

## MORPHOLOGY OF THE LARVAL STAGES OF THE WATER MITES *ARRENURUS BICUSPIDATOR*, *A. TRICUSPIDATOR*, AND *A. TETRACYPHUS* (ARRENURIDAE)

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**ABSTRACT:** The morphology of the larval stages of *Arrenurus bicuspidator*, *A. tricuspikator*, and *A. tetracyphus* is described, with particular attention to diagnostic characters: the shape of the dorsal plate, the proportions between the lengths of the median margins of coxal plates II and III, distances between seta *C1* and the median margin of *Cpl* and between seta *C4* and the median margin of *CpIII*, the shape of the excretory pore plates, and the leg setation.

**Key words:** *Arrenurus bicuspidator*, *A. tricuspikator*, *A. tetracyphus*, larvae, morphology, Arrenuridae, Hydrachnidia, water mites

### INTRODUCTION

Interest in larval stages of water mites has increased recently because of various aspects of their host relationships affecting distribution, dispersal, population size, and evolution.

Water mites have three active stages: larva, deutonymph and adults. The deutonymph and adults are predators, the larva is parasitic in most species (Gledhill 1985). In *Arrenurus*, the initial period of attachment by the larva to its host (phoretic period) is followed by parasitization (Böttger 1976).

The knowledge on the larval stage of the genus *Arrenurus* Dugès is particularly poor. Descriptions of several species of the genus can be found in the papers of Piersig (1896–1899), Wolcott (1905), Koenike (1909), Lundblad (1927), Münchberg (1936), Sparing (1959), Imamura and Mitchell (1967), Prasad and Cook (1972), Stechmann (1977), Wainstein (1980), Tuzovsky (1987), Smith I.M. (1978), Smith B.P. (1990), Smith and Cook (1991), Böttger and Martin (2003), and Zawal (2006 a, b, c).

The present paper gives a diagnostic description of three species of the subgenus *Arrenurus* s. str.: *A. bicuspidator*, *A. tricuspikator*, and *A. tetracyphus*. These species occur in the same habitats and *A. bicuspidator*, *A. tricuspikator* use the same odonate hosts (Münchberg 1935, Davids 1997). *Arrenurus bicuspidator* was inadequately described by Münchberg (1936) and *A. tricuspikator* was inadequately described by Piersig (1896, 1899), Wolcott (1905), Koenike (1909), Lundblad (1927), and Münchberg (1936). No larval description is available for *A. tetracyphus*.

### MATERIALS AND METHODS

Redescriptions of *A. bicuspidator*, *A. tricuspikator*, and *A. tetracyphus* are based on larvae hatched from eggs laid by females collected in the field.

Until egg laying, each female was kept in a separate 100 cm<sup>3</sup> container filled with water at 20–24°C and subsequently fixed in Wilson's liquid (250 mL H<sub>2</sub>O, 150 mL ethanol, 300 mL 5% acetic acid, 300 mL glycerol). The eggs were kept, until hatching, under the same conditions and 48 h after hatching the larvae were mounted in Hoyers medium (the 48 h period was necessary for the larvae to become fully sclerotized).

Drawings were prepared with a camera lucida attached to a Nikon ECLIPSE80i compound microscope. It is very difficult to accurately draw the arrangement of pectinations as they are often poorly visible.

Setal nomenclature follows that of Prasad and Cook (1972) with modification by Zawal (2006a) consisting, in addition, the number of leg in front of signature of seta.

Body parts were measured on progeny of 10 females of the three species (for one larva from each female, *N*=10). Females were collected from various freshwater reservoirs and various habitats, so that a relatively wide range of intraspecific variability could be detected. Measurements are given as ranges, mean, and standard deviations. The leg segments were measured from their distal margins. In this paper the following abbreviation is used: *Cp* — coxal plate. In addition, excretory pore is abbreviated as *Exp* and excretory pore plate is abbreviated as *Expp* in Tables.

Material is deposited in Department of Invertebrate Zoology and Limnology (KZB&L), University of Szczecin, 71-415 Szczecin, Wąska 13.

