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The Water Mites Parasitic on the Damselfly, *Cercion hieroglyphicum* Brauer I. Systematics and Life History*

With 4 Text-figures

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(*Communicated by* T. UCHIDA)

ABSTRACT *Arrenurus mitoensis* n. sp. is described and the larvae of that species and *A. agrionicolus* are discussed. Observations of parasitized hosts show that the larvae are active from May to November and thus there must be two or three life cycles completed per year. At the time of ecdysis of the damselfly host *A. agrionicolus* attach to the ventro-lateral membranes of the host abdomen and *A. mitoensis* attaches on the venter near the leg bases. The latter species will also attack mature damselflies as they rest or oviposit on floating vegetation. No other species of *Arrenurus* is known to attack hosts after ecdysis.

Two species of *Arrenurus* (Fam. Arrenuridae), *A. agrionicolus* Uchida and a species new to science, parasitize *C. hieroglyphicum*. Many specimens of all stages have been collected during ecological studies on these mites and descriptions of the larval stages of both species, as well as the adult of the new species are given below. A detailed study of the larval chaetotaxy and body sclerites provides a set of characters that form a clear basis for the identification of the larvae of these two species. This work suggests that it should be possible to develop a sound taxonomy for *Arrenurus* larvae and such a taxonomy would greatly assist ecological studies of the genus.

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Arrenurus (*Arrenurus*) *mitoensis* n. sp.
syn. *Arrenurus* (*A.*) *latipetiolatus*; Imamura, 1952.

Male. Length, excluding pygal lobes and petiole, 0.96 mm, maximum width 0.78 mm; petiole 0.17 mm long, 0.13 mm wide; genital field 0.54 mm wide; gonopore 0.06 mm wide; coxal area 0.67 mm long, 0.82 mm wide. Body green in color.

