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LARVAE OF ZOLINI (COLEOPTERA: CARABIDAE): GENERA *OOPTERUS*
GUÉRIN-MÉNEVILLE AND *IDACARABUS* LEA

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Abstract

Third-instar larvae of the zoline genera *Oopterus* Guérin-Ménéville and *Idacarabus* Lea are described and illustrated. It is confirmed that both studied taxa belong to the supertribe Trechitae; however, monophyly of Zolini remains doubtful. Larvae of the studied taxa possess a set of almost exclusively plesiomorphic character states and the relationships of the two genera within Trechitae are not evident.

Introduction

Members of the carabid tribe Zolini (Merizodini or Oopterini of some authors; see Deuve 1997:32) are distributed almost exclusively in the south temperate zone (Patagonia, Falkland Islands, New Zealand, Victoria, Tasmania) and for a long time the tribe was supposed to be strictly circumantarctic. Csiki (1928:223–226, 1933:1678) cited 40 species in the tribe. It includes ten valid genera (Y. Bousquet, pers. comm.): *Idacarabus* Lea, *Merizodus* Solier, *Oopterus* Guérin-Ménéville, *Percodermus* Sloane, *Pseudoopterus* Csiki, *Pterocyrtus* Sloane, *Sloaneana* Csiki, *Synteratus* Broun, and *Zolus* Sharp. Recently Deuve (1997) described a new genus, *Sinozolus*, from high mountains of south-western China, which is the first discovery of members of the tribe in the Northern Hemisphere.

The tribe Zolini has never been revised taxonomically and its monophyly is questionable (Deuve 1997). Based on imaginal characters, the tribe is placed within the supertribe Trechitae (Kryzhanovskij 1976:61, 1983:88; Erwin 1985:448). The immature stages were unknown until Johns' description (1974) of an unidentified *Oopterus* larvae and the phylogenetic position of the tribe based on characters of immature stages has never been previously discussed.

In the present paper, third instar Zolini larvae of *Oopterus soledadinus* (Guérin-Ménéville) and *Idacarabus cordicollis* Moore are described and illustrated. Based on their morphology, larval descriptions and a diagnosis of the tribe are presented. Finally, the monophyly and phylogenetic position of the tribe Zolini is discussed on the basis of shared larval synapomorphies.

Material and Methods

This work is based on the study of three third-instar larvae of the tribe Zolini: two specimens of *Oopterus soledadinus* and one specimen of *Idacarabus cordicollis*. These larvae were correctly identified by Drs. R. G. Booth (London, UK) and B. P. Moore (Canberra, Australia) by association with adults and are kept in the collections of The Natural History Museum, London, UK

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For comparative purposes, larvae of 24 genera belonging to the supertribe Trechitae have also been studied: *Aepopsis* Jeannel, *Perileptus* Schaum, *Thalassophilus* Wollaston, *Temnostega* Enderlein, *Amblystogenium* Enderlein, *Trechus* Clairville, *Epaphius* Stephens, and *Trechimorphus* Jeannel of the tribe Trechini, *Bembidion* Latreille, *Asaphidion* Des Gozis, *Ocys* Stephens, *Phrypeus* Casey, *Tachys* Dejean, *Paratachys* Casey, *Sphaerotachys* G. Müller, *Elaphropus* Motschulsky, *Porotachys* Netolitzky, *Tachyta* Kirby, *Mioptachys* Bates, and *Polyderis* Motschulsky of the tribe Bembidiini, *Pogonus* Dejean, *Pogonistes* Chaudoir, *Cardiaderus* Dejean, and *Thalassotrechus* Van Dyke of the tribe Pogonini.

Larvae were slide-mounted in Euparal medium and studied with a compound microscope MBI-1 at magnifications up to 900 \times . The morphological drawings were prepared with an aid of a Reichert camera lucida. Notation of primary sensilla follows Bousquet and Goulet (1984), that of secondary ones follows Bousquet (1985). All measurements were made using a micrometer.

