, larvae of the genus *Perileptus* (and *Thalassophilus*; see Grebennikov, 1996) can be easily recognised by the presence of a flat, curved claw seta as long as the claws themselves (Figs 13, 14). Differences between the genera *Perileptus* and *Thalassophilus* are noted below:

Perileptus (Figs 1, 3, 4, 6, 7, 9, 11 - 17): L_1-L_3: pore PA_b on parietale present (Figs 1, 3); L_1-L_3: antennomere 3 with rounded sensorium (Figs 1, 3, 7); L_1-L_3: mandibles with small teeth on terebra (Figs 1, 3); L_1: nasale as Fig. 4; L_1: setae EM_1 on meso- and as metanotum modified as pore-like sensilla (Fig. 12); L_1: central ventrite of abdomen without additional setae; L_1: seta EP_1 on ninth abdominal segment modified as 2 or 3 pore-like sensilla (Fig. 17).

Thalassophilus (Figs 2, 5, 8, 10): L_1-L_3: pore PA_b on parietale absent (Fig. 2); L_1-L_3: antennomere 3 with elongated sensorium (Figs 2, 8); L_1-L_3: mandibles with large teeth on terebra (Fig. 2); L_1: nasale as fig. 5; L_1: setae EM_1 on meso- and metanotum absent; L_1: central ventrite of abdomen with one long additional seta on each side; L_1: seta EP_1 on ninth abdominal segment absent.

Description

First instar larvae. Body almost colourless, head light brown; larva less sclerotised than usual for Trechitae members, sclerotisation of lateral margins of tergites



Figs 1-3. Larvae of the genera *Perileptus* and *Thalassophilus*: cephalic capsule, right antenna, left mandible, right maxilla, and labium, dorsal view: 1-2, first instar; 3, third instar. 1-3, *Perileptus areolatus*; 2, *Thalassophilus longicornis*. Scale bars: 0.2 mm.

unclear; all primary sensilla present (except as noted below), their positions as in the generalized type (see BOUSQUET & GOULET, 1984); additional sensilla absent (except as noted below).

Cephalic capsule (Fig. 1) parallel sided or slightly convergent posteriorly; ocelli absent; ocellar tubercles little developed or absent; postocellar and cervical grooves absent; frontal sutures more or less curved; epicranial suture present, rather long; nasale (Fig. 4) with numerous teeth; central projection of nasale composed of several rows of teeth one under another. Microsculpture (Fig. 1): frontale with slight transverse microsculpture at base; parietale with transverse microsculpture

throughout or on dorso-lateral surfaces; parietale near seta PA_1 with 6 - 8 microspones; egg-bursters absent. Chaetotaxy (Fig. 1): distance between setae FR_1-FR_2 = FR_2-FR_3; FR_3-FR_4 = FR_4-FR_5; anterior angles of hypopharynx with single seta on each side.

Antennae (Fig. 7). Distal part of antennomere 3 very long and fully sclerotised (including lateral surface between sensorium and base of antennomere 4); all conical and companiform sensilla on antennomeres 3 and 4 well developed; sensorium on antennomere 3 relatively large, round; seta AN_6 about 1.5 x length of antennomere 4.

Mandibles (Fig. 1) relatively straight, little curved; terebra with some slightly developed teeth; dorsal keel at apex of mandible not developed; microsculpture on dorsal surface absent; retinaculum perpendicular; penicillus not extending to apex of retinaculum.

Maxillae (Fig. 9) with comparatively narrowed and elongated articles, especially stipes and galeomere 2; dorsal surface fully sclerotised; group gMX comprising 6 - 11 setae, one of them placed apically at level of seta MX_6, the rest of the setae on basal half of stipes; seta MX_6 short, its length about 0.4 x that of MX_5; second galeomere 2 x longer than galeomere 1; seta MX_7 relatively short, reach only to basal 1/3 of galeomere 2; seta MX_8 at middle of galeomere 2; setae MX_{11}, MX_{12} small, not longer than 1/4 width of palpomere 3; palpomere 4 undivided.

Labium (Fig. 9). Setae LA_3 and LA_4 comparatively short and thin; ligula not developed and not sclerotised; seta LA_6 flat; second article complete, undivided.