### SYSTEMATICS

Family Arrenuridae Wolcott, 1905

Genus *Arrenurus* Dugès, 1833

*Arrenurus bicuspidator* Berlese, 1885

*Arrenurus dubius* Koenike, 1885



Fig. 1. Morphology of the larva of *Arrenurus bicuspidator* (gnathosomal base omitted): A — ventral side, B — dorsal plate, C — excretory pore plate, D — pedipalp, E — chelicera, F — leg I, G — leg II, H — leg III.

*Arrenurus rugosus* Protz, 1896

*Arrenurus bituberosus* Nordenskiöld, 1897

Fig. 1.

**Redescription. Larva.** Cheliceral base elongated, with slightly bent margins parallel to each other (Fig. 1 E).

Pedipalps five-segmented, with distinct tooth and 3 setae on segment IV. Segment V bears 8 setae. *PV1* seta represented by a solenidion, *PV6* is relatively short, *PV7* is pectinate, and *PV8* very long and pectinated on both sides; *PV2*, *PV3*, *PV4*, and *PV5* smooth. Segment III bears two setae, *PIII1*

Table 1.  
Measurements of three species of *Arrenurus* (µm)

Characters	<i>A. bicuspidator</i> (N=10) range, mean ± SD	<i>A. tricuspikator</i> (N=10) range, mean ± SD	<i>A. tetracyphus</i> (N=10) range, mean ± SD
length of idiosoma	228–252, 240.6 ± 8.69	224–260, 239.0 ± 10.68	214–260, 233.6 ± 14.01
width of idiosoma	182–196, 189.2 ± 4.73	183–214, 200.2 ± 8.40	180–208, 191.4 ± 8.11
length of dorsal plate	204–242, 218.8 ± 12.55	210–250, 223.4 ± 11.32	204–228, 218.2 ± 8.08
width of dorsal plate	164–182, 175.6 ± 5.64	162–188, 176.2 ± 7.80	152–176, 163.6 ± 7.17
CpI medial margin length	66–70, 67.8 ± 0.93	62–68, 65.7 ± 2.54	70–75, 73.1 ± 1.42
CpII medial margin length	34–38, 36.1 ± 1.66	38–43, 40.7 ± 1.75	29–34, 31.0 ± 1.85
CpIII medial margin length	35–38, 36.7 ± 0.88	28–32, 30.6 ± 1.73	40–46, 42.2 ± 1.89
distances: <i>Mp1–Mp1</i>	54–58, 56.2 ± 1.25	71–76, 73.4 ± 1.51	48–56, 52.3 ± 2.45
<i>Lp1–Lp1</i>	61–65, 62.5 ± 1.38	76–83, 78.1 ± 2.17	59–66, 62.3 ± 2.11
<i>Lp2–Lp2</i>	82–94, 87.1 ± 3.78	100–104, 102.2 ± 1.40	90–96, 93.1 ± 1.65
<i>Mp2–Mp2</i>	47–52, 49.8 ± 1.60	56–59, 57.4 ± 1.13	52–56, 54.0 ± 1.02
<i>Mh1–Mp2</i>	42–46, 43.8 ± 1.30	44–50, 46.4 ± 1.85	40–44, 42.1 ± 1.08
<i>Mp1–Lp1</i>	8–10, 9.2 ± 0.57	6–8, 7.1 ± 0.59	9–13, 11.0 ± 1.35
<i>Mp1–Lp2</i>	32–38, 35.4 ± 1.85	40–46, 42.4 ± 2.17	34–43, 39.5 ± 2.56
<i>Mp1–Mp2</i>	70–76, 73.8 ± 1.68	70–72, 71.1 ± 0.88	68–72, 69.6 ± 1.13
<i>Mp2–Mh1</i>	14–18, 15.8 ± 1.36	20–30, 23.6 ± 3.25	17–23, 20.1 ± 2.01
distance between <i>C1</i> and median margin of CpI	18–20, 19.0 ± 0.51	16–20, 17.4 ± 1.46	20–23, 21.2 ± 0.94