Tribe Zolini

Diagnosis. The group can not be readily distinguished by features of larvae; see diagnosis for the each genus treated.

Description. *First-instar larvae.* Unavailable for study but briefly described by Johns (1974:299) for an unidentified *Oopterus* species. According to his description, "the head has a short, pointed egg-tooth, on each side of the dorsal midline near the posterior edge." *Second-instar larvae.* Unavailable; according to Johns (1974) for *Oopterus* sp. they "differ from L_3 in absence of occipito-gular groove and the sides of the head are nearly parallel." *Third-instar larvae.* Cephalic capsule subquadrate, without narrow neck basally. Parietale with 3 stemmata disposed along anterior row, and no or only one stemma in posterior row. Postocular groove present, cervical groove absent; dorso-lateral surface of parietale in basal third with markedly developed constriction. Frontale with transverse microsculpture basally at level of seta FR_2 ; parietale with transverse microsculpture dorsolaterally in basal third. Frontal sutures markedly sinuate; coronal suture about $0.8 \times$ length of antennomere 1. Nasale produced and denticulate, with one row of denticles. Antennae subequal in length to mandibles; second antennomere $0.7-0.9 \times$ longer than first; third antennomere about as long as first; fourth antennomere $0.5-0.7 \times$ longer than first; antennomere 3 laterally with sensorial appendage, one placoid and one (*Idacarus*) or two (*Oopterus*) campaniform sensilla; antennomere 4 apically with two conical and one campaniform sensilla; lateral side of antennomere 3 between sensorial appendage and base of antennomere 4 not sclerotized. Mandible with single retinaculum; penicillus with more than 5 setae; cutting edges of terebrum and retinaculum smooth, not serrate; dorsal surface between MN_6 and MN_1 without pointed microsculpture. Maxilla without lacinia; stipes without teeth at base; galeomeres subequal in length; palpomere 4 not subdivided. Labium with short and not sclerotized ligula; second palpomere not subdivided, its length $0.6-0.8 \times$ that of first. Leg with one simple claw without hyaline organ on its dorsal surface. Urogomphi fused to ninth tergite, rather long, not joined, without nodules. *Chaetotaxy:* All primary sensilla, except 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_6 on abdominal tergites 1-8, and setae TA_3 , TA_4 , TA_5 , and TA_6 on tarsus, present. Distance between setae FR_1-FR_2 about $0.5 \times$ that of FR_2-FR_3 ; distance between FR_3-FR_4 about $2 \times$ that of FR_4-FR_5 ; seta FR_6 about $2 \times$ closer to lateral side of frontale than to pore FR_c ; anterior angles of hypopharynx with single seta on each side; parietale and frontale with only few (*Oopterus*) or without (*Idacarus*) secondary short setae. Antennae without secondary setae. Mandible laterally with 1-2 secondary setae at base. Stipes with 1 (*Idacarus*) or 2 (*Oopterus*) secondary setae laterally; group gMX with

8–33 setae; seta MX_8 located at base of galeomere 2; seta MX_9 located at apex of galeomere 2; setae MX_{11} and MX_{12} not longer than $\frac{1}{4}$ width of palpomere 3. Labium with seta LA_5 present (*Oopterus*) or not (*Idacarabus*); setae LA_5 (if present) and LA_6 normal, not flat; lateral sides of labium with 1–4 secondary seta on each side. Setae PR_7 and ME_{10} on thorax not longer than basal diameters of setae PR_6 and ME_{11} , respectively; length of setae PR_{13} and ME_{14} about 0.2–0.3 \times that of setae PR_{12} and ME_{13} , respectively; all tergites with only a few small secondary setae. One claw with one basal seta about 0.3 \times as long as width of claw at base; seta TA_1 located at middle of tarsus; setae TI_1 and TI_2 not longer than setae TI_3 , TI_4 , TI_5 , TI_6 , TI_7 ; secondary setae on tarsus, tibia and femur absent. Seta TE_8 on abdominal tergites not longer than basal diameter of seta TE_9 ; length of seta TE_{11} about 0.2–0.3 \times that of TE_{10} . Seta UR_3 near UR_2 ; seta UR_9 as long as diameter of seta UR_7 at base; seta UR_α present; urogomphi with 7 long setae (UR_4 – UR_8 , UR_9 , UR_α); lateral margins of ninth tergite without secondary seta at middle; urogomphi with 1–3 short and irregular secondary setae on each side; pygidium with 3–6 secondary setae in apical half; seta PY_2 about 10 \times shorter than PY_3 .

