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Description of the larvae of a representative of *Anillina* with a key to the Palaearctic genera of *Bembidiini* (Coleoptera: Carabidae)

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Abstract

Larvae of *Typhlocharis* DIECK, 1869 are described and illustrated. They are the first representatives of the bembidiine subtribe *Anillina* known in the preimaginal stage. The studied larvae show several markedly derived character states which are autapomorphies for at least a part of *Anillina*, e.g. three-segmented antennae, unusually shaped mandibles with two large terebral teeth, frontale with a highly protruding anterior margin with rounded nasale and a peculiar chaetotaxy. Diagnostic larval characters for the supertribe *Trechitae* and a key to the larvae of the tribes of *Trechitae* and genera of *Bembidiini* from the Palaearctic region are given.

Key words: Coleoptera, Carabidae, *Bembidiini*, *Typhlocharis*, larvae, larval key, Palaearctic region.

Introduction

The *Anillina* are a subtribe of the *Bembidiini* (supertribe *Trechitae*) which comprises also the *Tachyina* (including *Lymnastina*, ERWIN 1974), *Bembidiina*, and *Xystosomina*. With adult beetles ranging in length from 0.7 mm (*Argiloborus brevis* JEANNEL, 1963, see JEANNEL 1963: 122) to about 7.0 mm (seen in an undescribed genus and species from California, H. Goulet pers. comm.) the *Anillina* include the smallest soil-dwelling carabids. The group is distributed in all zoogeographical regions and 42 genera were treated in the last world-wide revision of the subtribe by JEANNEL (1963). Since JEANNEL's (1963) revision some new taxa have been discovered and actually 60 valid genera are described. Very little is known about the biology of *Anillina*. Specimens are frequently collected in the talus of small river banks, where they live in the soil or under stones. A specimen of *Geocharis* EHLERS, 1883 was fed with living collembols in the laboratory (ZABALLOS 1990). Larvae of *Anillina* have been previously unknown.

In the present paper we describe the external morphology of the smallest bembidiine larvae collected from soil samples and identified as representatives of the anilline genus *Typhlocharis* DIECK, 1869. Based on this description, larvae of *Anillina* are compared with those of other *Bembidiini* taxa and a determination key to genera of the Palaearctic *Bembidiini* is given.

Material & Methods

The description is based on study of the following material: 9 larvae of *Typhlocharis* sp., collected in Spain, Prov. Toledo, Los Navalucillos, 700 m, 22.XI.1994, by J.M.P. Zaballo and I. Ruiz-Tapiador. All larvae were obtained from soil samples using Berlese funnels. The soil samples were taken from a talus of the bank of a small, ephemeral river near an oak tree. The larvae were collected together with numerous adults of four *Typhlocharis* species (see ZABALLOS & RUIZ-TAPIADOR 1994, 1997 for the detailed description of the locality and three described *Typhlocharis* species from this locality; one species is still undescribed). The generic determination of the larvae is certain, as no other carabid beetle genus of comparable small size is

known to occur at the same locality. One further larva of *Anillina* was collected in NW Spain, Prov. Cáceres, Santa Cruz di Paniagua, 475 m, 14.III.1997 by J.M.P. Zaballos. It was associated with adults of one *Typhlocharis* sp. and one *Geocharis* sp. No other carabid species of comparable small size occurs at that locality. The larva from Santa Cruz di Paniagua was studied for comparative purposes. According to their chaetotaxy, all specimens are most probably third instar larvae. Larvae are deposited in the collection of E. Arndt, adults in the collection of J.M.P. Zaballos.

Larvae were mounted in Euparal on microscope slides and studied with a compound microscope MBI-1 at magnifications up to 900x. Figures were prepared with aid of a Reichert camera lucida. Morphological terminology follows LAWRENCE (1991: 146-170). The notation of first instar setae and pores follows BOUSQUET & GOULET (1984), that of second instar setae BOUSQUET (1985), that of pore FRg on frontale and seta CI1 on hypopharynx MAKAROV (1996). Following BOUSQUET & GOULET (1984), primary setae and pores are ground plan structures of the first larval instar and their homologous structures in the later instars, secondary setae and pores are ground plan structures of second and third instars. An asterisk (*) after a number or letter indicates that the homology of the sensilla is uncertain. Because of poorly pigmented sclerites and very small size of the larvae, some primary sensilla were not found, nor is their absence confirmed; they are noted in the description as not recognized.