distance between <i>C4</i> and median margin of CpIII	30–33, 30.7 ± 1.08	28–33, 29.4 ± 1.89	34–38, 36.0 ± 1.41
distance between <i>C1</i> and <i>C2</i>	45–46, 45.6 ± 0.49	47–54, 49.3 ± 2.01	42–44, 43.3 ± 0.72
excretory pore plate length	26–29, 27.8 ± 0.74	24–28, 25.4 ± 1.30	23–32, 27.0 ± 2.63
excretory pore plate width	30–34, 32.5 ± 0.94	28–30, 29.2 ± 0.86	28–34, 29.9 ± 1.74
distance between Exp and Expp posterior margin	12–14, 13.4 ± 0.66	10–16, 13.2 ± 1.52	13–16, 14.5 ± 1.03
distance between <i>E1</i> setae and Expp anterior margin	4–6, 6.0 ± 0.78	10–14, 4.2 ± 1.45	4–6, 4.6 ± 0.74
distance between <i>E2</i> setae and Expp posterior margin	9–11, 10.2 ± 0.66	3–6, 13.0 ± 0.66	8–13, 11.4 ± 1.80
PI length	13–17, 14.3 ± 1.28	10–13, 11.5 ± 0.67	12–14, 13.0 ± 0.91
PII length	30–34, 32.6 ± 1.07	34–38, 36.2 ± 1.13	29–34, 31.6 ± 1.52
PIII length	26–29, 27.4 ± 0.93	27–30, 28.2 ± 0.66	28–33, 30.4 ± 1.41
length of PIV claw	28–31, 29.5 ± 1.38	26–28, 27.3 ± 0.59	24–30, 27.2 ± 1.96
length of cheliceral segment I	71–73, 71.8 ± 0.86	67–72, 69.5 ± 1.71	67–70, 68.4 ± 1.17
length of <i>PV</i> 8 seta	109–113, 110.6 ± 1.53	89–96, 92.8 ± 2.55	96–107, 103.1 ± 3.09
length of torchanter of I leg	22–26, 23.4 ± 1.46	24–28, 26.3 ± 1.79	19–26, 22.8 ± 1.07
length of femur of I leg	38–42, 40.2 ± 1.05	32–36, 34.3 ± 1.62	38–46, 41.4 ± 2.26
length of genu of I leg	35–40, 37.3 ± 1.32	34–41, 37.9 ± 2.30	37–42, 38.2 ± 1.50
length of tibia of I leg	48–56, 52.0 ± 2.26	54–62, 57.4 ± 2.52	54–59, 56.3 ± 1.20
length of tarsus of I leg	84–88, 85.6 ± 1.64	72–80, 76.2 ± 2.66	78–82, 79.5 ± 1.32
length of torchanter of II leg	22–27, 25.4 ± 1.46	27–30, 28.5 ± 0.86	21–26, 22.4 ± 1.46
length of femur of II leg	38–42, 40.8 ± 1.46	36–38, 37.6 ± 0.84	41–48, 44.5 ± 2.30
length of genu of II leg	38–42, 40.9 ± 1.22	38–42, 39.8 ± 1.00	40–46, 41.9 ± 1.69
length of tibia of II leg	24–58, 55.8 ± 1.51	60–64, 61.9 ± 1.37	58–62, 59.7 ± 1.01
length of tarsus of II leg	88–94, 90.9 ± 2.11	78–80, 79.2 ± 0.84	78–86, 81.9 ± 2.14
length of torchanter of III leg	27–34, 30.4 ± 2.26	25–28, 26.3 ± 1.10	20–28, 24.2 ± 2.74
length of femur of III leg	40–44, 41.9 ± 1.14	36–42, 37.8 ± 2.10	38–45, 41.8 ± 1.80
length of genu of III leg	38–42, 40.6 ± 1.07	39–44, 41.6 ± 1.69	40–45, 42.0 ± 1.47
length of tibia of III leg	56–60, 57.9 ± 1.14	59–66, 62.2 ± 1.92	59–64, 61.8 ± 1.95
length of tarsus of III leg	85–92, 87.4 ± 2.45	79–82, 80.3 ± 0.86	79–86, 82.2 ± 1.92

bipectinate. Segment II with single smooth seta (Fig. 1 D).

