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The water mite *Thyas barbigera* Viets (Hydrachnellae: Thyasidae) parasitizing mosquitoes

Boy Overgaard Nielsen
Department of Zoology, Institute of Biological Sciences, Building 135,
University of Aarhus, Universitetsparken, DK-8000 Aarhus C, Denmark

The larvae of several species of water mites are ectoparasites on adult mosquitoes, the majority of the mites recorded belonging to the genera *Thyas* (Thyasidae) and *Arrenurus* (Arrenuridae). Mullen (1975) presented 238 world-wide records of acarine parasites of mosquitoes but more than half of the observations concerned unidentified or doubtfully identified mites. In Europe parasitism of mosquitoes by water mites is mainly recorded from England and Germany (Mullen, 1975). From Denmark only *Thyasides dentata* (Thor) (on *Aedes flavescens* (Müller) and *Arrenurus globator* (Müller) (on *Anopheles maculipennis* Meigen) have been recorded (Lundblad, 1927). However, Danish woodland mosquitoes are frequently parasitized by water mites. In this paper aspects of the parasitic association are analysed.

Materials and methods

The mixed Lisbjerg Forest and Trige Forest (56° 10'N, 10 ° 12'E), about 10 km north-west of Aarhus, eastern Jutland, Denmark are rich in temporary pools. From late May to early September 1984-1997 mosquitoes attracted to man were hand-netted weekly or every fortnight. Further, specimens were swept from the herb layer surrounding the pools. The mosquitoes were removed from the net with a battery-powered aspirator and stored in an icebox in the field. In the laboratory the mosquitoes were identified, specimens parasitized by water mites were separated, the attachment site of each parasite was recorded, and host parity was established by examination of the ovaries (Detinova, 1962). The mites remained firmly attached to the hosts and only two loose parasites were observed. For identification, mites were slide-mounted in polyvinyl lacto-phenol and examined under a compound microscope, using phase contrast. The larval keys of Mullen (1974, 1977) and larval descriptions of Biesiadka & Cichocka (1991) were used.

Results

In 1984-1997 5.2% (N = 591) of all female woodland mosquitoes examined (N = 11,384) were parasitized by larval water mites, in all cases *Thyas barbigera* Viets. No parasitized male *Aedes* (1,748 specimens examined) were found. The following mosquito species were identified as hosts: *Aedes annulipes* (Meigen), *Ae. cantans* (Meigen), *Ae. cataphylla* Dyar, *Ae. cinereus* Meigen., *Ae. communis* (De Geer), *Ae. excrucians* (Walker), *Ae. leucomelas* (Meigen), and *Ae. punctor* (Kirby). No water mites were observed on specimens of *Ae. geniculatus* (Olivier) (N = 20) and *Coquillettidia richiardii* (Ficalbi) (N = 7). Among predominant mosquito species attracted to human bait the incidence of acarine parasitism varied from 2.6% in *Ae. communis* to 6.5% in *Ae. cantans* (Table 1). However, the proportion of mosquitoes parasitized in each host species was not the same (X^2 = 21.338, df = 4; $p < 0.001$). The X^2-values indicate that the proportion of *Ae. cantans* parasitized was higher than expected, whereas the reverse was true for *Ae. communis*.

Table 1. The abundance of predominant culicid species attracted to human bait in Danish woodland 1984 - 1997 and the number and proportion (%) within each species parasitized by the water mite *Thyas barbigera*.

Aedes host species	*cantans*	*annulipes*	*communis*	*cataphylla*	*punctor*
No. of mosquitoes	4.926	1.033	802	406	200
Relative abundance of mosquito species (%)	66.9	14.0	10.9	5.5	2.7
No. of mosquitoes parasitized	320	46	21	20	12
% hosts parasitized	6.5	4.5	2.6	4.9	6.0

The seasonal occurrence of larval *Thyas barbigera* on mosquito species attracted to human bait was: *Ae. cantans* 8 June - 25 August, *Ae. annulipes* 26 June - 3 September, *Ae. communis* 19 June - 6 August, *Ae. cataphylla* 10 June - 15 August, and *Ae. punctor* 19 June - 7 August. In *Ae. cantans* (N = 4.926) the seasonal incidence of *T. barbigera* parasitism increased from 0.2% in the first half of June to 4.1% in the second half of June, 9.8% in July, and 23.5 % in August. In the four other mosquito species a similar seasonal increase in parasitism was observed, i.e. from 0-0.6% in early June to 16.7 - 22.2% in July-August. In *Ae. cantans* swept in the herb layer the incidence of parasitism increased from 0.1% in early June to 22.0% in early August. The same seasonal increase was observed in *Ae. annulipes, Ae. communis, Ae. cataphylla,* and *Ae. punctor* swept in the vegetation.

All parasitized female *Aedes* attracted to man (Table 1) were parous. This also applied to parasitized female mosquitoes swept in the vegetation, i.e. *Ae. cataphylla* (N = 50) and *Ae. cantans* (N = 100), with the exception of one dubious case.

The average number of larval *T. barbigera* per host varied from 2.0 to 4.5 (Table 2). The maximum number of mites recorded was: *Ae. cantans* 15, *Ae. communis* 13, *Ae. cataphylla* 14, and *Ae. punctor* 17. The length of attached *T. barbigera* larvae varied from 203µm to 870µm (N = 44) and in case of multiple parasitism larval sizes were approximately the same. No seasonal trend in larval size was observed.

