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ECTOPARASITISM OF ANISOPTERAN DRAGONFLIES (INSECTA: ODONATA) BY WATER MITE LARVAE OF *ARRENURUS* SPP. (ARACHNIDA: HYDRACHNIDA: ARRENURIDAE) IN CENTRAL INDIA

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ABSTRACT: There is no report on the frequency, species selection and site specificity of water mites' ectoparasitism within and among dragonfly species of India. Here, we present a field survey of the species selection and site specificity of ectoparasite larval arrenurid mites on anisopteran adults at Nagpur city of central India. Since the female odonates returns to water to oviposit, it would be of some advantage for the mite to show a female-biased parasitism in order to return to water easily and continue the remaining aquatic part of their life cycle. A total of 204 specimens of anisopteran odonates belonging to 11 species were examined for the presence of larval *Arrenurus* spp. as ectoparasites during the post-monsoon (August–September 2010) and summer (March–April 2011) months from a large pond in central India. Only 14 dragonflies specimens of six species (*Acisoma panorpoides*, *Brachythemis contaminata*, *Crocothemis servilia, Diplacodes trivialis, Neurothemis t. tullia*, and *Trithemis pallidinervis*) were found to be parasitized (overall prevalence of 6.86%). The prevalence for *C. servilia* was 28.6%, followed by *Trithemis pallidinervis and Acisoma panorpoides* at 21.4%. The total number of parasites recorded was 465 at an average of 33.26 per specimen. The parasite load per host species was the highest in *T. pallidinervis (92.6) followed by C. servilia* (24). In *C. servilia, A. panorpoides* and *D. trivialis* the mites were attached venterally to the thorax and were mostly arranged in a 'v' or triangular shape, while in *B. contaminata* and *T. pallidinervis* the mites were found all over the ventral abdomen. In one *T. pallidinervis* male and one *C. servilia* female, mites were found both on the thorax as well as the abdomen. The maximum number of mites found on an individual dragonfly was on the female abdomen of *T. pallidinervis* (114), while only one mite was found on the thorax of a male *C. servilia.* Mite infestation was sex-biased — 71.0% and 85.7% of infested odonates were females in August–September and March–April, respectively

KEY WORDS: Dragonfly, Anisoptera, water mites, Central India, *Arrenurus*

INTRODUCTION

Several orders of insects with aquatic larvae and non-aquatic imagos, including Odonata, are parasitized by mites. Larvae of *Arrenurus* spp. are common and widespread ectoparasite of dragonflies and damselflies (Smith and Oliver 1986; Smith 2009). More than 55 species of the mite *Arrenurus* have been described as ectoparasites of Odonata (Corbet 1999). Arrenurid larvae are true parasites and exploit their odonates hosts for both food and dispersal. They also form a phoretic association with the last instar larvae of the host. As the host emerges out of water during the final metamorphosis, the mite larvae crawl from the exuvia to the newly emerged adult and become parasitic (Andre and Cordero 1998; Zawal 2004). They start penetrating the host cuticle and full engorgement of the mite larvae can be detected 48 hours later (Abro 1982). Mites remain attached to the host throughout the pre-reproductive period of the host and progressively change color almost in unison. They drop off in water when the odonate comes to copulate and oviposit in water.

Mite parasitism can reduce host longevity and fecundity, because of fluctuating asymmetry of forewing length and cell number (Bonn et al. 1967). Their flight is less frequent and less brief while the infected odonates males compete less successfully for females and are also less likely to form a tandem (Forbes 1991a).

Smith and Oliver (1976) and Smith (1988) examined and reviewed the host parasite interaction and impact of water mite on insect in general and the relationship between mites and odonates has been reviewed more recently by Corbet (1999). Most of the studies of the host parasite relationship in odonates deal with the population dynamics of this relationship in Zygoptera since the damselflies appear to be more often parasite by mites than the anisopteran dragonflies (Corbet 1999). Therefore, no major attempts have yet been made to study this relationship in anisopteran dragonflies. This paper describes species selection and site specificity of larval arrenurids on anisopteran adults during the summer and post-monsoon months in the city of Nagpur in central India.

MATERIAL AND METHODS

Dragonflies were collected during the months of August–September, 2010 (post-monsoon) and March–April, 2011 (summer) from the west border of Telenkhedi pond (20° 9′ N and 79° 9′ E) located on the foothills of the Seminary hillock of Nagpur city of central India. This section of the pond is covered with submerged (*Hydrilla* sp.), floating (*Nymphea* sp., *Eichornnia* sp.) and marginal (*Ipomea* sp., *Eleocharis* sp., *Fimbristylis* sp., *Cleome* sp., *Alternanthera* sp. and *Eriocaulon* sp.) aquatic flora. A total of 204 individuals of 11 spe-

Table 1.
Infected odonates observed during August–September, 2010 (post monsoon) and March–April, 2011 (summer). The number of infected host specimens is given in parentheses.