Dorsal plate shield-shaped, distinctly narrow in posterior part, with almost straight anterior and

rounded posterior margin. Anterio-lateral incisions of dorsal plate directed at straight angle, relatively deep; they reach about 1/5 of length of dorsal plate, and 1/4 of its width. *Lp1* tripartite, *Lp2* and *Mh1* bipectinate and thicker than others, remaining dorsal plate setae are relatively thin and smooth (Fig. 1 B).

Median margins of coxal plates II and III more subequal, coxal plate I margin twice as long. *C1*, *C2*, and *C3* bipectinate; *C4*, *Lh2*, and *Lh3* pectinate (Table 1, Fig. 1 A). Distance between *C1* seta and CpI median margin reaches about 2/3 of distance between *C4* and CpIII median margin. Distance between *C1* and *C2* setae relatively long (Table 1, Fig. 1 A).

Excretory pore plate pentagonal, width and length subequal. Excretory pore situated almost at middle of the shield and slightly anterior to *E2* (Table 1, Fig. 1 C).

Proportions between segments of each leg is more or less identical (Fig. 1F, G, H). Trochanter clearly shortest segment, its length equal to about 2/3 of that of femur and genu which equal in length; tibia and tarsus 1.5 and 2 times longer, respectively (Table 1). *ITi8* thin, long and pectinate. Setae *ITa13*, *IITa13* long and pectinate. Setae *IFe2*, *IFe3*, *IGe3*, *ITi5*, *ITa7*, *ITa8*, *ITa9*, *ITa10*, *ITa12*, *IIFe2*, *IIFe3*, *IIGe3*, *IITi5*, *IITa7*, *IITa8*, *IITa9*, *IITa10*, *IITa12*, *IIIFe3*, *IIITi4*, *IIITa8*, *IIITa9*, *IIITa10*, *IIITa11*, *IIITa12*, *IIITa13*, and *IIITa14* pectinate. *IIITa13* situated nearer to anterior margin of tarsus than *IIITa14* seta (Fig. 1 H).

**Material.** 1 female, 10 larvae (KZB&L 01.05.2001, 228a–d) from a small lake near Dolice, Zachodniopomorskie Province, Poland, 53°18' N, 15°25' E, above sandy bottom, 1 May 2001, coll. A. Zawal.

***Arrenurus tricuspikator* (O. F. Müller, 1776)**  
*Hydrachna tricuspikator* O. F. Müller, 1776  
*Trombidium tricuspikator* Fabricius, 1793  
*Atax tricuspikator* Fabricius, 1805  
*Hydrachna (Arrenurus) tricuspikator* Gervais, 1844  
*Arrenurus maximus* Piersig, 1894

Fig. 2.

**Redescription. Larva.** Cheliceral base bottle-shaped, with one margin flat and other one hook-shaped (Fig. 2 E).

Pedipalps as in *A. bicuspidator* (Fig. 2 D).

Dorsal plate ovoid with widest part in mid-length, with almost straight anterior and incised posterior margins. Anterior-lateral incisions relatively small (1/6 of plate length), with slightly obtuse angles, and reach about 1/4 of plate width.

*Lp1* tripartite, *Lp2* and *Mh1* setae bipectinate, other setae smooth (Fig. 2 B).

Ratios of median margins of coxal plates I–III 2/1.3/1 respectively (Table 1). All setae on coxal plates and *V3* setae bipectinate, *Lh2* and *Lh3* pectinate. Setae *C2*, *C3*, *C4*, and *V3* thicker than others (Fig. 2 A). Distance between seta *C1* seta and CpI median margin reaches about 3/5 distance between *C4* seta and CpIII median margin. Distance between *C1* and *C2* setae very large (Table 1, Fig. 2 A).

Excretory pore plate pentagonal, its width slightly exceeds length. Excretory pore situated almost in middle of shield and at same level as setae *E2* (Table 1, Fig. 2 C).

