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FIRST RECORD OF PARASITIZED *TRITHEMIS PALLIDINERVIS* (KIRBY) FROM TAMIL NADU, INDIA BY *ARRENURUS* LARVAE, WITH A DESCRIPTION OF LARVAL MORPHOLOGY (ANISOPTERA: LIBELLULIDAE; ACARI: HYDRACHNIDIA)

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Out of a total of 20 adult *T. pallidinervis* specimens (Odonata), collected in Tamil Nadu, India, 164 larvae of *Arrenurus* sp. were found; prevalence: 57.5%, intensity: 5-12. They were attached to the mesosternum and metasternum. Their morphology is very similar to that of *A. cuspidator* and *A. maculator*, but differs by the absence of Mp1 tripartite seta, V2 seta and secondary seta in PIII 1 and the presence of secondary setae on both sides of V3 setae. They also differ from *A. maculator* by the absence of hairbrush on the base of C1 seta.

INTRODUCTION

The genus *Arrenurus* has many species and is a particularly important group among the Hydracarina. Species of the genus live in almost all biotopes and in most zoogeographic regions. This genus, as with other freshwater mites, has been studied mostly from the point of view of the morphology and taxonomy of the adult stages. Larvae of most water mite species parasitize aquatic insects and this is how water mites disperse and colonize new water bodies (MITCHELL, 1970; BOHONAK, 1999; BOHONAK et al., 2004).

Water mites can be classified into two groups, depending on which insect order they parasitize: parasites of insects whose imagines stay under water or on

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Table I

Dimensions (in μm) of individual body parts of the larvae of *Arrenurus maculator*, *A. cuspidator* (ZAWAL 2006b) and *Arrenurus* sp. (N = 10)

	A. maculator			*A. cuspidator*			*A.* sp.		
Morphological characters	Range	Mean	Standard deviation	Range	Mean	Standard deviation	Range	Mean	Standard deviation
dorsal plate length	188-196	193.0	2.70	166-202	187.2	10.63	178-196	186.8	5.59
dorsal plate width	140-146	143.4	1.90	124-146	139.2	6.20	124-158	139.8	11.13
CpI medial margin length	60-62	61.3	0.94	61-67	63.5	2.27	54-60	56.6	1.77
CpII medial margin length	31-33	32.4	0.68	28-30	29.0	0.76	21-26	24.1	1.66
CpIII medial margin length	31-32	32.0	0.38	24-28	26.0	1.21	26-32	28.6	2.02
distance: Mp1-Mp1	58-61	59.7	1.14	52-61	56.2	3.46	55-64	57.7	2.54
distance: Lp1-Lp1	62-70	66.9	2.30	58-67	62.6	2.23	60-66	64.7	2.46
distance: Lp2-Lp2	77-93	85.2	4.70	80-84	81.1	1.13	80-89	84.5	2.70
distance: Mp2-Mp2	44-50	47.8	2.13	42-44	43.0	0.74	37-44	40.1	2.01
distance: Mh1-Mp2	35-44	39.8	2.82	34-44	38.8	2.56	3-41	35.8	2.39
distance: Mp1-Lp1	4-8	5.8	1.12	3-6	5.4	0.93	5-8	6.1	1.14
distance: Mp1-Lp2	30-36	33.4	2.20	34-42	37.0	2.72	26-33	30.1	1.93
distance: Mp1-Mp2	58-66	62.7	2.27	55-67	62.3	3.49	44-54	50.1	2.62
distance: Mp2-Mh1	27-30	28.8	1.07	19-29	25.0	3.30	22-30	25.0	2.45
distance between C1 and CpI median margin	19-22	20.4	0.68	13-18	15.4	1.36	16-22	18.1	2.75
distance between C4 and CpIII median margin	28-30	29.4	0.85	22-28	26.5	1.90	21-24	22.2	1.13
distance between C1 and C2	38-41	39.2	1.19	45-50	47.8	3.27	30-41	35.7	3.35
excretory pore plate length	20-22	20.6	0.63	19-24	21.2	1.52	22-26	22.9	1.32
excretory pore plate width	22-26	23.3	1.16	22-28	24.6	1.64	22-26	23.8	1.24
distance between Exp and Expp posterior margin	6-10	8.3	1.37	8-10	8.4	0.57	10-12	10.7	0.77
distance between E1 setae and Expp anterior margin	4-6	4.6	0.63	4-6	4.8	0.84	4-6	4.6	0.54
distance between E2 setae and Expp posterior margin	8-12	10.2	1.24	10-13	10.6	0.98	9-11	9.8	0.83
PIII length	26-30	27.1	1.38	22-26	24.0	1.19	22-26	23.4	1.25
length of PIV claw	26-29	27.6	0.86	26-28	27.1	0.80	31-38	33.9	1.93
length of PV 8 seta	115-130	122.2	4.44	88-102	92.4	4.25	111-116	113.8	1.51