Body oval, projecting slightly over the eyes but distinctly concave between

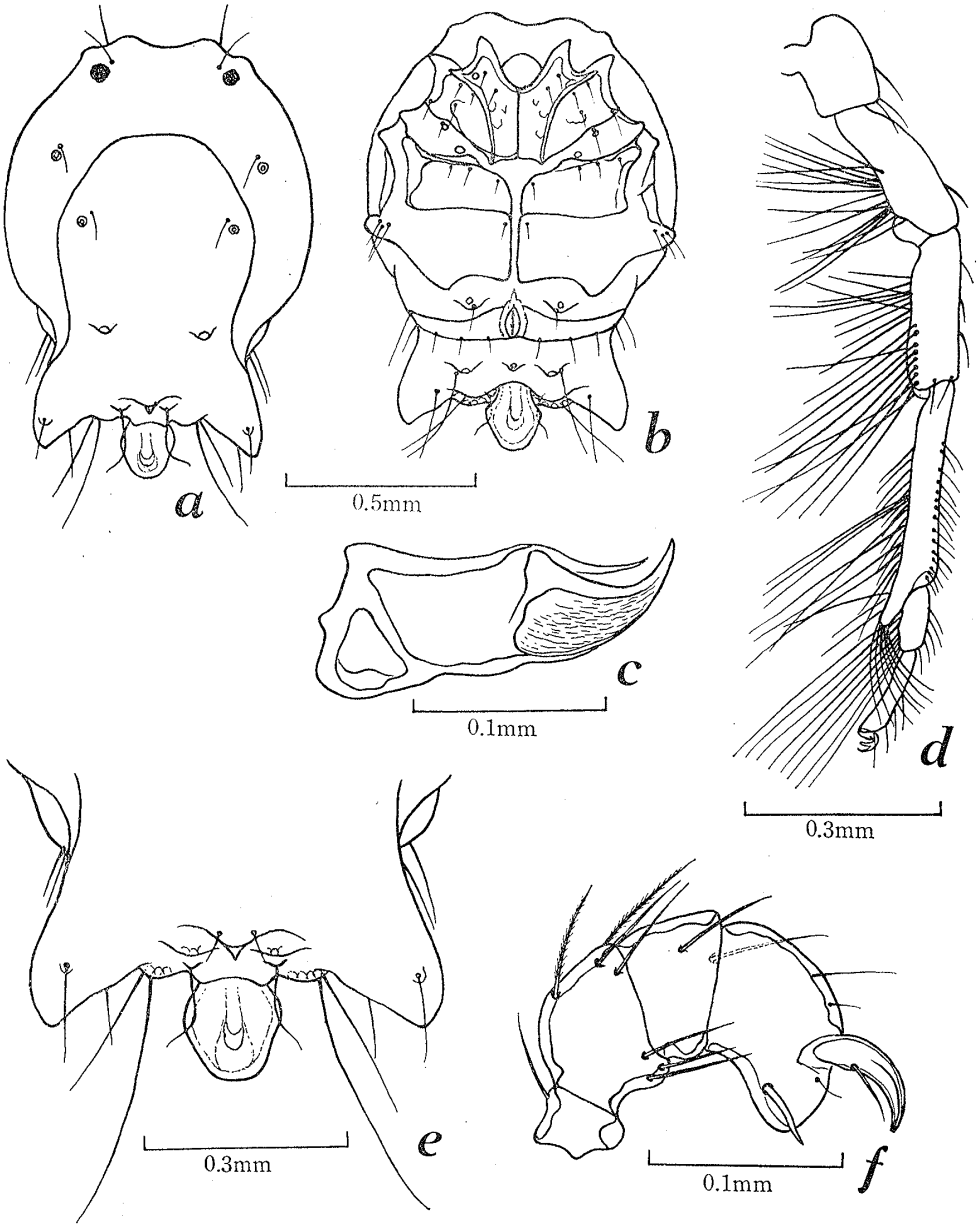

Fig. 1. *Arrenurus mitoensis* n. sp., male: **a**, dorsal aspect; **b**, ventral aspect; **c**, chelicera; **d**, left IVth leg; **e**, cauda, dorsal aspect; **f**, left palp.

the eyes, constricted abruptly at the base of the cauda. Pygal lobes angular and divergent in dorsal aspect but truncate from lateral aspect. Body humps not prominent from the lateral aspect. Hyaline appendage reduced to a low ridge. Petiole ovoid with no setae or projections, dorsal surface flat, convex ventrally and extending almost parallel with the body axis when viewed laterally. Number of simple setae per palp segment from base to tip 1-5-2-3-1. Segment 2 with 2 additional pectinate setae and segment 4 with a massive seta. Capitulum 0.16 mm long. Chelicera 0.19 mm long, 0.08 mm wide. Length of legs, anterior to posterior: 0.82 mm, 0.83 mm, 0.88 mm, 1.14 mm. Segment 6, legs I–II with many long slender setae, legs III–IV with abundant long setae on segments 3–5. Seven long curved hairs insert at the tip of the spur of segment 4, leg IV.

Female. Body ovoid; 1.15 mm long, 1.02 mm wide; interocular distance 0.38 mm: dorsal shield 0.80 mm long, 0.70 mm wide. A distinct interocular concavity and projecting postero-lateral lobes, body oval from the lateral aspect. Genital field 0.74 mm wide, 0.16 mm long with the genital plates approximately parallel-sided. Gonopore 0.14 mm long, 0.18 mm wide. Length of legs, anterior to posterior: 0.70 mm, 0.82 mm, 0.85 mm, 0.99 mm.