Proportions between leg segments as in *A. bicuspidator* (Table 1). Setae *IITi10* and *IIITi10* pectinate. *IITi10* situated almost at same place as *IITi9* (Fig. 2 F, G, H).

**Material.** 1 female, 10 larvae (KZB&L 01.05.2001, 65a–c) from a small lake near Dolice, Zachodniopomorskie Province, Poland, 53°18' N, 15°25' E, above sandy bottom, 1 May 2001, coll. A. Zawal.

***Arrenurus tetracyphus* Piersig, 1894**

Fig. 3.

**Description. Larva.** Cheliceral base in form of curved cylinder, slightly narrow posteriorly (Fig. 3 E).

Pedipalps similar to those of *A. bicuspidator*; *PV6* slightly shorter (Fig. 3 D).

Dorsal plate ovoid, widest part in mid-length; with large antero-lateral incisions which have slightly obtuse angles, and reach about 1/4 of plate width and 1/5 of its length. *Lp1* tripartite, *Lp2* and *Mh1* setae pectinate, remaining setae smooth (Fig. 3 B).

Ratios of median margins of coxal plates I–III 2.5/1/1.5 respectively (Table 1). Setae *C2*, *C3*, *C4*, and *V3* setae bipectinate, and *C1* smooth. *Lh2* and *Lh3* pectinate (Fig. 3 A). Distance between *C1* seta and CpI median margin reaches about 3/5 of distance between seta *C4* and CpIII median margin. Distance between setae *C1* and *C2* relatively long (Table 1, Fig. 3 A).

Excretory pore plate pentagonal, its width distinctly exceeds its length. Excretory pore situated slightly anterior to middle of the shield and slightly anterior *E2* setae (Table 1, Fig. 3 C).

Proportions between leg segments as in *A. bicuspidator* (Table 1). Seta *ITi8* thin, long and pectinate; *ITa13*, *IITa13*, and *IIITa13* long and pectinate; *ITa7*, *ITa8*, *ITa9*, *ITa10*, *ITa12*, *IITa7*,