No.	Species	August–September 2010	March–April 2011	Total number observed
1	*Acisoma panorpoides*	12 (1)	9 (2)	21(3)
2	*Brachythemis contaminata*	20 (1)	12 (1)	42 (2)
3	*Bradinopyga geminata*	–	3	3
4	*Crocothemis servilia*	14 (4)	10	24 (4)
5	*Diplacodes trivialis*	12	14(1)	26 (1)
6	*Neurothemis t. tullia*	27 (1)	5	32 (1)
7	*Orthetrum. s. sabina*	15	12	27
8	*Rhyothemis v. variegata*	6	10	16
9	*Tramea basilaris*	3	–	3
10	*Trithemis aurora*	2	–	0
11	*Trithemis pallidinervis*	10	8 (3)	18 (3)
	Total	121 (7)	83 (7)	204 (14)

Table 2.
Distribution of parasitic mites *Arrenurus* by host species and sex.

Host species	Infected hosts	Number of mites	
		M	F
Acisoma panorpoides	3F	0	22
Brachythemis contaminata	2F	0	63
Crocothemis servilia	3F, 1M	1	86
Diplacodes trivialis	1F	0	4
Neurothemis t. tullia	1M	11	0
Trithemis pallidinervis (F)	2F, 1M	1	208
Total	14	82	383

Abbreviations: M — male, F — female

cies of anisopteran dragonflies were netted (*Acisoma panorpoides*, *Brachythemis contaminata*, *Bradinopyga geminata*, *Crocothemis servilia, Diplacodes trivialis, Neurothemis tullia tullia*, *Orthetrum. sabina sabina*, *Rhyothemis variegata variegata*, *Tramea basilaris, Trithemis aurora* and *Trithemis pallidinervis*). Only those individuals infested with arrenurids were photographed and fixed in the Bouins fluid for further studies. Uninfected individuals were set free after noting their reproductive status for a different popular dynamic study.

OBSERVATION

From a total of 204 host specimens belonging to 11 species, only 14 specimens of six species (*Acisoma panorpoides*, *Brachythemis contaminata*, *Crocothemis servilia, Diplacodes trivialis, Neurothemis t. tullia* and *Trithemis pallidinervis*) were parasitized. The overall prevalence was 6.86% (Table 1). The prevalence of the dragonfly *C. servilia* was 28.6%, followed by *T. pallidinervis* and *A. panarpoides* at 21.4%. The total number of parasites recorded was 465, with an average of 33.21 per host specimen. The highest parasite load per individual host species was in *T. pallidinervis* (92.6), followed by *Crocothemis servilia* (24). In *C. servilia, A. panorpoides* and *D. trivialis* the mites were attached venterally to the thorax, forming a 'v' or triangle, while in *B. contaminata* and *T. pallidinervis* the mites were found all over the ventral abdomen. In one *Tritthemis pallidinervis* male and one *Crocothemis servilia* female, mites were found on the thorax and abdomen. The maximum number of mites found on an individual dragonfly was 114 (female *T. pallidinervis*, abdomen), while only one mite was found on the thorax of a male of *C. servilia.* Mite distribution on hosts was female-biased, from August to September 71.0% of collected mites were found on host females, while from March April, 85.7% of infested hosts were females (Tables 2–4).

Table 3.
Mite attachment sites on odonate hosts collected in August–September, 2010.

No	Host species	Mite colour	Mite number	Attachment site		
				wings	thorax	abdomen
1	*Acisoma panorpoides* (F)	orange	1	–	mid-thorax	–
2	*Brachythemis contaminata* (F)	greenish black	42	–	–	3rd to 6th abdominal segment (Fig. 1)
3	*Crocothemis servilia* (M)	black	1	–	mid-thorax (Fig. 2)	–
4	*Crocothemis servilia* (F)	orange	8	–	arranged in V-shaped	–
5	*Crocothemis servilia* (F)	black	24	–	arranged in triangular cluster (Fig. 3)	–
6	*Crocothemis servilia* (F)	orange	54	–	arranged in V-shape (Fig. 4)	1st and 5th abdominal segment
7	*Neurothemis t. tullia* (M)	greenish black	11	–	arranged in V-shape	–