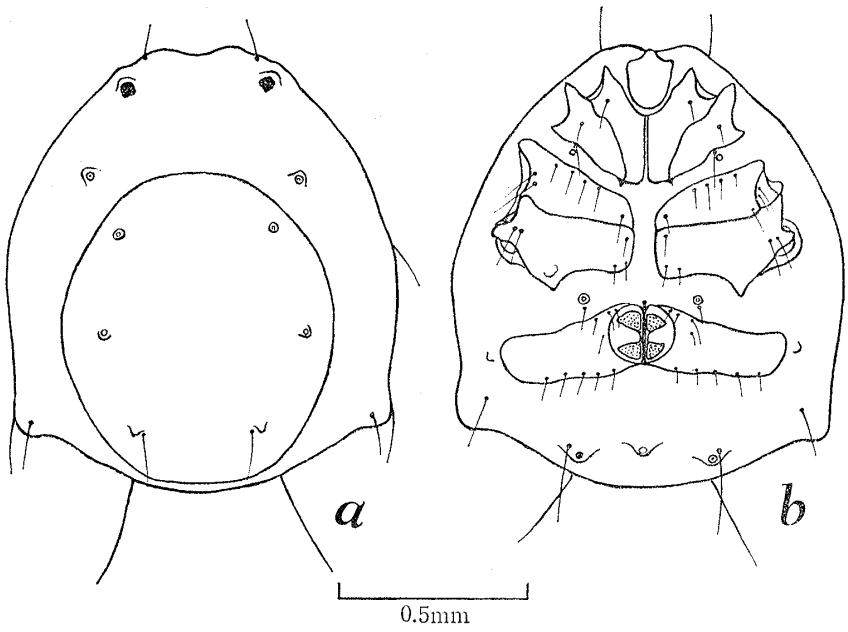

Fig. 2. *Arrenurus mitoensis* n. sp., female: **a**, dorsal aspect: **b**, ventral aspect.

Specimens. 4 males and 3 females from Senba Lake, Mito City, Ibaraki-ken September 29, 1965. The Holotype (Prep. no. 1649) and Allotype (Prep. no. 1653) are preserved in the collection of the Biological Institute, Ibaraki University. 1 male, Yatsushiro, Kumamoto-ken, Kyushu, September, 1935.

Remarks. The specimens agree with those obtained from Kyushu which were at that time reported as *A. latipetiolatus* Piersig by Imamura (1952). On closer examination, it was revealed that our water mites are quite different from

Piersig's species in the shapes of petiole, pygal lobes and in the P IV, and thus belong to a new species. The female of this new species is easily distinguished from that of *A. agrionicolus* Uchida, sympatric in the habitat, by features of the genital flaps.

Larva. Dorsal shield 0.172–0.186 mm long, 0.107–0.137 mm wide; bearing 10 simple setae. Four of the setae in a transverse row. Eyes, marginal setae and venter as in *A. agrionicolus*. Capitulum (Fig. 4e) 0.090–0.095 mm long, 0.071–0.076 mm wide. Palp setal formula as in *A. agrionicolus*. Palp segment 5 with seta *v-5* bearing many fine long pectinations, *v-4* a simple seta and *d-3* (Fig. 4f) a coarse seta with 3 heavy pectinations on one side. Other setae simple. Legs longer than dorsal shield (Tables 1 and 2). Leg setae heavier (Figs. 4h-j) than in *A. agrionicolus*. No blade-like setae on segment 5. A heavy strongly pectinate seta inserts antero-distally on segments 2–4 of all legs. A ventrally-inserted long pectinate seta on all segments. Segment 5, legs II–III bear pectinate terminal setae. Segment 5, legs I–II with a terminal seta originating on a

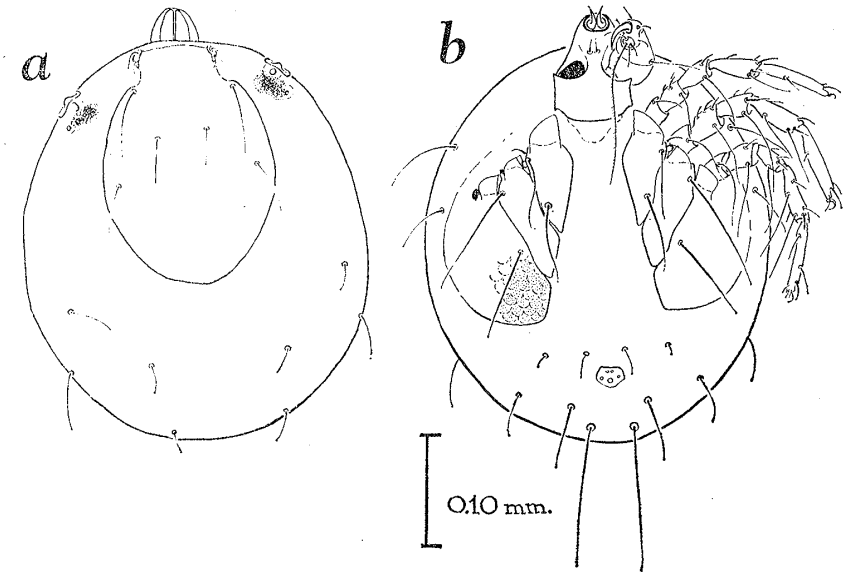

Fig. 3. *Arrenurus agrionicolus* Uchida, larva: **a**, dorsal aspect; **b**, ventral aspect.