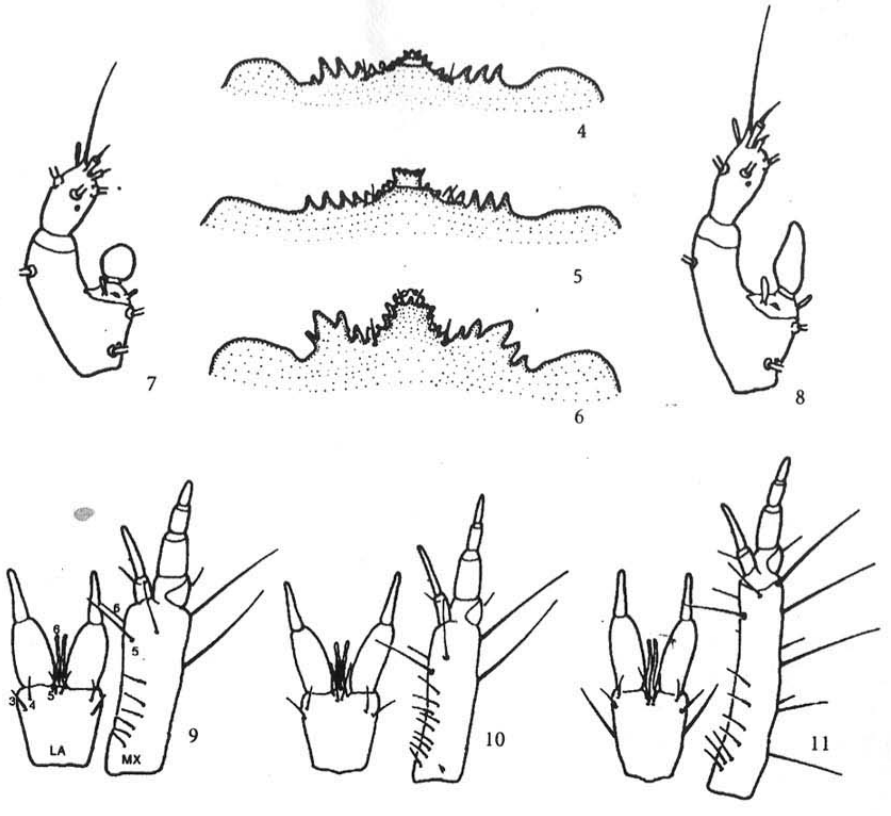
Thorax (Fig. 12) without primary pores PR_c, PR_e, PR_i, PR_j on pronotum, ME_d, ME_e on meso-and metanotum, and seta ES_1 on meso- and metathorax; setae EM_1 on meso- and metathorax absent; one pore-like sensillum presents at position of EM_1 on meso- and metathorax; all other sensilla present (including PS_2 and MS_4 on ventral surface); additional pore-like sensillum presents near seta MS_1; setae PR_7 and ME_{10} comparatively long, as long as 7 - 10 basal diameters of the longest setae on tergite; length of setae PR_{13} and ME_{14} about 0.7-0.9 x that of setae PR_{12} and ME_{13} respectively; surface of tergites smooth; fine microsculpture present only at middle of pretergites of meso- and metanotum.

Legs (Fig. 13) with two claws (Fig. 14), anterior one about 1/10 longer than posterior; middle of anterior claw with hyaline organ on dorsal surface, extending to its apex; a long, flat, ventrally curved single claw seta attached between base of the two claws, its length about as long as claw; setae TA_3, TA_4, TA_5, TA_6 absent; seta TA_1 at basal 1/5 of tarsus; setae TI_1 and TI_2 much thinner and longer than setae TI_3, TI_4, TI_5, TI_6, TI_7.

Abdomen without primary pore TE_b on tergites 1-8; seta TE_8 as long as 5-7 basal diameters of seta TE_9; length of seta TE_{11} about 0.7-0.9 x that of TE_{10}; tergites with fine pointed microsculpture on all surface.

Urogomphi and pygidium (Fig. 17). Urogomphi relatively straight; seta EP_1 on ninth abdominal segment absent; 2 or 3 pore-like sensilla present at position of EP_1; seta UR_3 near seta UR_4; seta UR_9 as long as 7-10 basal diameters of setae UR_8.

Second and third instar larvae. Cephalic capsule (Fig. 3) more elongated and sclerotised; with developed latero-ventral keel; postocellar grooves present as short lines medially to seta PA_9; cervical grooves absent; nasale: Fig. 6. Microsculpture



Figs 4–11. Larvae of the genera *Perileptus* and *Thalassophilus*, dorsal view: 4-6, nasale; 7-8_T right antennomeres 3 and 4; 9-11, labium and right maxilla. 4, 5, 7-10, first instar larvae; 6, 11, third instar larvae. 4, 6, 7, 9, 11, *Perileptus areolatus*; 5, 8, 10: *Thalassophilus longicornis*.