Abbreviations: M — male, F — female

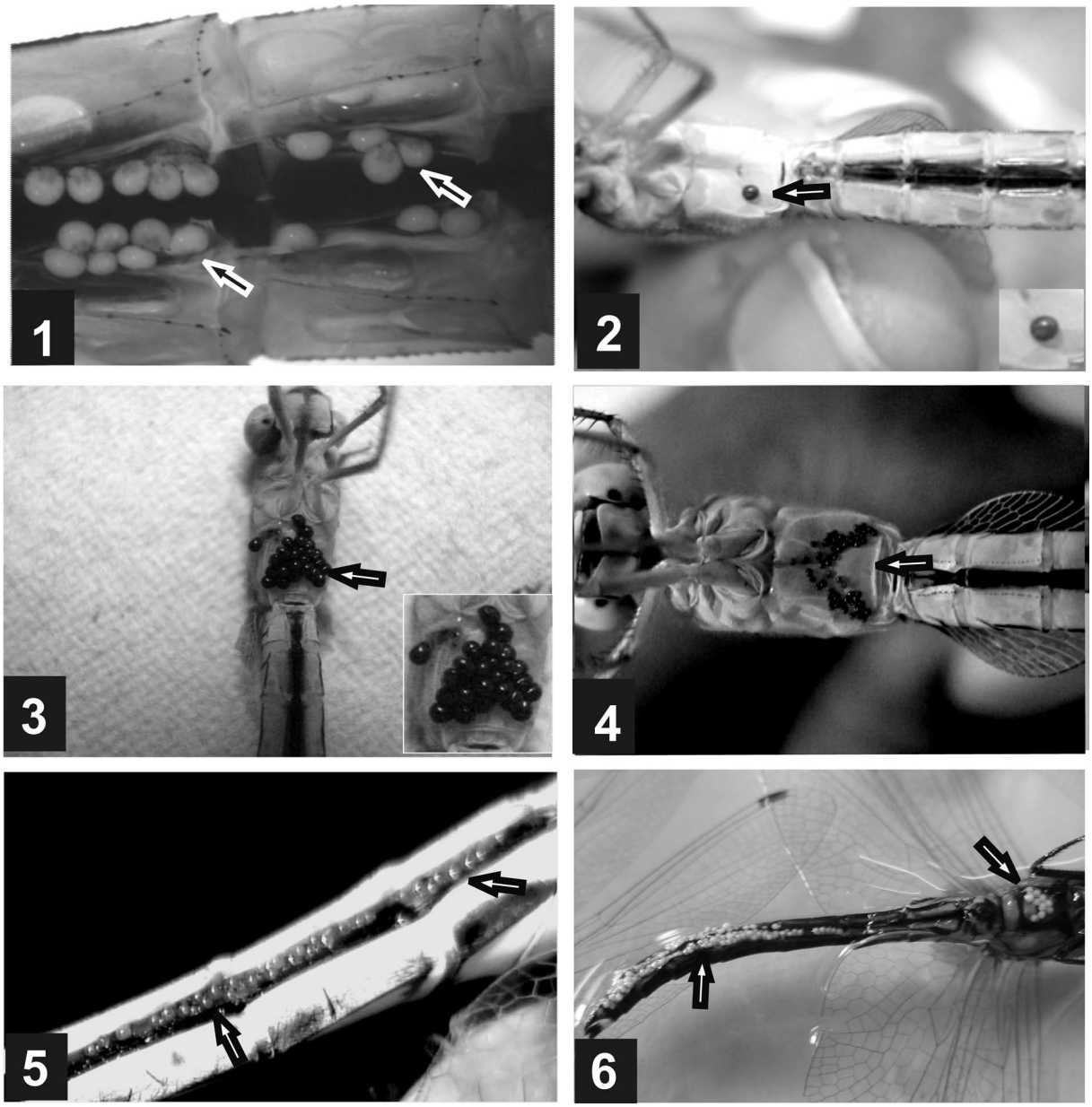
Table 4.
Collection of mite infested dragonflies during the months of March–April, 2011.

No	Species	*Arrenurus* spp.		Host region		
		colour	No.	wings	thorax	abdomen
1	*Acisoma panorpoides* (F)	orange	13	–	arranged in V-shape	–
2	*Acisoma panorpoides* (F)	orange	8	–	arranged in V-shape	–
3	*Brachythemis contaminata* (F)	bottle green	21	–		2nd to 6th abdominal segment
4	*Diplacodes trivialis* (F)	brownish black	4	–	arranged in triangular shape	–
5	*Trithemis pallidinervis* (F)	orange	94	–	–	all over the abdomen (Fig. 5)
6	*Trithemis pallidinervis* (F)	orange	114	–	–	all over the abdomen
7	*Trithemis pallidinervis* (M)	pale orange	70	–	arranged in triangular shape	all over the abdomen (Fig. 6)