For comparative purposes larvae of 25 genera of Trechitae representing five tribes have been studied: Trechini (*Perileptus* SCHAUM, 1860, *Thalassophilus* WOLLASTON, 1854, *Amblystogenium* ENDERLEIN, 1905, *Trechus* CLAIRVILLE, 1806, *Epaphius* STEPHENS, 1827, *Aepopsis* JEANNEL, 1922, *Trechimorphus* JEANNEL, 1927); Bembidiini (Bembidiina: *Bembidion* LATREILLE, 1802, *Asaphidion* DES GOZIS, 1886, *Ocys* STEPHENS, 1829, *Peryphus* CASEY, 1924; Tachyina: *Tachyta* KIRBY, 1837; *Tachys* DEJEAN, 1821; *Polyderis* MOTSCHULSKY, 1862; *Elaphropus* MOTSCHULSKY, 1839; *Sphaerotachys* G. MÜLLER, 1926; *Paratachys* CASEY, 1918; *Porotachys* NETOLITZKY, 1914; Xystosomina: *Mioptachys* BATES, 1882); Pogonini (*Pogonus* DEJEAN, 1821, *Pogonistes* CHAUDOIR, 1870, *Cardiaderus* DEJEAN, 1829, *Thalassotrechus* VAN DYKE, 1918); Zolini (*Ooptychus* GUÉRIN-MÉNEVILLE, 1841, *Idacarabus* LEA, 1910).

Description of the last instar larvae of *Typhlocharis* DIECK, 1869 (Figs. 1 - 10)

General characters: Sclerites almost colourless, very little pigmented and sclerotized. Width of head capsule 0.160 - 0.182 mm, n = 9. Microsculpture of head capsule consisting of isodiametral meshes, dorsal surface of prementum with very fine teeth; regular microsculpture absent from the remaining sclerites.

Head: Cephalic capsule (Fig. 1) parallel-sided and slightly elongated. Frontale slender, U-shaped at base, reaching posterior margin of head capsule; coronal suture absent. Stemmata and ocular groove absent, cervical groove strongly reduced to small depression on lateral side of cranium at level of seta PA6. Nasale (Fig. 4) without serration, rounded apically. Antennal fossa separated from pleurostoma by relatively wide strip of sclerotized cuticle. Antenna three-segmented (Figs. 1, 9); about 0.6 - 0.7x shorter than mandible; basal and apical antennomeres subequal in length; penultimate antennomere about 1.2x as long as basal. Mandible (Figs. 3, 5) with very wide base; penicillus lacking; retinaculum comparably small; terebrum apically of retinaculum with two teeth, a smaller one directed medially and very large tooth directed dorso-medially; dorsal surface of terebrum smooth, without carina; ventral condyle of mandible comparably long; dorsal acetabulum markedly undeveloped. Maxilla (Figs. 7, 8) without lacinia; with comparably wide stipes (ratio length/wide about 2.0); widest part of stipes at level of seta MX2; apical galeomere about 1.2x as long as basal; palpus including palpifer about 1.4x as long as galea; palpifer and two basal palpomeres subequal in length, apical palpomere about 1.4x as long as penultimate; dorsal surface of stipes sclerotized. Labium (Fig. 2) with short ligula; apical palpomere about

1.4x as long as basal.

Thorax: Legs comparably short; with single simple claw; tarsus about 2x as long as wide; tibia about as long as wide; femur and trochanter subequal in length; coxa without teeth on dorsal surface.

Abdomen: Urogomphi (Fig. 10) with branches almost parallel, about as long as pygopod.