Table 1

Measurements of body sclerites of the larva in mm
(Mean values from a sample of 5 are given.)

Species	Dorsal shield		Capitulum		Ratio of leg length to dorsal shield length		
	Length	Width	Length	Width	Leg I	Leg II	Leg III
A. agrionicolus	0.183	0.129	0.095	0.064	1.00	1.05	1.11
A. mitoensis	0.178	0.125	0.093	0.074	1.33	1.33	1.39

postero-lateral projection.

Specimens. Several hundred larvae were examined. Cast skins of larvae reared to the adult stage in the laboratory were the basis for the larval identification. All larvae were attached to the thorax of *C. hieroglyphicum* or *C. sexlineatum* Selys from Senba Lake, Mito City, Ibaraki-ken in August and September of 1965 and from May to August of 1966.

Arrenurus (*A.*) *agrionicolus* Uchida

Larva. The dorsal shield, 0.175–0.187 mm long, 0.107–0.138 mm wide, nearly covers the dorsum of the unengorged larva (Fig. 3a). Two small short setae insert on the heavily sclerotized antero-lateral angles of the dorsal shield. The antero-lateral concavity of the shield surrounds the lateral eyes in the unengorged larvae and an elongate seta lies just posterior to the concavity. Two pairs of simple setae insert centrally on the shield, the median pair distinctly anterior to the lateral pair. Lateral eyes lie close together but only the anterior eye is encapsulated. Four pairs of marginal setae (Fig. 3a); the first and second dorsal, the others marginal.

Coxal plates nearly cover the venter of unengorged larvae (Fig. 3b). A row of 4 short simple setae anterior to the excretory plate, 6 elongate heavy setae posterior to the plate and a pair of finer setae lateral to these. Two pairs of long setae lateral to the central area of the coxal plates. Coxal setae simple and arranged 3-1-1. A long median seta on coxae I, III, a long lateral seta on coxae I–II and a short seta disto-posterior on coxa I.

Capitulum 0.090–0.104 mm long, 0.060–0.068 mm wide, with a pair of median setae just anterior to the palp sockets and a pair of short heavy setae at the tip. Palp segment 1 a narrow ring, segments 2–3 massive, segment 4 broad and flat with 2 massive disto-dorsal claw-like setae and segment 5 reduced to a small pad on the ventro-median surface of segment 4 (Figs. 4a-b). Palp setal formula

Table 2

Chaetotaxy and length in micra of the leg segments of the larva
(Mean values from a sample of 5 are given.)

Species	Leg I					Leg II					Leg III				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
A. agrionicolus															
Length	25	27	29	41	55	26	29	30	45	61	30	29	30	46	61
Simple setae	1	4	5	8	12	1	6	5	9	13	1	4	4	8	11
Pectinate setae	0	3	1	1	0	0	1	1	3	0	0	1	1	2	0
A. mitoensis															
Length	29	36	38	53	82	32	34	37	55	81	34	37	37	56	82
Simple setae	0	4	4	7	12	0	5	3	9	12	0	2	4	9	6
Pectinate setae	1	3	2	2	2	1	2	3	2	2	1	3	2	2	5

0-1-2-4-8. Short simple setae in positions *d-1, 2* and *v-1, 2, 3* of segment 5, seta *v-4* very heavy and short, seta *d-3* (Fig. 4d) short, heavy with about 10 pectinations on one surface. Seta *v-5* elongate, bearing a few short pectinations (Fig. 4c). All other palpal setae fine and hair-like.

Legs as long as dorsal shield (Tables 1 and 2) and most setae hair-like, a few weakly pectinate setae present (Figs. 4k-m). All legs with a disto-ventral pectinate seta on segment 4 and dorsal pectinate setae on segments 2–3. Segment 5, legs I, II with a blade-like disto-dorsal seta. No pectinate setae on segment 5.