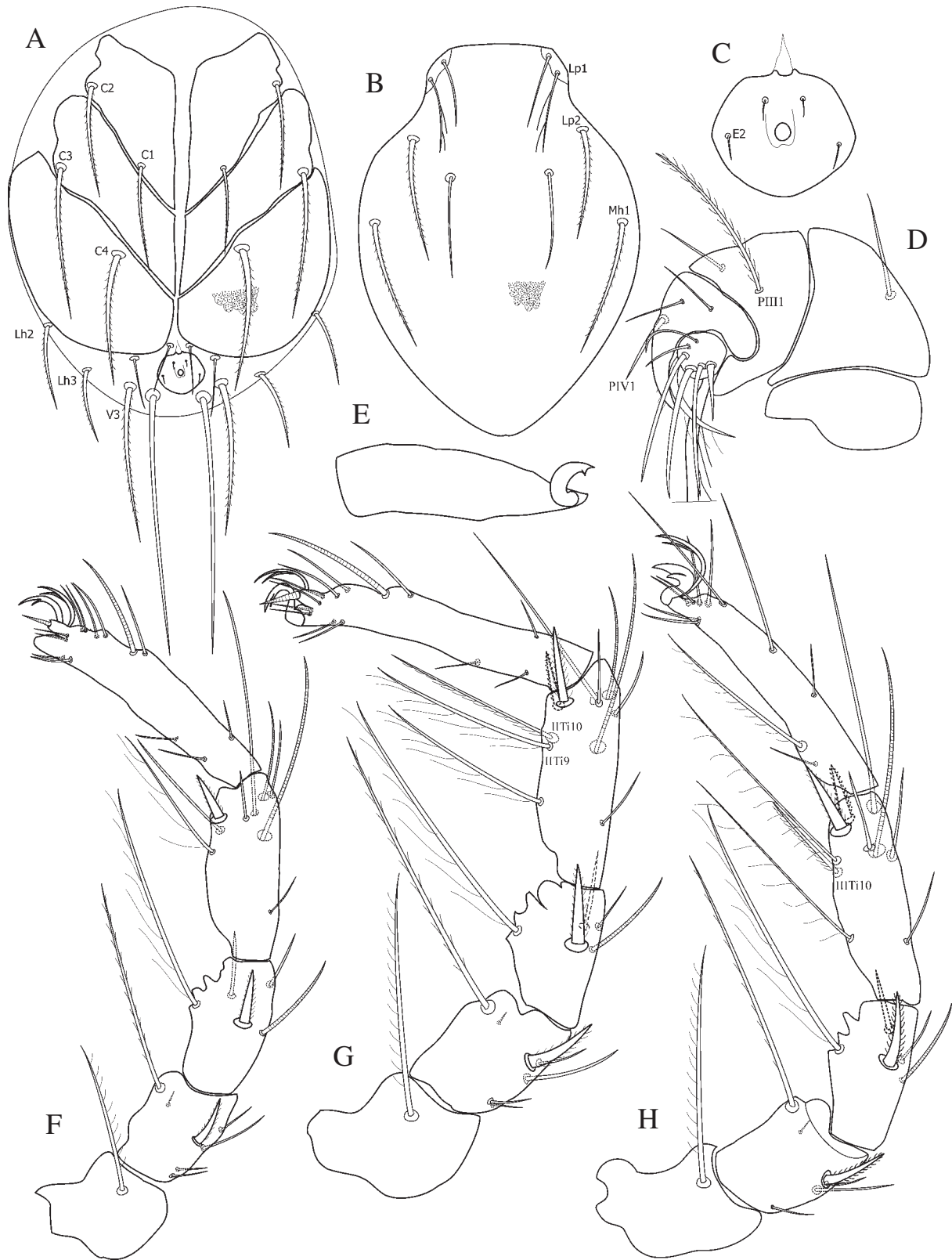


Fig. 2. Morphology of the larva of *Arrenurus tricuspidator* (gnathosomal base omitted): A — ventral side, B — dorsal plate, C — excretory pore plate, D — pedipalp, E — chelicera, F — leg I, G — leg II, H — leg III.

*IITa8*, *IITa9*, *IITa10*, *IITa12*, *IIITa8*, *IIITa9*, *IIITa10*, *IIITa11*, and *IIITa12* pectinate, and *ITa14*, *IIITa14* setae long (Fig. 3 F, G, H).

**Material.** 1 female, 10 larvae (KZBL 21.05.2001, 660a–c) from a mid-forest pool near Borne Sulnowo, Zachodniopomorskie Province,