Monophyly. I have found no autapomorphic character state based on larval morphology to support monophyly of the tribe Zolini. It should be mentioned that Deuve (1997) did not find autapomorphies for Zolini based on adults.

Phylogenetic Relationship. Larval features of Zolini support their inclusion in the supertribe Trechitae (sensu Kryzhanovskij 1976:61, 1983:88; Erwin 1985:468, 1991:10) along with the tribes Trechini, Bembidiini (including Tachyini) and Pogonini. Zolini larvae share with those of the remaining Trechitae groups the absence of the 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. These structures are part of the ground plan of the family Carabidae (Bousquet and Goulet 1984) and their absence in Trechitae larvae is very likely a synapomorphic condition.

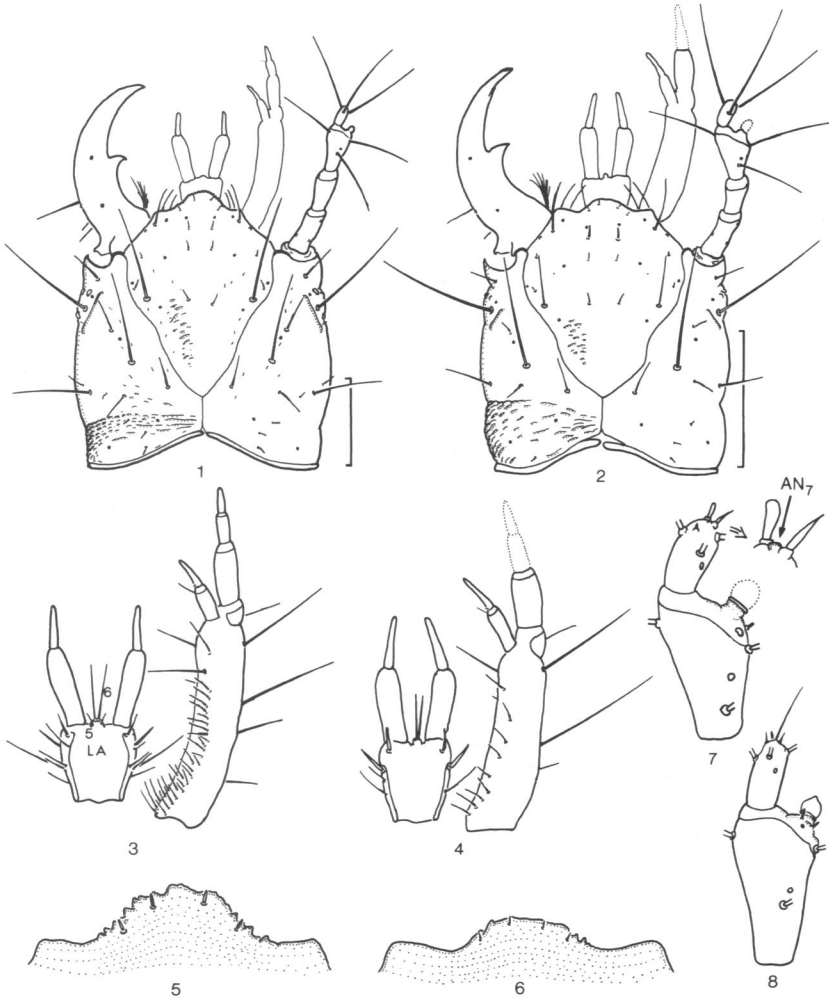
Two authors proposed phylogenetic hypotheses for the tribe Zolini so far. Erwin (1985:444, 448) postulated that “if they [Zolini] are part of the Trechitae, they are undoubtedly a very early pulse of that group that successfully adapted to harsh south temperate conditions” Deuve (1997:31) noted that the discovery of a Zolini in the Northern Hemisphere “challenges the validity of the subfamily (= the tribe Zolini), which might become paraphyletic with respect to the world-wide distributed subfamily Bembidiinae.”