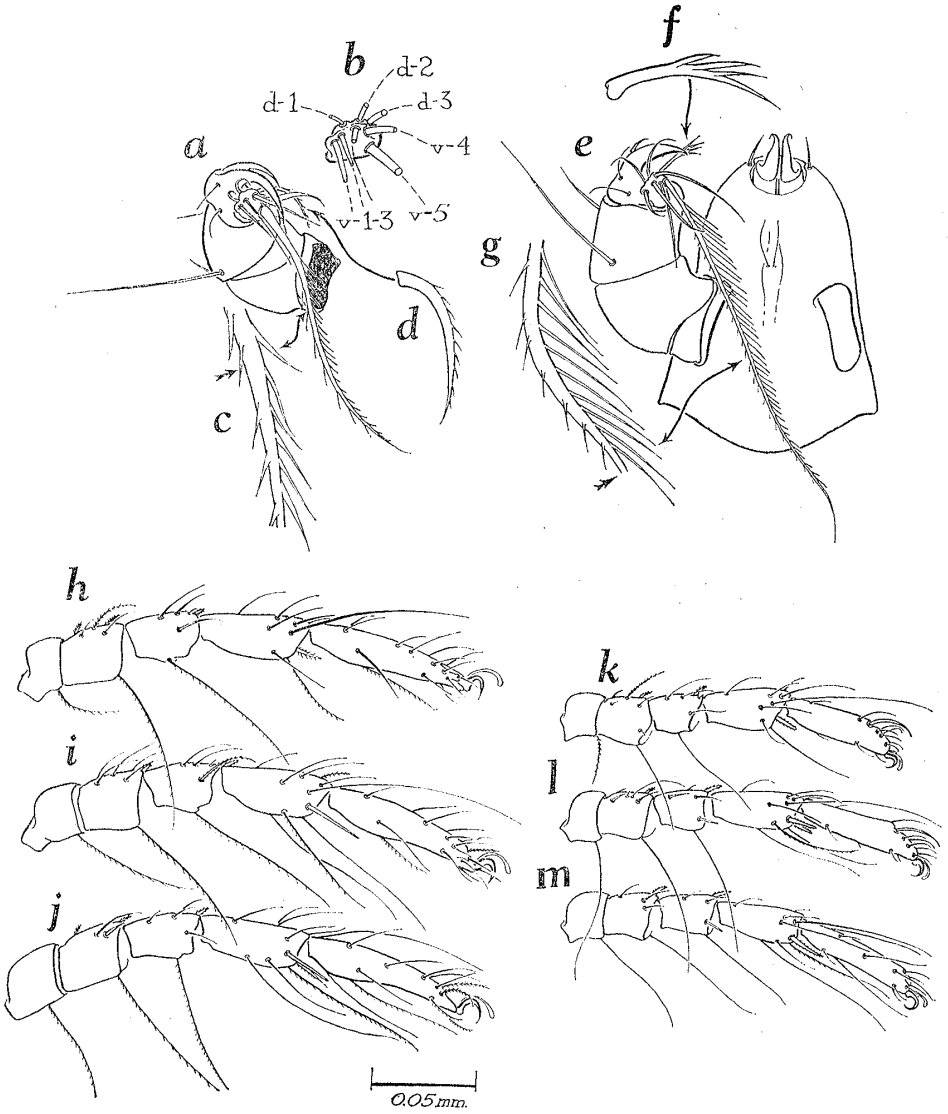

Fig. 4. Larval mouthparts and legs. *A. agrionicolus*: **a**, palp, ventral aspect; **b**, diagramatic representation of palp segment 5 with setae labelled; **c**, seta *v-5*; **d**, seta *d-3*. *A. mitoensis*: **e**, capitulum and right palp; **f**, seta *d-3*; **g**, seta *v-5*; **h, i, j**, posterior aspect legs I, II, III. *A. agrionicolus*: **k, l, m**, posterior aspect legs I, II, III.

Specimens. Several hundred larvae from the same host series as *A. mitoensis* n. sp. were examined. Cast skins of larvae reared to the adult stage in the laboratory were the basis for the larval identification.

TAXONOMY OF LARVAE

The above mentioned two species differ from each other in the arrangement of the dorsal shield setae, the length width ratio of the capitulum, the shape and form of setae *d-3*, *v-4* and *v-5* of palp segment 5, the relative length of the legs and leg segments and the numbers and modifications of the leg setae, especially on segments 5.

Since such a varied set of features distinguish these two species it seems likely that the identification of larval *Arrenurus* is practical. The larval taxonomy must always be correlated with the advanced adult taxonomy; thus, all larval descriptions using taxonomic binomials should be based on larval-adult associations established by rearings.