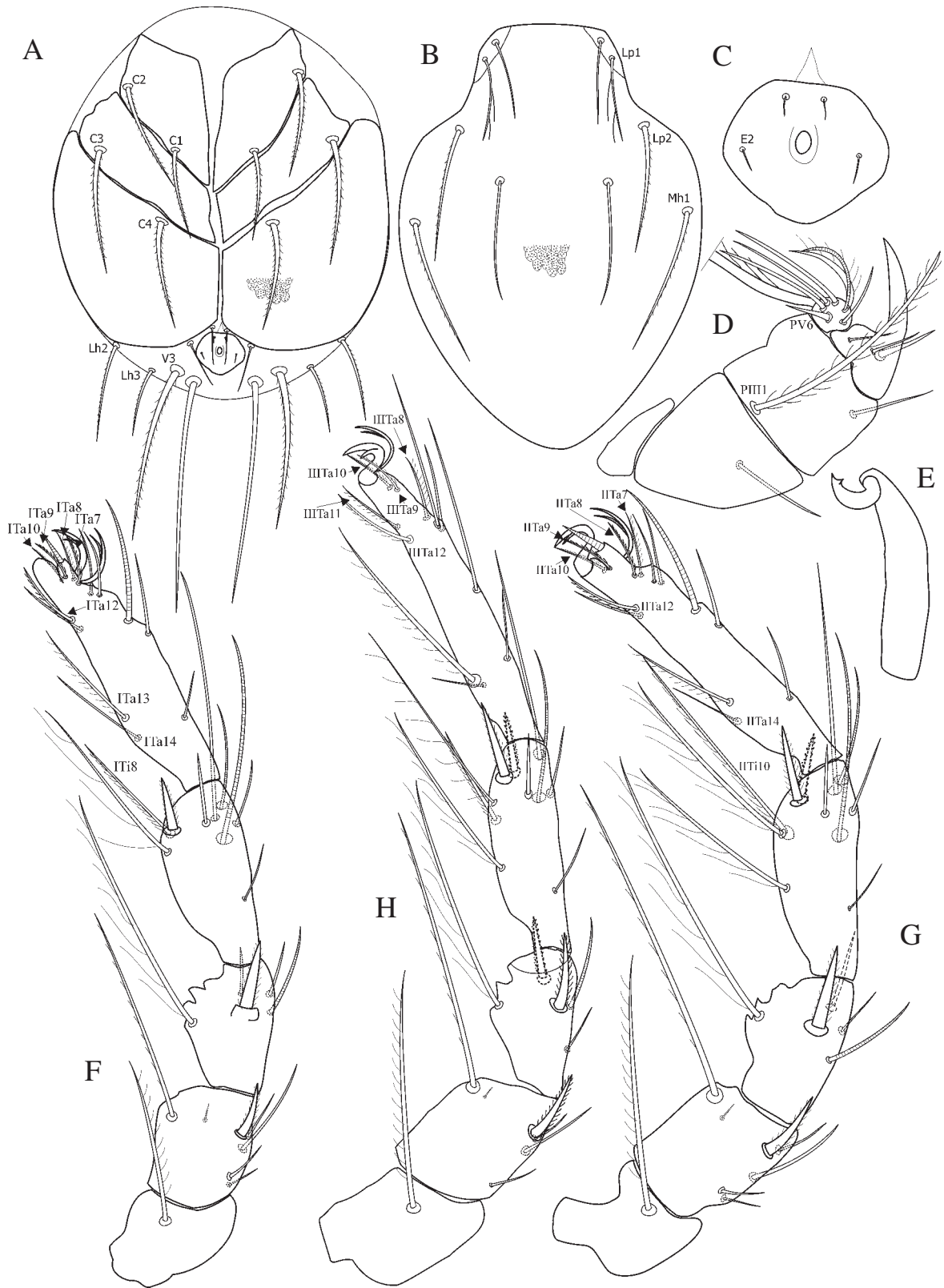


Fig. 3. Morphology of the larva of *Arrenurus tetracyphus* (gnathosomal base omitted): A — ventral side, B — dorsal plate, C — excretory pore plate, D — pedipalp, E — chelicera, F — leg I, G — leg II, H — leg III.

### DISCUSSION

Poland, 53°55' N, 16°59' E, among sedges, 21 May 2001, coll. A. Zawal.

The redescrptions of larval morphology given above generally agree with the generic diagno-

Table 2.

Diagnostic characters of three species of *Arrenurus*

Characters	<i>A. bicuspidator</i>	<i>A. tricuspikator</i>	<i>A. tetracyphus</i>
Dorsal plate length/width	1.2	1.3	1.3
Dorsal plate — antero-lateral incisions	large with rectilinear margins	small with obtuse margins	small with obtuse margins
CpI/CpII/CpIII	1.9/1/1	2.1/1.3/1	2.4/1/1.4
C1–C2 distance	median	large	small
C1–CpI/C4–CpIII	1.6	1.7	1.7
V3	smooth	bipectinate	bipectinate
locality of Expp	centre of Exp, above the E2	centre of Exp, at the same level as E2	above the centre of Exp, above the E2
cheliceral segment I	curved cylinder, large	bottle-shaped, median	curved cylinder, small
<i>IFe2, IFe3, IGe3, ITi5, ITa7, ITa8, ITa9, ITa10, ITa12, IIFe2, IIFe3, IIGe3, IITi5, IITa7, IITa8, IITa9, IITa10, IITa12, IIIFe3, IIITi4, IIITa5, IIITa8, IIITa9, IIITa10, IIITa11, IIITa12, IIITa13</i>	pectinate	smooth	pectinate
localisation of <i>IIITa13</i> to <i>IIITa14</i>	proximally	distally	distally

sis and with earlier descriptions of *Arrenurus* larvae (Prasad and Cook 1972; Stechmann 1977; Smith 1978; Vajnstejn 1980; Tuzovsky 1987), except for eupathidia on the legs mentioned by Wainstein (1980) and Tuzovsky (1987).