its surface, leaving the water only sporadically (Coleoptera and Hemiptera) and those parasitizing insects whose imagines are terrestrial/aerial while only their preimaginal stages are aquatic (Odonata, Trichoptera, Diptera) (ZAWAL, 2006a). Different genera of water mites parasitize particular orders of aquatic insects. For example, *Hydrachna* and *Eylais* parasitize Coleoptera and Heteroptera, respectively; *Limnochares* parasitize Heteroptera (SMITH, 1988) and Odonata (SMITH & COOK, 1991) and *Arrenurus* parasitise Odonata, Coleoptera and Diptera (SMITH & COOK, 1991; BOTTGER & MARTIN, 2003; ZAWAL, 2006a). Larvae from different *Arrenurus* subgenera are specific to insect orders: *Arrenurus* s. str. to Odonata adults and larvae (DAVIDS, 1997; ROLFF et al., 2001; BAKER et al., 2006). Regarding parasitism by water mite larvae, most papers are concerned with adult insects (MITCHELL, 1959; STECHMANN, 1977; ZAWAL, 2006a) and little attention has been paid to the relationship between the larvae of water mites and those of insects (ZAWAL, 2006a; BAKER & SMITH, 1997). Water mite larvae may influence Odonata populations, as indicated by mite larvae which remain on exuviae of Odonata which failed to moult from the final stage larvae to imagos (ZAWAL, 2006a). The larval morphology of the genus *Arrenurus* has been studied by IMAMURA & MITCHELL (1967), PRASAD & COOK (1972), STECHMANN (1977), VAJNŠTEJN (1980), SMITH (1990) and ZAWAL (2006b).

The aim of this paper is to present the first record of the parasitization of *Trithemis pallidinervis* by *Arrenurus* sp. larvae, together with a description of the larval morphology, paying particular attention to those features which differ from *A. cuspidator* and *A. maculator*, also to compare the last two species with the earlier description by ZAWAL (2006b).

MATERIAL AND METHODS

Twenty *Trithemis pallidinervis* (Kirby) adults collected from a marshy land area near a pond at Ariyalur (altitude: 75 m a.s.l., latitude: 1°8′ and longitude: 79°5′), Tamil Nadu, India, were examined under a stereo zoom microscope. The water mite larvae were loosely attached on the ventral side of the dragonflies, from where they were removed using a camel hair brush/forceps. They were mounted in Hoyer's medium and permanent slides were prepared. Measurements of the important taxonomic structures of 10 mites were made with the help of a calibrated ocular micrometer.

The material is deposited in the Department of Agricultural Entomology, Acarology Laboratory, Tamil Nadu Agricultural University, Coimbatore, India and in the Department of Invertebrate Zoology and Limnology, University of Szczecin, Szczecin, Poland.