Abbreviations: M — male, F — female

DISCUSSION

Although arrenurid mites do not have species-specific hosts, resource partioning may occur since their choice of attachment sites is conspicuous (Davids 1997; Baker et al. 2007). In the present study, *Arrenurus* spp. larvae are found attached to the ventral side of the thorax and abdomen of their hosts, anisopteran dragonflies. In *C. servilia, A. panarpoides* and *D. trivialis* they were attached only to the thorax and were mostly arranged in a 'v' or triangule, while a few were found on the anterior abdominal segments probably due to overcrowding. In *Coenagrion puella* the mite *Arrenurus maculator*, although typically occurring at the posterior end of thorax, is also found on the first abdominal segment, suggesting that overcrowding on its favoured site may lead to occupation of an adjacent area (citation). In contrast, the mite *Arrenurus claviger,* although invariably found on the abdomen, was also occasionally found, in small numbers, further forward on the thorax (Botman et al. 2002; Zawal 2006). In *Coenagrion pulchellum, Ischnura elegans and Erythromma najas* water mites always appear on the thorax. In *Enallagma cyathigerum* and *Erythromma najas* greater intensity of infestation by water mites is also found on the thorax than on the abdomen (Zawal 2006; Zawal and Dyatlova 2006). In *Brachythemis contaminata* and *Trithemis pallidinervis* mites were found all over the ventral abdominal region. Similarly, in *Lestes sponsa*, water mites are almost exclusively attached to the abdomen. Zawal (2004, 2006) proposed that the posture of the host during oviposition determines the location of the mite on the body, while Mitchell (1969 a,b) observed that the part of the body (thorax or abdomen) that comes out of the exuvia most slowly during adult eclosion determines the segregation of mites on the specific site. According to Smith (1998) each species of



Figs 1–6. *Arrenurus* sp. mite infestation (arrows) on anisopteran dragonflies: 1 — *Brachythemis contaminata* female with heavy infestation over the abdomen; 2 — *Crocothemis servilia* male with a single *Arrenurus* sp. mite attached to the thorax; 3 — *Crocothemis servilia* female with a cluster of *Arrenurus* mites on the thorax (note the triangular shape of the cluster); 4 — same as previous (note the V-shaped cluster); 5 — *Trithemis pallidinervis* female abdomen loaded with *Arrenurus* mites; 6 — *Trithemis pallidinervis* male with heavy infestation of *Arrenurus* mites on the thorax and abdomen.

mite has a clearly defined attachment site but initial contact could be made at an alternative site. The mites tend to occupy species-specific attachment site, rather than choosong a random site. Choice of different sites reduces interspecific competition for feeding and growing space. Although in some Anisoptera, like *Sympetrum fonscolombeii* and *Sympetrum meridionale*, mites are always located on the wings (Abro 1982; Corbet 1999), such condition was never observed in the 204 dragonflies observed in the present investigation.

The abundance of parasitic larvae on the bodies of adult odonates varied distinctly according to the time of collection. In the present study, the higher number of larvae were recorded in March–April then in August–September. In conrast, Zawal (2004, 2006), recorded the greatest number of larvae in June–July. During the post-monsoon season, a total of 141 mites were found on 7 individuals (20 per individual), whereas in the summer collection a total of 324 mites were found on 7 individuals (46.3 per individual). Heavy parasitism was observed in *Trithemis pallidinervis* and *Crocothemis servilia* in March–April and August–September.

According to Corbet (1999) "mites infest male and female Odonata apparently without

bias". Rolff (2000) and McKef et al. (2003) also found unbiased distribution of mites on odonates. In the present study 71% of the August–September collection of infested odonates were females. In March–April 87.7% infested odonates were females. Robb and Forbes (2006), Lajeunesse et al. (2004) and Forbes et al. (2004) and this study found significant differencesin numbers, with mites apparently preferring females to males (p=10%). There are probably two major reasons for this: on host males mites mature early and detach readily from the body in humid conditions, probably when they fly over a water body (Rehfeldt, 1995); host females have to return to water to oviposit, while the males may or may not accompany females [depending upon the male guarding (contact and non-contact) and solitary oviposition behavior during oviposition]. Therefore it would be of major advantage for the mites to show a female-biased parasitism in order to return to water easily and continue the aquatic part of their life cycle. All the infected dragonflies species described in this paper (*A. panorpoides, B. contaminata, C. servilia, D. trivialis, N. t. tullia* and *T. pallidinervis*) exhibit solitary or non-contact guarding behaviour during oviposition.

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