Chaetotaxy: All primary setae and pores present if not mentioned otherwise. Cranium (Figs. 1, 6) without seta PA5 and pore FRa; pores PAe, PAf, PAg and PAh not recognized; position of sensilla on frontale strongly modified (Fig. 1); seta CII at anterior angles of hypopharynx not recognized; lateral sides of hypopharynx with numerous very long hairs reaching level of penultimate maxillary palpomere. Antenna (Fig. 9) with pores ANa* and ANb* on basal antennomere, remaining primary pores on basal antennomere absent; chaetotaxy of penultimate and ultimate antennomeres as that of the ground plan; sensorial appendage strongly enlarged, about as large as ultimate antennomere; attached to penultimate antennomere latero-ventrally; membranous area near base of sensorial appendage with one long campaniform sensillum apically and one small placoid sensillum basally; setae AN4, AN5 and AN7 about as long as antenna; length of seta AN6 about 0.6x that of apical antennomere; ultimate antennomere with one short conical, one long conical and one long campaniform sensilla apically. Mandible (Figs. 3, 5) with seta MN1 and pore MNa at basal fifth on ventro-lateral surface; seta MN2 located ventrobasally of apical terebral tooth and about as long as MN1. Maxilla (Figs. 7, 8) with group gMX consisting of about 20 - 25 very long setae; setae MX5 and MX6 subequal in length; setae MX11 and MX12 as long as penultimate palpomere wide; second galeomere with one long conical sensillum apically. Labium (Fig. 2) without setae LA4 and LA5; setae LA6 about 1.8x as long as basal palpomere. Prothorax without primary pores PRc, PRe, PRh, PRj, PRi; pore PRf not recognized. Sensillum PR1 located anteriorly of PRb; seta PR7 as long as PR8 or PR10; lateral membranous edge of prothorax between tergum and pleuron with three short secondary setae on each side at level of setae PR6, PR7 and PR10 respectively; two secondary conical sensilla located on membranous edge of prothorax ventrally of seta PR5; prosternum with one long secondary seta on each side at anterior margin; setae ES1 and EM1 about half as long as PR6; setae ES2 - ES4 short, pore-like; seta PS2 not recognized. Meso- and metathorax without primary pores MEc, MEd and MEe; pores MEa, MEf, MEG not recognized. Pleuron and epimeron with relatively long setae PL1 and EM1 respectively; episternum with short setae ES5 and ES6 and one long secondary seta; setae MS2 and MS4 not recognized. Leg with setae TA3, TA4, TA5 and TA6 at apex of tarsus absent; seta of single claw as long as basal diameter of claw; seta TA1 located in basal fifth of tarsus; setae TI2, TI3, TI4, TI5, TI6 and TI7 modified to short spines. Abdominal terga I-VIII with pore TEB absent, other pores not recognized; epipleurite with one long and three moderately long setae; borders of ventral sclerites not recognized, subsequently mediosternite, sternellum, laterosternites, and hypopleurite together with seven setae on each side; seta ST1 not recognized. Abdominal tergum IX (Fig. 10) with long secondary seta UR α ; urogomphi with seven long setae UR4, UR5, UR6, UR7, UR8, UR γ and UR ϵ *; pores on urogomphi not recognized except URf and URg. Pygidium with one secondary seta ventrally; pores not recognized.

The larva collected in Santa Cruz di Paniagua shows the same morphological character states, but has a larger head width (0.208 mm). It is very likely that this larva belongs to *Geocharis* sp. whose adults are 0.3 - 0.5 mm longer than the *Typhlocharis* at the same locality.

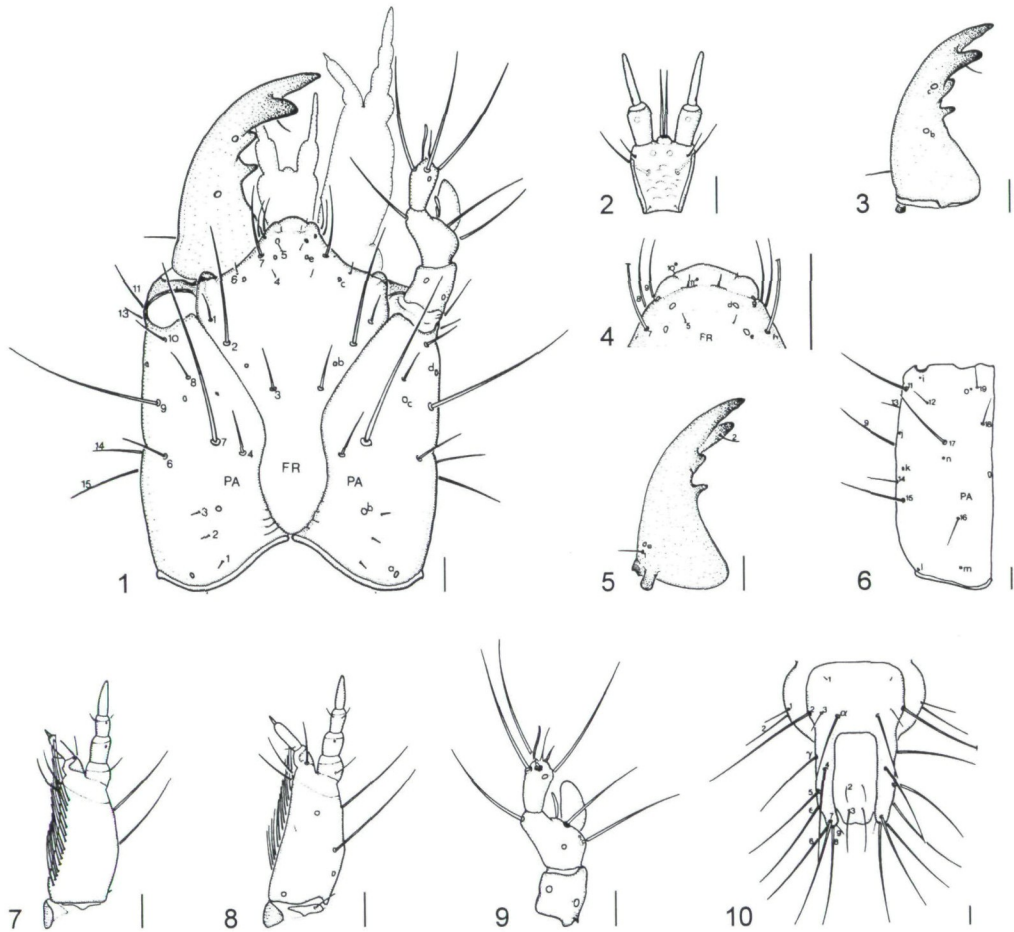
Diagnostic characters of larvae of the supertribe Trechitae