The setal notation follows, with some modification, that of PRASAD & COOK (1972) (Lp1, Lp2, Mp1, Mp2, Mh1: setae on dorsal plate; – Hu, Mh2-Mh4 and Lh1-Lh3: setae on dorsal side outside of dorsal plate; – C1-C4: setae on coxal plates; – V1-V4: setae on ventral side outside of coxal plates; – E1, E2: setae on case excretory pore plate PII1; – PIII1-2, PIV1-3, PV1-8: setae on particular segments of pedipalp; – ITr1: setae on trochanter of leg I; – IFe1-7: setae on femur of leg I; – IGe1-5: setae on genu of leg I; – ITi1- 9: setae on tibia of leg I; – ITa1-14: setae on tarsus of leg I; – IITr1: setae on trochanter of leg II; – IIFe1-7: setae on femur of leg II; – IIGe1-5: setae of genu leg II; – IITi1-11: setae on tibia of leg II; – IITa1-14: setae on tarsus of leg II; – IIITr1: setae

Fig. 1. *Arrenurus* sp.: (A) dorsal plate; – (B) ventral side; – (C) pedipalp; – (D) excretory pore plate; – (E) leg I; – (F) leg II; – (G) leg III. – [Scale bars: A: 50 µm, – B: 100 µm, – C: 20 µm, – D: 10 µm, – E, F, G: 20 µm]

on trochanter of leg III; – IIIFe1-7: setae on femur of leg III; – IIIGe1-5: setae of genu of leg III; – IIITi1-11: setae on tibia of leg III; – IIITa3-14: setae on tarsus of leg III) (Fig. 1).

The measured characters based on 10 *Arrenurus* sp. larvae which were removed from particular hosts are reported with their ranges, mean values and standard deviations. The leg segments were measured along their distal margins. The measured characters of *A. maculator* and *A. cuspidator* came from ZAWAL (2006b) and are based on 10 individuals of each species.

In this paper, the following abbreviations are used: Cp: coxal plate, – Exp: excretory pore, – Expp: excretory pore plate.

RESULTS

On 20 specimens of adult *Trithemis pallidinervis,* 164 larvae of *Arrenurus* sp. were found: prevalence: 57.5%, intensity: 5-12. They occurred only on females and were attached to the ventral side of the body. The preferred areas were the mesosternum and metasternum. These larvae have not been named and described earlier. Therefore we add a short morphological description.

MORPHOLOGICAL DESCRIPTION

M a t e r i a l examined. – 5 larval slides, India: Tamil Nadu, Coimbatore, 12-VIII-2006, ex *Trithemis pallidinervis*. Coll. V. Radhakrishnan (No. 260/5).

The dorsal plate is egg-shaped, with a bend in the anterior lateral sides and a rounded posterior margin. The antero-lateral indents are relatively deep (Fig. 1A). The dorsal plate setae as Mp1, Mp2, Lp1, Lp2, Mh1 and Mh2 are thin, long and smooth. The dorsal plate length and width, the CpI medial margin length and the CpII medial margin length are all shorter than in *A. maculator* and *A. cuspidator*. The CpIII medial margin length and the distances between Mp1-Mp1, Lp1-Lp1 and Lp2-Lp2 are longer than in *A. cuspidator*. The distances between Mp2-Mp2, Mh1-Mp2, Mp1-Lp2 and Mp1-Mp2 are shorter than in *A. maculator* and *A. cuspidator* (Tab. I).

The C1, C2, C3 and C4 setae bear secondary setae on both sides. The brush of hairs on the base of C1 seat is not present. The distance between the C4 seta and

Table II

Number of setae on leg segments of *Arrenurus maculator*, *A. cuspidator* (ZAWAL 2006b) and *Arrenurus* sp.