(Fig. 3): parietale with developed transverse microsculpture; without microspines medially of seta PA_1; frontale smooth, without microsculpture. Chaetotaxy (Fig. 3): parietale with 45-55 secondary setae on each side; frontale with a pair of secondary setae at base and 18-22 microsetae on basal half.

Antennae without secondary setae.

Mandibles (Fig. 3) without microsculpture and secondary setae; teeth on terebra larger than in first instar.

Maxillae (Fig. 11). Group gMX with 7 (in L_2), 7-11 (in L_3) setae; stipes laterally with 5 (L_2) or 7 (L_3) setae.

Labium (Fig. 11) with one thin and long secondary seta on each side.

Thorax (Fig. 15). Each side of tergite with 110-130 (pronotum) or 100-120 (meso- and metanotum) secondary setae; membranous zone at posterior angles of pronotum with three setae on each side near seta PR_{11}; ventrite of pronotum with 18-22 setae on each side; pleurites of meso- and metanotum with one secondary seta; each small sclerite around seta MS_1 with 1 (L_2) or 3-5 (L_3) pore-like sensilla; epimerite without sensilla; metathorax with one secondary seta at place of primary seta ES_1.

Legs (Fig. 13) without any secondary sensilla (except 2-3 setae on coxa).

ABDOMEN. Tergites with 50-70 secondary setae on each side; epipleurites with 2 secondary setae; hypopleurites with 15, outer postventrites with 15, inner postventrites with 8-10, central ventrite with 20 setae; sclerites of seta ST1 with 1 (L_2) or 2-6 (L_3) pore-like sensilla.

Urogomphi and pygidium (Fig. 16). Seta UR_{alpha} present; urogomphi with 7 long setae (5 of them primary); lateral margins of ninth tergite with secondary seta at middle; urogomphi with 18-33 small secondary setae on each side; sternal sclerite with 15 small secondary setae on each side; epipleurites without pore-like sensilla, with 2 setae (the longest seta placed more anteriorly than the shorter one); pygidium with 70-90 small secondary setae on apical half dorsally, ventrally and laterally.

PHYLOGENETIC POSITION

1. Why does Perileptus belong to the supertribe Trechitae? Larvae of the genus *Perileptus* share all presumably apomorphic characters of the supertribe Trechitae: lack of primary pores PR_c, PR_e, PR_i, PR_j on pronotum, pores ME_d, ME_e on meso- and metanotum, seta ES_1 on metathorax, pore TE_b on abdominal tergites 1-8, and setae TA_3, TA_4, TA_5, TA_6 on tarsus. Presence of these sensilla is considered as plesiomorphic condition.

2. Sister group of Perileptus. Within all Trechitae larvae known to us, the genus *Perileptus* is most closely related to the genus *Thalassophilus* based on the presence of these three synapomorphies of all instars larvae:

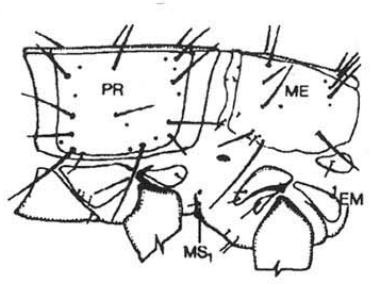
1. The anterior claw bears a hyaline organ on its dorsal surface, extending to its apex (Figs 13, 14) (presumed plesiomorphic character state: claw (or claws) is without any hyaline organ on dorsal surface). This is a unique feature within the supertribe, but it should be noted that a somewhat similar structure is found by BOUSQUET (1996) on the claws of *Schizogenius lineolatus* Say, 1823, a member of the tribe Clivinini.

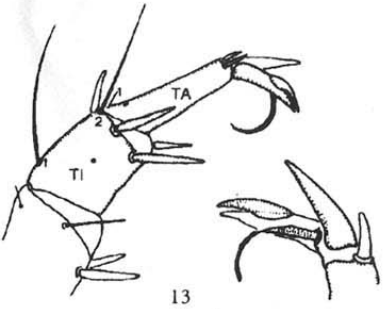
2. Claws bear a long, flat, ventrally curved single claw seta, which is about as long as the claws themselves (Figs 13, 14) (presumed plesiomorphic character state: claw seta short, at least 5 x shorter than claw (or claws), not flat, not curved).

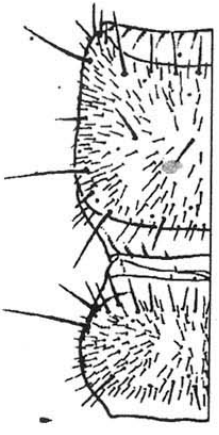
3. Seta UR_3 on urogomphi located near seta UR_4, not near UR_2 (Figs 16, 17) (presumed plesiomorphic character state: seta UR_3 on urogomphi located near UR_2).