Unfortunately, the studied zoline larvae possess a set of almost exclusively plesiomorphic character states and the present study cannot verify these hypotheses. Known bembidiine larvae do not share any apomorphic character states with those of Zolini, and so, an origin of the Bembidiini from a zoline ancestor can not be supported. Erwin’s (1985) hypothesis also can not be supported because the remaining Trechitae tribes do not share any larval synapomorphy not present in Zolini. Larvae of both studied genera possess one shared, presumably derived character state, namely the absence of secondary seta on the lateral side of the ninth abdominal tergite in older instars. The same character has been noted for larvae of the tribe Pogonini as well as those of the bembidiine genera *Ocys* and *Tachyta* (unpublished) and is very likely homoplastic within the supertribe Trechitae.

Genus *Oopterus* Guérin-Ménéville

Figs. 1, 3, 5, 8, 9, 11, 13

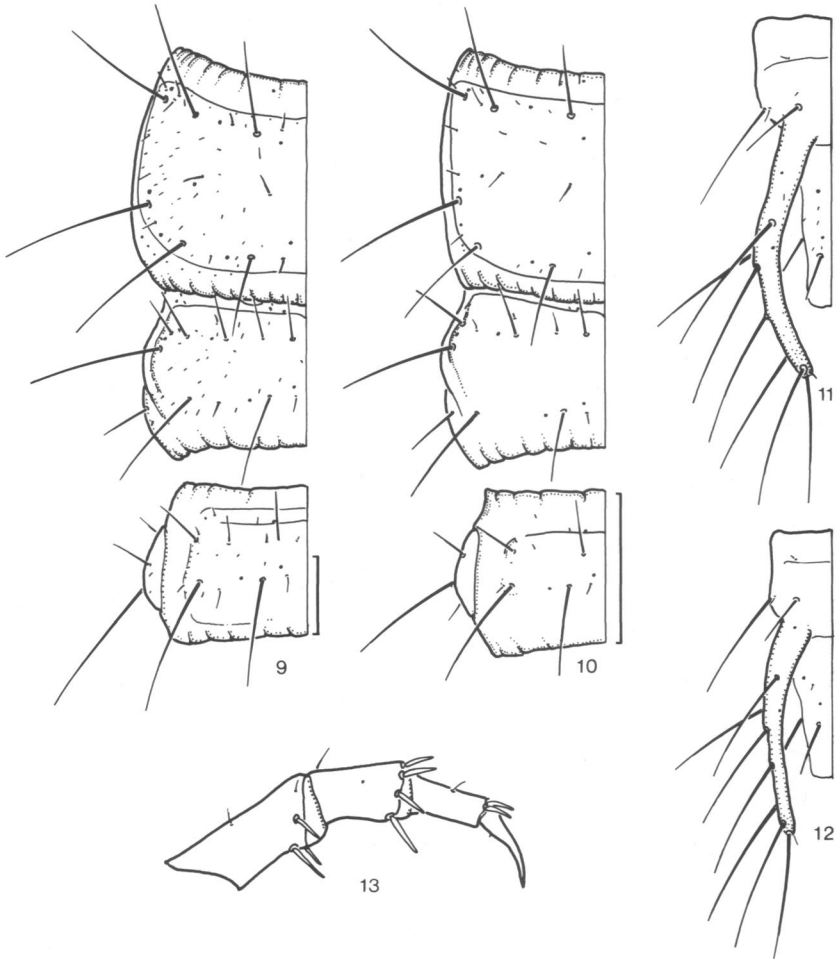
Diagnosis. Third instar larvae of the genus *Oopterus* can be separated from the rest of the supertribe Trechitae by unique combination of glabrous antennomere 2, urogomphi having 7 long setae, single claw, absence of secondary