Species	Legs	Trochanter	Femur	Genu	Tibia	Tarsus
Arrenurus maculator	I	1	7	5	9	14
and *A. cuspidator*	II	1	7	5	11	14
	III	1	6	5	10	11
Arrenurus sp.	I	1	7	5	9	14
	II	1	7	5	11	14
	III	1	6	5	10	12

Table III

Dimensions (in µm) of leg segments of *Arrenurus maculator*, *A. cuspidator* (ZAWAL 2006b) and *Arrenurus* sp.

Species	Legs	Trochanter			Femur			Genu			Tibia			Tarsus		
		range	mean	sd	range	mean	sd	range	mean	sd	range	mean	sd	range	mean	sd
A. maculator	I	16-18	17.5	0.70	24-28	26.6	1.17	21-26	24.9	1.66	41-45	42.7	1.37	58-61	59.6	0.68
	II	18-20	18.6	0.76	29-32	30.3	0.88	26-30	28.5	1.14	47-50	48.3	0.77	62-66	64	1.19
	III	18-21	19.3	0.80	28-32	30.2	1.45	28-31	29.4	1.07	45-50	47.0	1.92	59-66	63.8	2.26
A. cuspidator	I	16-20	18.0	1.02	24-31	27.2	1.85	23-27	25.0	1.25	36-42	40.7	2.01	50-58	55.5	2.30
	II	16-18	17.4	0.91	26-32	30.4	1.92	21-28	25.1	2.56	40-46	43.1	1.65	55-64	61.8	2.87
	III	16-21	18.7	1.32	22-32	27.6	3.31	22-29	26.6	1.95	41-48	45.4	2.00	54-64	62.3	3.17
Arrenurus sp.	I	22-26	23.8	1.00	32-36	33.6	1.41	29-31	29.8	0.93	45-46	45.3	0.56	56-60	58.2	1.20
	II	24-28	25.8	1.18	34-39	35.8	1.68	30-37	33.4	1.80	47-50	48.8	1.00	62-70	64.0	1.19
	III	26-30	27.1	1.43	36-38	36.6	0.74	30-37	34.1	2.00	48-53	50.3	1.58	65-70	67.4	1.60

sd = standard deviation

the median CpIII edge is longer that the distance between the C1 seta and the CpI margin. The distance between C1 and C2 setae is longer than the distance between the C4 seta and the median CpIII edge and the distance between the C1 seta and the CpI margin (Tab. I).

The dorsal and coxal plates feature a microrelief in the form of a regular porous reticulum (Fig. 1B). The excretory pore plate width and length are almost equal, the plate surface bearing two pairs (E1 and E2) of short setae (Fig. 1D). The palps have a pronounced tooth and three setae on segment IV. Segment V bears 8 setae. One seta (PV1) is a solenidion, another one (PV6) is relatively short and stout, PV7 is characteristically bent and bears secondary setae on one side and seta PV8 is very long (113.8) and bears secondary setae on both sides. The remaining setae (PV2, PV3, PV4 and PV5) are smooth. Segment III bears 2 smooth setae one of which is larger than the other. Segment II has a single smooth seta (Fig. 1C).

Each leg has five segments, the last segment bearing three claws (Figs 1E, F, G). The number of setae on each segment is given in Table II. The genu of each leg bears a single solenidion (IGe1, IIGe1, IIIGe1), tibia I and II feature two solenidia each (ITi1, ITi2, IITi1, IITi2), tibia III shows one solenidion (IIITi1) and the tarsi of legs I and II each bear one solenidion

(ITa1, IITa1). The tarsi of legs I and II each bear a single eupathidium (ITa2, IITa2). The femur of leg III lacks IIIFe2 seta. The setae of IGe5, ITi9, IIGe5, II Ti9, IITi11, IIIGe5, IIITi9 and IIITi11 bear characteristically long secondary setae on one side only, spaced widely apart which are a general character of *Arrenurus* larvae.