LIFE HISTORIES

These species show the usual life cycle pattern of species of the genus *Arrenurus*. Six-legged larvae hatch from the eggs and then seek out terminal damselfly naiads. When the naiad undergoes ecdysis the larvae transfer to the imago, attach with their mouthparts and proceed to engorge. After engorgement the larvae drop from their host. If they drop into the water the larvae enter the nymphochrysalis stage and later emerge as four-legged nymphs which, in the laboratory, have a great appetite for *Daphnia*. A second quiescent stage, the teleiochrysalis, follows and then the adult emerges. Adults also prey on *Daphnia*. In the laboratory the engorged larva develops to the adult stage in 16 to 27 days and the adults will usually live two or three months.

It probably takes over four weeks to reach the engorged larva stage; two weeks for egg development and at least two weeks for host discovery and engorgement. The life cycle should be completed in less than three months during the summer season.

Mite larvae are found on the preferred host, *C. hieroglyphicum*, throughout the emergence period of the host (early May to October in Mito City). Thus, there must be at least one and possibly two summer cycles per year followed by a fall generation of mites that overwinters as adults. The annual life cycle pattern of both of these species of mites has been greatly modified to fit the emergence pattern of the host.

Most other Odonata and all other larvae of *Arrenurus* have a very short activity period and a single generation per year.

These two species are similar in their pattern of seasonal host exploitation but dissimilar in most other ways. *A. agrionicolus* larvae find hosts that will emerge in less than 4 or 5 days. The number of these mites found on a naiad increases as the naiad shows greater differentiation of adult structures so there must be an accumulation of larvae over a period of several days. When the

naiad leaves the water for ecdysis it carries all the *A. agrionicolus* it will ever have. Larvae that do not transfer from the naiad to the imago at ecdysis will die.

The long-legged *A. mitoensis* larvae are much more active than *A. agrionicolus* and they tend to be abundant in surface waters away from shore where floating leaves of plants such as *Potamogeton* and *Trapa* are common. They seem to find naiads that are in this habitat shortly before ecdysis or, perhaps, even during ecdysis. The probability of a damselfly receiving a heavy *A. mitoensis* infection evidently depends on the site of ecdysis and host activity shortly before ecdysis. This contrasts with *A. agrionicolus* which has greater opportunities to find its host and probably seeks hosts throughout the range of host habitats.

These differences in host seeking behavior seem to explain why 100 per cent of the hosts carry *A. agrionicolus* and a variable fraction of the hosts are parasitized by *A. mitoensis*. The variation in the size of parasite load is much greater in *A. mitoensis* which is most likely the result of the larval mites being clumped in the host range.

A. mitoensis is radically different from other known *Arrenurus* species in being able to parasitize mature damselflies. Hosts undergoing maturation, which takes about one week after ecdysis, carry the larvae of both species which became attached at the time of ecdysis. Both mite species grow at similar rates and are mature at the end of the host maturation period. The loss of these mites from mature hosts is rather prompt and the hosts showing scars from the original mite infection will regularly carry a number of unengorged or engorging *A. mitoensis* larvae. The damselflies must get these secondary infections of *A. mitoensis* when they rest on leaves or sticks in the water away from the shore. Hosts often rest with one or more legs touching or under water and even the abdomen will sometimes touch water. In addition, the female and sometimes the male will have parts of their bodies under water at the time of oviposition and this is generally carried out in zones where *A. mitoensis* larvae are most common.

Secondary parasitic attachments of *A. mitoensis* may be found on almost any of the ventral body membranes, although the thoracic membranes are preferred. The primary infection of *A. mitoensis* is always limited to the thorax and the larvae clump together around leg bases and membranes around the base of the second leg are preferred, regardless of larval density.

A. agrionicolus attach only at the time of ecdysis and attachment is limited to abdominal segments. The ventro-lateral membranes of segments 5 through 7 are the first to be filled with mites as the density of mites increases the more anterior ventro-lateral membranes are used by mites. At densities of 50 larvae per host it is common to find a few *A. agrionicolus* attached to the thorax.

The differing site preferences seem to insure that all or nearly all the mites of one species compete only with each other for attachment sites. When the density of one of the mite species is very high, the mites will cause host mortality by tearing the integument of the host at preferred attachment sites. Such damage occurs before potential attachment sites are fully exploited by the mites.

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