Based of the shape of the dorsal plates; the pectinated *Lp2*, *Mh1*, *C1*, *C2*, *C3*, *C4*, *Lh2* and *Lh3* setae; the length of the legs and pectinated setae of some of the legs, the three described larvae are related to *A. bruzelii* (Zawal 2006b).

Diagnostic characters of larvae of the three species are discussed below given in Table 2. The dorsal plate of *Arrenurus bicuspidator* is the most distinct: its length/width ratio is much smaller than that in the remaining species, the antero-lateral incisions are larger and their margins are almost rectilinear (Fig. 1 B). The dorsal plates of the remaining two species, are almost similar to each other, differ from that of *A. bicuspidator* by being longer and more ovoid in shape and by having smaller antero-lateral incisions. The incisions are slightly larger in *A. tetracyphus* (Fig. 2 B and 3 B). Another distinguishing characteristic is the proportion between lengths of the median margins of coxal plates II and III. The coxal plates are equal in *A. bicuspidator* [as in *A. latus* (Stechmann 1977), and *A. maculator* (Zawal 2006a)], while in *A. tricuspikator*, coxal plate II is longer than coxal plate III [like in *A. sinuator* (Stechmann 1977, Zawal 2006c)] and in *A. tetracyphus*, coxal plate II is shorter than coxal plate III [like in the remaining species of the genus *Arrenurus* (Stechmann 1977, Smith 1990)]. Setae on the coxal plates are pectinate in all those species, while setae *V3* are smooth in *A. bicuspidator* and bipectinate in the remaining two species (Fig. 1 A, 2 A and 3 A).

Distances between seta *C1* and CpI median margin and between *C4* and the CpIII median margin in the three species are very long in comparison with other *Arrenurus* species, and the distance between *C1* and CpI median margin reaches to about 3/5 of the distance between *C4* seta and CpIII median margin in *A. tricuspikator* and *A. tetracyphus* (in *A. tetracyphus* they are longer) while in *A. bicuspidator* the distance between the *C1* seta and CpI median margin reach to about 2/3 distance between the *C4* seta and the CpIII median margin. The distance between setae *C1* and *C2* is the longest in *A. tricuspikator* followed by *A. bicuspidator* and *A. tetracyphus* (Table 1). The excretory pore plates are similar in shape, the excretory pore in *A. bicuspidator* and *A. tricuspikator* being located centrally on the plate and slightly above the centre in *A. tetracyphus*; in *A. bicuspidator* and *A. tetracyphus* the excretory pore is located above the *E2* setae and aligned with them in *A. tricuspikator* (Fig. 1 C, 2 C, and 3 C).

The pedipalps are very similar, whereas the chelicerae of the three species differ in size and shape.

There are also differences in leg setation. Setae *IFe2, IFe3, IGe3, ITi5, ITa7, ITa8, ITa9, ITa10, ITa12, IIFe2, IIFe3, IIGe3, IITi5, IITa7, IITa8, IITa9, IITa10, IITa12, IIIFe3, IIITi4, IIITa5, IIITa8, IIITa9, IIITa10, IIITa11, IIITa12, IIITa13* in *A. bicuspidator* and *A. tetracyphus* are pectinate and smooth in *A. tricuspikator*. Seta *IIITa13* in *A. bicuspidator* is situated closer to the proximal end of the segment than *IIITa14*, the opposite being the case in the remaining two species (Fig. 1 F, G, H; 2 F, G, H and 3 F, G, H).

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