The mites were always found attached to membranous areas of the host body. In all mosquito species the most common attachment site was the back area of coxae III followed by the ventral part of cervix and an area immediately behind coxae I (Table 2). The distribution pattern of *T. barbigera* on the thorax of the mosquito species was compared by a X^2 test (mites from sections 1-4 and 5-9 respectively were pooled; see Table 2). The distributions on *Ae. cantans* and *Ae. annulipes* (X^2 = 0. 1853, df = 2, NS), *Ae. communis* and *Ae. punctor* (X^2 = 1.2539, df = 2, NS), *Ae. communis* and *Ae. cataphylla* (X^2 = 1.2117, df = 2, NS), and *Ae. punctor* and *Ae. cataphylla* (X^2 = 3.7953, df = 2, NS) were not significantly different. However, the distribution of the mites on species of the *annulipes* group (*Ae. cantans* and *Ae. annulipes*) and the *communis* group (*Ae. communis, Ae. punctor, Ae. cataphylla)* differed significantly (X^2 = 13.2303, df = 2, $p<0.005$), in the former group being distinctly skewed towards the back area of coxae III.

Table 2. Attachment pattern of larval water mites *(Thyas barbigera) on Aedes* hosts. Number of attached larvae and percentage distribution (in brackets) presented.

	cantans	*annulipes*	*communis*	*cataphylla*	*punctor*
Cervix, dorsal	17 (3.6)	3 (2.9)	3 (4.2)	0 (-)	3 (6.0)
Cervix, ventral	57 (12.2)	12 (11.4)	14 (19.4)	14 (15.7)	13 (26.0)
Pronotum	0 (-)	1 (1.0)	2 (2.8)	0 (-)	0 (-)
Prosternum	15 (3.2)	2 (1.9)	2 (2.8)	6 (6.7)	3 (6.0)
Behind coxae I	59 (12.6)	9 (8.6)	14 (19.4)	12 (13.5)	2 (4.0)
Pleura	6 (1.3)	2 (1.9)	0	0 (-)	1 (2.0)
Behind coxae II	1 (0.2)	2 (1.9)	0	4 (4.5)	0 (-)
Mesosternum	12 (2.6)	5 (4.8)	2 (2.8)	4 (4.5)	4 (8.0)
In front of coxae III	0 (-)	0 (-)	0 (-)	0 (-)	1 (2.0)
Back of coxae III	294 (62.8)	67 (63.8)	33 (45.8)	48 (53.9)	23 (46.0)
Abdominal terga/sterna	2/5 (1.5)	2/0 (1.9)	1/1 (2.8)	1 /0 (1. 1)	0 (-)
No. of mites	468	105	72	89	50
No. of mosquitoes	226	52	22	39	11
Average mites/host	2.1	2.0	3.3	2.3	4.5

Discussion

Thyas barbigera is a holarctic species originally described from Europe (Mullen, 1977); the non-parasitic adults and nymphs are previously recorded from Denmark (Lundblad, 1927). Thyasid mites are primarily associated with temporary pools, where nymphs and adults can be observed crawling at the bottom; the eggs are deposited along the pool margin, where the newly hatched larvae concentrate (Mullen, 1974, 1977). *T. barbigera* was predominant

among water mites recorded from woodland pools in Northern Germany (Böttger & Völkl, 1987). As demonstrated by Mullen (1977), larval attachment normally occurs when the female returns to the breeding site for oviposition. Consequently, typically parous females are parasitized by *T. barbigera,* even early in the season, when nulliparous females are predominant. Thus the present investigation confirms that this water mite is a reliable indicator of female parity.

In USA at least 13 *Aedes* species have been identified as hosts, for instance, *Ae. cinereus, Ae. excrucians,* and *Ae. punctor* (Mullen, 1974, 1975, 1977). In Danish woodland the same species as well as *Ae. annulipes, Ae. cantans, Ae. cataphylla, Ae. communis,* and *Ae. leucomelas* are parasitized by *T. barbigera,* which is a parasite typical of *Aedes* species breeding in temporary pools. Since also Tipulidae, Ptychopteridae, Empididae and other aquatic or semiaquatic dipterans are parasitized, the mite is not very host specific.

The distinct overrepresentation of *Ae. cantans* and the corresponding underrepresentation of *Ae. communis* among hosts may reflect that the blood-feeding and oviposition of the former species start later in the summer than in *Ae. communis,* i.e. when the density of newly hatched *T. barbigera* larvae has increased significantly. Further, *Ae. cantans* and *Ae. communis* oviposit at different levels in the dried-up woodland pools (Iversen, 1971), possibly affecting the probability of host-parasite encounters and thus the risk of acarine infection.

The attachment pattern of *T. barbigera* observed in North American (Mullen, 1977) and Danish *Aedes* populations is similar. The difference in acarine distribution pattern observed between hosts of the *annulipes* and the *communis* group is not explained by discrepancy in the area of attachment sites in the species; possibly behavioural traits of the host are decisive.

According to Mullen (1977), newly attached and fully engorged *T. barbigera* larvae measure 200-240µm and up to 780µm in length respectively; complete engorgement requires 5 - 8 days and larval detachment from the host normally occurs during oviposition. In Danish *Aedes* populations newly attached as well as fully engorged mites were observed throughout the summer, thus larval attachment and detachment is a continuous process, concurrently with gonotrophic cycles and oviposition of the host species.

While parasitic *Arrenurus* larvae may reduce the survival and egg production of mosquito hosts (Lanciani, 1979; Lanciani & Boyt, 1977; Smith & McIver, 1984), the effect of *Thyas barbigera* larvae on the host is unknown.

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