Lacinia absent. Usually one claw with short seta at base (if two claws, the single seta of claw flat, as long as claws, dorsal surface of one claw with hyaline structure; mandibular terebrum serrate). Pores PRc, PRe, PRi, PRj on prothorax, pores MEd and MEe on meso- and metathorax, pore

TEb on abdominal terga I-VIII, and setae TA3, TA4, TA5, TA6 on tarsus absent; number of setae on urogomphi in second and third instars reduced to 6 or 7, UR8 always lacking.

Key to the second and third instar larvae of the tribes of Trechitae and the genera of Bembidiini of the Palaearctic region

- 1 Antenna three-segmented Bembidiini in part (subtribe Anillina, *Typhlocharis*)
- Antenna four-segmented 2
- 2 Each urogomphus with 6 long setae; ligula with one pair of setae (LA6) (Bembidiini in part, subtribe Tachyina) 3
- Each urogomphus with 7 long setae; ligula with two pairs of setae 8
- 3 Ocular groove present; head capsule with rounded lateral sides; group gMX on stipes with five setae *Tachyta*
- Ocular groove absent; head capsule with parallel lateral sides; group gMX on stipes with six setae 4
- 4 Cutting edge of mandible markedly serrate 5
- Cutting edge of mandible smooth 7
- 5 Cutting edge of mandible with more than 10 relatively small and equal teeth *Sphaerotachys*
- Cutting edge of mandible with 4-7 relatively large teeth in basal half 6
- 6 Frontale more elongated (ratio length/width 1.5); pore PAa located posteriad to level of seta PA1 *Paratachys*
- Frontale less elongated (ratio length/width 1.3); pore PAa located at level of seta PA1 *Porotachys*
- 7 Pore PRh on prothorax absent; pore MXc located at middle of ventral surface of stipes *Tachys*
- Pore PRh on prothorax present; pore MXc located at apical fourth of ventral surface of stipes *Elaphropus*
- 8 Leg with one claw; cutting edge of mandible smooth, without serration 9
- Leg with two claws; cutting edge of mandible with markedly developed serration Trechini in part (*Perileptus* and *Thalassophilus*)
- 9 Antennomere II with one long secondary seta mesoapically Trechini in part (without *Perileptus* and *Thalassophilus*)
- Antennomere II without secondary seta or with more than one secondary seta 10
- 10 Pore PRh on prothorax absent; distance between setae FR3-FR4 on frontale about 5x as long as distance between setae FR4-FR5; dorsal sclerites without short spindle-shaped setae; lateral side of tergum IX with secondary seta at middle anteriorly of seta UR2 (except *Ocys*) (Bembidiini in part, subtribe Bembidiina) 11
- Pore PRh on prothorax present; distance between setae FR3-FR4 on frontale less than 3x as long as distance between setae FR4-FR5; dorsal sclerites with short spindle-shaped setae; lateral side of tergum IX without secondary seta at middle anteriorly of seta UR2 Pogonini
- 11 Lateral side of tergum IX with secondary seta at middle anteriorly of seta UR2 12
- Lateral side of tergum IX without secondary seta at middle anteriorly of seta UR2 *Ocys*
- 12 Dorsal and lateral sclerites of body with characteristically frayed setae; setae MX11 and MX12 on penultimate palpomere of maxilla longer than half width of palpomere; setae LA6 on ligula divergent with angle about 30° between them *Asaphidion*
- Dorsal and lateral sclerites of body with simple setae only; setae MX11 and MX12 on penultimate palpomere of maxilla shorter than 1/4 width of palpomere; setae LA6 on ligula parallel to each other *Bembidion*