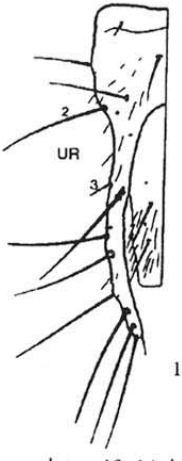
As for the presence of two claws, we believe this is a plesiomorphic character, shared by larvae in question with those of the genera *Temnostega*, *Amblystogenium* and *Trechimorphus* (unpublished data, partly). We do not use this assumed ancestral similarity to support a relationship between these genera. All other known members of the supertribe Trechitae have a single claw (presumably the apomorphic character state).

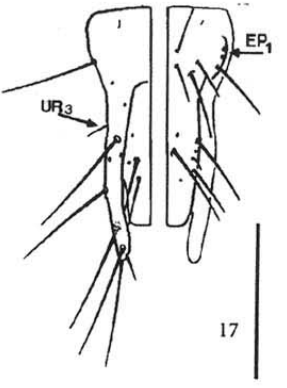
3. Relationship with Trechini is not supported. Taxonomic position of the genera *Perileptus* and *Thalassophilus* within the Trechitae is unclear. According to the imaginal classification, the genera *Perileptus* and *Thalassophilus* belong to the tribe Trechini. However, their larvae share no important apomorphic characteristics of the tribe Trechini. The synapomorphies of Trechini (which are absent in *Perileptus* and *Thalassophilus)* are as following:











Figs 12-17. Larvae of *Perileptus areolatus*: 12–14, lateral view; 15, 16, dorsal view; 17, dorsal and ventral views. 13, 14, all instar larvae; 12, first instar larvae; 15-17, third instar larvae. 12, prothorax and mesothorax; 13, claws, tarsus, tibia and apex of femur; 14, claws and apex of tarsus; 15, pronotum and mesonotum, left side; 16, urogomphi and pygidium, left side; 17, urogomphi and pygidium, left side dorsally and ventrally. Scale bars: 0.2 mm.

1. L_2-L_3: Antennomere 2 bears relatively long secondary seta at apex (presumed plesiomorphic character state of *Perileptus* and *Thalassophilus*: antennomere 2 bears no secondary seta (Fig. 3)).

2. L_2-L_3: Tarsus and tibia bear secondary setae (presumed plesiomorphic character state of *Perileptus* and *Thalassophilus*: tarsus and tibia bear no secondary seta (Fig. 13)).

3. The third important difference between larvae of *Perileptus* + *Thalassophilus* and those of other Trechini is the number of setae at anterior angles of hypopharynx in all larval instars. The phylogenetic direction of this transformation series is unclear. Larvae of *Perileptus* and *Thalassophilus* (as well as all known larvae of the tribes Bembidiini, Tachyini, Pogonini and Zolini) have a single seta at anterior angles of hypopharynx in all instar larvae. On the other hand, known Trechini larvae have two setae at anterior angles of hypopharynx (except for the larvae of the strange genus *Amblystogenium*).

4. *Homologue or homoplasy with different Trechitae larvae.* Larvae of the genera *Perileptus* (and *Thalassophilus*) share some presumably apomorphic characters with

other members of the different branches of the supertribe Trechitae. We believe, however, that almost all of these similarities are the result of convergention and do not reflect the true relationships between the taxa. These taxa and presumably convergent characters are as following:

1. L_1-L_3: Seta LA_6 on ligula is flat (Figs 9, 10, 11) (presumed plesiomorphic character state: seta LA_6 on ligula normal, more or less conical, not flat). This character is shared by larvae of the genera *Perileptus* + *Thalassophilus* and the subgenera *Synechostictus* Motschulsky, 1864 and *Pseudolimnaeum* Kraatz, 1888 of the genus *Bembidion* of the tribe Bembidiini (GREBENNIKOV, 1997).

2. L_1-L_3: Distal part of antennomere 3 is relatively long; lateral surface between sensorium and base of antennomere 4 is fully sclerotised (Figs 7, 8) (presumed plesiomorphic character state: distal part of antennomere 3 is relatively short; lateral surface between sensorium and base of antennomere 4 is membranous, not sclerotised). This character state is shared between larvae of the genera *Perileptus* + *Thalassophilus* and those of the tribe Trechini.

3. L_1-L_3: Terebra on mandible bears some teeth (Figs 1-3) (presumed plesiomorphic character state: terebra on mandible smooth, without teeth). This character state is shared between larvae of the genera *Perileptus* + *Thalassophilus* and those of the genera *Sphaerotachys*, *Paratachys* and *Porotachys* of the tribe Tachyini (unpublished data).