Figs. 1–8. Larvae of the tribe Zolini (Coleoptera: Carabidae), third instar, dorsal view. **1, 2**) cephalic capsule, right antenna, left mandible, right maxilla, labium; **3, 4**) right maxilla, labium; **5, 6**) nasale; **7, 8**) antennomeres 3 and 4. **Figs. 1, 3, 5, 8**) *Ooapterus soledadinus*; **2, 4, 6, 7**) *Idacarabus cordicollis*. Scale lines = 0.4 mm (Figs. 1–2).

setae at lateral margins of ninth abdominal tergite, seta AN₆ longer than width of antennomere 4, and absence of spindle-shaped setae on body.

Description of Third-instar Larva. Head width 1.18 (1.16–1.20) mm, head length 1.16 (1.10–1.22) mm. Posterior row of stemmata with single stemma. Postocular groove about 2× longer than in *Idacarabus* (Fig. 1). *Chaetotaxy*: Seta FR₂ about 2× longer than FR₁. Lateral part of antennomere 3 apically near sensorium with two campaniform sensilla; seta AN₆ normal, about subequal in length to antennomere 4 (Fig. 8). Stipes with gMX consisting of 30–33 setae; seta MX₅ subequal in length to MX₆; lateral side of



Figs. 9–13. Larvae of the tribe Zolini (Coleoptera: Carabidae), third instar. **9–12**) dorsal view; **13**) posterior view. **9, 10**) pronotum, mesonotum, and fourth abdominal segment, left half; **11, 12**) urogomphi and pygidium, left half; **13**) claw, tarsus, tibia, femur. **Figs. 9, 11, 13**) *Oopterus soledadinus*; **10, 12**) *Idacarabus cordicollis*. Scale lines = 0.4 mm (Figs. 9, 11); 0.4 mm (Figs. 10, 12).

stipes with two secondary setae (Fig. 3). Labium with setae LA₅, lateral side of labium with 5 secondary setae (Fig. 3). Secondary setae on cephalic capsule, tergites and urogomphi more numerous than in *Idacarabus* (Figs 1, 9, 11).

Material Studied. Two Third-instar larvae of *Oopterus soledadinus* collected by R. G. Booth at King Edward Point on the South Georgia Island on November 11, 1980.

Phylogenetic Relationship. The studied larvae are unique within the supertribe Trechitae by the fact that they possess exclusively plesiomorphic char-

acter states. It is impossible now to discuss the relationship of the genus; see also discussion about the relationship of the tribe.

Nomenclature. *Oopterus soledadinus* was originally described by Guérin-Méneville as a *Trechus* (cf. Johns 1974). Jeannel (1926:246) transferred it to the zoline genus *Merizodus*. Johns (1974:229) transferred it to *Oopterus*. However, Reichardt (1977:401) cited it as a *Merizodus*, apparently unaware of Johns' article. Therefore, the current generic name of the species is *Oopterus*.

The genus *Oopterus* was originally established for a single species, *O. clivinoidea* Guérin-Méneville from New Zealand which is the sole species cited by Csiki (1933:1678) in the genus. Earlier, Csiki (1928:225) proposed a new genus, *Pseudoopterus* in which he included 27 species from New Zealand and Auckland Islands, at least some of them were previously described as members of *Oopterus*. Later Johns (1974), used the name *Oopterus* for *O. clivinoidea* and some *Pseudoopterus* species, as well as transferred the former *Merizodus soledadinus* from Falkland Islands to *Oopterus*. None of the authors provided reasons for these nomenclature actions and the concepts of the cited genera have not been clearly established.