The proportions between the segments of each leg are more or less identical. The trochanter is clearly the shortest segment, its length being equal to about 2/3 of that of the femur and genu which are almost equal in length; the tibia and tarsus are 1.5 and 2 times longer, respectively than the genu (Tab. III). The ventral margins of the genu are clearly convex and show characteristic indents, the ventral margins of the tarsus being slightly concave. The remaining margins of all the segments are almost straight.

DISCUSSION

Although this is probably the first record of odonate parasitization by water mites from southern Asia, the phenomenon was reported from various other Asian regions, such as Kazakhstan (KLIMSHIN & PAVLYUK, 1972) and Japan (IMAMURA, 1951a, 1951b; IMAMURA & MITCHELL, 1967). Many authors have mentioned that Zygoptera are more frequently infected by *Arrenurus* larvae than Anisoptera (SMITH & COOK, 1991; CONROY & KUHN, 1997; DAVIDS, 1997; ZAWAL, 2004, 2006a, 2006c; BAKER *et al.*, 2006, 2007; ZAWAL & DYATLOVA, 2006, 2008). Therefore a new record of an infected anisopteran is of interest, particularly so as it concerns a new host species and genus. In the case of this and former records of *Arrenurus* larvae attached to dragonflies, they occur mainly on the ventral side of the thorax and abdomen (MÜNCHBERG, 1935, 1963; CASSAGNE-MÉJEAN, 1966; MITCHELL, 1959, 1961, 1965; FORBES *et al.*, 1999, 2002; ZAWAL, 2004, 2006a), although *A. papillator* and *A. postulator,* which infect *Sympetrum meridionale* and *S. fonscolombii* are attached to the wings (MÜNCHBERG, 1935, 1963, 1982; CASSAGNE-MÉJEAN, 1966; ZAWAL & JASKULA, 2008).

The description of the new *Arrenurus* sp. larval morphology given above is in general agreement with the earlier descriptions of congeneric larvae. The number of setae agrees with the data reported by PRASAD & COOK (1972), STECHMANN (1977) and SMITH (1978). VAJNŠTEJN (1980) and TUZOVSKIJ (1987) mentioned a higher number of eupathidia on the legs. The larval morphology of this new species is very closely related to that of *A. cuspidator* and *A. maculator* (ZAWAL, 2006b. The IGe5, ITi9, IIGe5, IITi9, IITi11, IIIGe5, IIITi9 and IIITi11 setae bear characteristically long secondary setae, spaced widely apart (Fig. 1) which are a general character of *Arrenurus* larvae.

According to ZAWAL (2006b), the larval stage of *Arrenurus* sp. is similar to *A. maculator* and *A. cuspidator* in most of the morphological characters but dif-

fers in a few, such as the shape of Expp, by the V2 seta and secondary seta in PIII 1 and by the presence of secondary setae on both the sides of V3setae. Also, the location of Exp in the *Arrenurus* sp. from India Exp is above the E2 setae, whereas in *A. maculator* and *A. cuspidator* it is below the E2 setae. Furthermore it differs from *A. maculator* by the absence of a hairbrush on the base of C1 seta. Its tarsal (III) leg setation was different from that of *A. maculator* and *A. cuspidator* (Tab. II). Secondary setae (IIITr1 and IIIFe7) were found on one side in *A. maculator* and *A. cuspidator* as against simple setae in the new *Arrenurus* sp. Similarly secondary setae (IIIFe4, IIIGe2, IIITi7 and IIITi8) occur on both sides in *A. maculator* and *A. cuspidator*, but only simple ones in the new species.

The larva of *Arrenurus* sp. is easily distinguished from that of *A. agrionicolus* Uchida and *A. mitoensis* Imamura described from Japan (IMAMURA & MITCHELL, 1967) by the shape of Expp and the locality of Exp (below the E2 setae) and by the number of setae on tarsus III.

It should be mentioned that many of the secondary setae were visible at 1250× magnification using the Nikon microscope, but could not be discerned with a lower resolution microscope (Jenaval).

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