4. L_1-L_3: Seta MX_8 is located at middle of galeomere 2 (Figs 9-11) (presumed plesiomorphic character state: seta MX_8 is located at base of galeomere 2). This character state is shared between larvae of the genera *Perileptus* + *Thalassophilus* and those of the tribes Tachyini and Trechini (unpublished data).

5. L_1: Setae EM_1 on both meso- and metathorax and seta EP_1 on ninth abdominal segment are strongly modified. They are absent (*Thalassophilus*) or replaced by pore-like sensilla (*Perileptus*) (presumed plesiomorphic character state: all these sensilla are short trichoid setae, as in generalized type; see BOUSQUET & GOULET, 1984). This character (modified sensilla EM_1 and EP_1) is shared by larvae of the genera *Perileptus* + *Thalassophilus* and all members of the tribes Pogonini (spindle-like setae), Tachyini (pore-like sensilla) and some genera of the tribe Trechini (pore-like sensilla) (unpublished data).

6. L1: Setae TI_1 and TI_2 on tibia are much thinner and longer than setae TI_3, TI_4, TI_5, TI_6, TI_7 (Fig. 13) (presumed plesiomorphic character state: setae TI_1 and TI_2 on tibia are similar to setae TI_3, TI_4, TI_5, TI_6, TI_7). This character state is shared by larvae of the genera *Perileptus* + *Thalassophilus* and those of the genus *Aepopsis* (unpublished data).

BIONOMICS

Little is known about the bionomics of *Perileptus* larvae. The majority of larval material in our hands was reared in Petri-dishes - neither of us collected larvae in nature. During the two years that we kept adults on a soil substrate (granules of soil taken under broad-leaved forest with diameter ranging from 2 to 5 mm) we had no success in obtaining larvae. We reared many larvae as soon as we changed the soil substrate for the moist sand and fine alluvium from the river's beach where the adults were captured.

Perileptus areolatus (Creutzer, 1799)

MATERIAL: nearly 30 specimens reared *ex ovo* ($6L_1$, $2L_2$, $2L_3$ were mounted on permanent microscope slides), from adults collected 28. V. 1996, Goriachiy Klyuch, West Caucasus, Russia, V. Grebennikov. $1L_1$ (BMNH), labelled «Coll. V.E.», «b.VIII-35», «*Perileptus* 21.VII-35», «F.I. van Emden Collection B.M. 1977-248». $1L_3$ (BMNH), labelled «Larvae (1?) *Perileptus ?areolatus* Cr. MPL 92», «F.I. van Emden Collection B.M. 1977-248».

DIAGNOSIS. First instar larvae hardly differ from *P. mesasiaticus* with less developed microsculpture on parietale; older instar larvae can not be separate from those of the second known species.

DESCRIPTION. With features of the genus. L_1: HW - 0.22 mm, HL - 0.23 mm (n=1); L_2: HW -0.28 mm, HL - 0.30 mm (n=1); L_3: HW - 0.38 mm, HL - 0.47 - 0.49 mm (n=2). First instar larvae with less developed microsculpture on parietale dorsally; ventral surface of parietale without microsculpture.

Perileptus mesasiaticus Uéno, 1976

MATERIAL: nearly 15 specimens reared *ex ovo* ($2L_1$, $2L_2$ were mounted on permanent microscope slides), from adults collected 9. V. 1996, Dere-Dere stream, west slope of Kugitang Mountain Range, West Turkmenia, V. Grebennikov.

DIAGNOSIS. First instar larvae differ from those of *P. areolatus* by having the parietale almost fully covered with microsculpture.

DESCRIPTION. With features of the genus. L_1: HW - 0.23 mm, HL - 0.23 mm, (n=1); L_2: HW - 0.30 mm, HL - 0.31 - 0.32 mm (n=2). First instar larvae with well developed microsculpture on parietale dorsally; ventral surface of parietale with microsculpture.

CONCLUSION

We want to reemphasize the following. First, the genera *Perileptus* and *Thalassophilus* are likely highly derived members of the supertribe Trechitae since they share a number of apomorphic character states (at least three of them are autapomorphic). Second, they exhibit no evident relationships with the tribe Trechini (the group, to which the genera *Perileptus* and *Thalassophilus* belong according to imaginal classification), or with any other members of the supertribe. Probably, *Perileptus* and *Thalassophilus* could be more appropriately considered as a distinct evolutionary line because their larvae are so derived and isolated. However, because this study is based on a limited number of Trechitae taxa, we refrain from proposing any taxonomic changes to the current classification.

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