Geographical Distribution and Diversity. In Johns' (1974) sense the genus includes about 25 species, mainly from New Zealand, Campbell and Auckland Islands, with one species, *O. soledadinus* from Falkland Islands.

Genus *Idacarabus* Lea

Figs. 2, 4, 6, 7, 10, 12

Diagnosis. Larvae of the genus *Idacarabus* can be readily distinguished from the remaining groups of the supertribe Trechitae, by having the lateral part of antennomere 3 apically with only one campaniform sensillum instead of two and, by having the seta AN₆ at apex of antennae reduced to a very short sensillum (Fig. 7).

Description of Third Instar Larva. Head width 0.72 mm, head length 0.68 mm. Posterior row of stammata absent. Postocular groove about 2× shorter than in *Oopterus* (Fig. 2). *Chaetotaxy*: Seta FR₂ about as long as FR₇. Lateral part of antennomere 3 apically near sensorial appendage with one campaniform sensillum; seta AN₆ reduced to very short sensillum (Fig. 7). Stipes with gMX consisting of 8 setae; length of seta MX₅ 0.5× that of MX₆; lateral side of stipes with one secondary seta (Fig. 4). Labium without setae LA₅, lateral side of labium with 1 or 2 secondary setae (Fig. 4). Secondary setae on cephalic capsule and tergites almost totally absent (Figs. 2, 10, 12).

Material Studied. One third-instar larvae of *Idacarabus cordicollis* collected by T. Goede in the King George V Cave near Hasting in Tasmania on October 21, 1971.

Phylogenetic Relationship. The described larva exhibits several apomorphic features, some of which are apparently unique within the supertribe Trechitae. They are: (1) the presence of only one campaniform sensillum near sensorial appendage on third antennomere instead of two; (2) reduction of seta AN₆ in length and size to a very short non-trichoid sensillum; (3) absence of seta LA₅ on ligula; also shared by larvae of the bembidiine subtribes Tachyina and Xystosomina; (4) secondary setae on cephalic capsule and tergites almost totally absent; also the case for larvae of the genera *Tachyta* and *Ocys*. Judging by this combination of characters, no unambiguous phylogenetic hypothesis can be suggested and, respectively, the relationship of the genus *Idacarabus* within the supertribe remains uncertain.

Remarks. The single larva studied has two apical maxillary palpomeres and

sensorial appendage on antennomere 3 damaged on both sides and, consequently, these structures cannot be studied. The remaining features discussed here were carefully examined on both sides of the single specimen available but it is necessary to study more larvae of the same species to confirm the fixity of the described characters.

Geographical Distribution and Diversity. The genus consists of three rare species *I. cordicollis*, *I. longicollis* Moore, and *I. troglodytes* Lea, from Tasmanian caves (Moore 1987:123).

Concluding Remarks

Some points of the present study should be emphasized. Larval structures of the two studied genera of Zolini support inclusion of the tribe in the supertribe Trechitae. On the other hand, monophyly of the tribe is not supported and the question of its relationships is unsolved. The tribe needs taxonomic revision on imaginal material which has never been done. And, undoubtedly, any additional Zolini larvae may be of a great help for understanding the relationship of this enigmatic group of carabids.

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Jane Beard and Martin J. D. Brendell (NHM, London, UK) sent me *Oopterus* larvae; Barry P. Moore (CSIRO, Canberra, Australia) did the same for the *Idacarabus* larva. David R. Maddison (Tucson, USA) and Martin L. Luff (Newcastle upon Tyne, UK) provided me with numerous larvae of Trechitae for comparative purposes. My supervisors Inessa Kh. Sharova (Moscow, Russia) and Yves Bousquet (Ottawa, Canada) morally supported the study. James K. Liebherr (Ithaca, USA), Yves Bousquet and an anonymous reviewer critically read the manuscript. Financial support was provided by the Russian Presidential Fellowship (co-ordinator Pavel A. Sitalev, Moscow, Russia).

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