Figs. 1 - 5: Mature larva of *Typhlocharis*, 1) Head capsule with right antenna, left mandible, right maxilla and labium, dorsal view, 2) labium, dorsal view, 3) left mandible, dorsal view, 4) nasale, dorsal view, 5) left mandible, ventral view, 6) right half of cephalic capsule, ventral view, 7) right maxilla, dorsal view, 8) left maxilla, ventral view, 9) right antenna, dorsal view, 10) abdominal segments IX and X, dorsal view. Scale = 0.02 mm.

Discussion

The relationship of the subtribe Anillina is not clearly defined based on imaginal character states. JEANNEL (1937: 244, 1963: 44) believed that the group is a monophyletic lineage and proposed

the subtribe Lymnastina as sistergroup. ERWIN (1982), however, suggested that Anillina represents a grade of numerous parallel lineages derived from *Paratachys* and allies, each of which adapted independently to deep-humus environments.

Larval characters confirm that Anillina are representatives of the supertribe Trechitae. The studied larvae share with those of the remaining groups of Trechitae the absence of pores PRC, PRe, PRi, PRj on prothorax, pores ME_d and ME_e on meso- and metathorax, pore TE_b on abdominal terga I-VIII, and setae TA3, TA4, TA5, TA6 on tarsus. These structures are part of the ground plan of the family Carabidae (BOUSQUET & GOULET 1984) and their absence in Trechitae are autapomorphies of the supertribe (cf. GREBENNIKOV 1996). However, the described larvae of Anillina are the most derived among those of known genera of Trechitae. Autapomorphic character states of *Typhlocharis* larvae are: (1) frontal chaetotaxy strongly modified (Fig. 4), (2) nasale without serration, rounded apically (Fig. 4), (3) antennal fossa separated from pleurostoma by a wide strip of sclerotized cuticle (Fig. 1); (4) antenna three-segmented and very short with enlarged sensorium (Fig. 9), (5) mandibles with two large and peculiar terebral teeth (Figs. 3, 5); (6) cranium without seta PA5 and pore FRa (Fig. 1); (7) hypopharynx and stipes with very long and anteriorly directed setae.

Larvae of *Typhlocharis* share with those of Tachyina + Xystosomina two apomorphic character states: (1) the loss of the second pair of setae on ligula and (2) a very short coronal suture. However, a close relationship of Anillina with Tachyina + Xystosomina is still not evident and must be confirmed with more convincing characters. One indication also exists for ERWIN's (1982) supposition of a close relationship between Anillina and *Paratachys*. The peculiar dentate terebrum of *Typhlocharis* could be developed from a serrate origin as in *Paratachys*. The interpretation of the distribution of urogomphi setae in second and third instars of Bembidiini is problematic. While Tachyina have six setae (UR4-UR8, only one secondary seta UR_δ, cf. BOUSQUET 1985), Bembidiina and Anillina both have seven setae (character state in Xystosomina unknown). The Bembidiina, as in the remaining tribes of Trechitae (Trechini, Pogonini, Zolini), have setae UR4-UR8, UR_δ and UR_ε. Mature larvae of *Typhlocharis* however seem to have UR4-UR8, UR_ε as well as UR_γ. The character state in *Typhlocharis* is maybe derived independently from other groups of Bembidiini. The phylogenetic relationship of Anillina thus needs further investigation.

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Zusammenfassung

Mit der Larve von *Typhlocharis* Dieck wird das erste immature Stadium der Bembidiini Subtribus Anillina beschrieben und illustriert. Die Larve weist eine Reihe stark abgeleiteter Merkmale auf, die als Autapomorphien zumindest für einen Teil der Anillina angesehen werden, unter anderem: Antenne dreigliedrig; Mandibel gestreckt mit zwei unregelmäßigen, langen Terebralzähnen; Nasale stark vorspringend, abgerundet, ohne Zähnen; Chaetotaxie der Frontale. Es wird ein Bestimmungsschlüssel für die Larven der Triben der Trechitae und die Gattungen der Bembidiini der Paläarktischen Region sowie eine Diagnose für die Larvalmerkmale der Supertribus Trechitae gegeben.

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