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OBSERVATIONS ON THE BIOLOGY
OF TWO HYGROBIOTIC TROMBIDIID MITES (ACARI: PROSTIGMATA: PARASITENGONAE), WITH SPECIAL REGARD TO HOST RECOGNITION
AND PARASITISM TACTICS

BY A. WOHLTMANN* and F.-E. WENDT**

SUMMARY: The biology and parasitism of Centrotrombidium schneideri Kramer, 1896 (Johnstonianidae) and Valgothrombium major (Halbert) 1920 (Microthrombidiidae) were investigated in the field and in the laboratory. For the larval instars of both species taxonomical descriptions are given. From laboratory experiments, a confinement of both species to hygric biotopes was established. It appears that both species have univoltine life cycles. The postlarval instars of both species prey on larvae of Nematocera. The larvae of both species parasitize Culicoides sp. (Diptera: Ceratopogonidae) and display an unique host recognition behaviour (hitherto unknown for terrestrial Parasitengonae), in that they recognize the pupae of the host. The larvae then wait for the imaginal host instar to emerge. The parasitic phase is restricted to the imaginal host instar. This type of host recognition is evidently a good tactic when short-lived instars of Insecta serve as hosts. The relatively high host specificity for hygrophilic Ceratopogonidae decreases the risk of the mite larvae being displaced into unsuitable biotopes.

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COMPORTEMENT PARASITISME DEVELOPPEMENT CYCLE DE VIE TAXONOMIE MICROTHROMBIDIIDAE JOHNSTONIANIDAE PARASITENGONAE CERATOPOGONIDAE

Résumé : La biologie et le parasitisme, dans la nature et en laboratoire, ont été observés chez *Centrotrombidium schneideri* Kramer, 1896 (Johnstonianidae) et *Valgothrombium major* (Halbert) 1920 (Microthrombidiidae). La description morphologique du stade larvaire est donnée pour les deux espèces. Dans les expériences de laboratoire, les deux espèces sont confinées à des biotopes humides. Les deux espèces paraissent avoir des cycles de vie univoltins. Les stades postlarvaires des deux espèces sont prédateurs de Nematocères. Les larves parasitent des *Culiculoides* sp. (Diptera : Ceratopogonidae) et montrent un comportement de la reconnaissance de l’hôte (inconnu jusqu’à présent chez les Parasitengonae terrestres) unique en ce que ce sont les pupes de leur hôte qui sont reconnues. Les larves attendent alors l’émergence de l’imago de l’hôte. La phase parasite est limitée au stade imaginal de l’hôte. Ce type de reconnaissance de l’hôte est évidemment une bonne tactique quand les hôtes sont des stades d’insectes à vie courte. La spécificité pour l’hôte relativement élevée vis à vis des Ceratopogonidae hygrophiles abaisse le risque de se trouver déplacées dans des biotopes défavorables pour ces larves.

**Introduction**

Parasitengone mites are characteristic in that their larval stage is parasitic while their postlarval mobile instars, deutonymphs and adults, are free-living predators. Parasitism on arthropods, especially flying insects, is common (Welbourn, 1983, Smith & Oliver, 1986); only few groups parasitize other animals (e.g. Trombiculidae parasitizing vertebrates) or are predatory in the larval instar (Balaustium, Putman, 1970, some species of Abrolophus, Witte, 1972, Welbourn & Young, 1987). Several parasitengone species are considered to be potential agents of biological control (Welbourn, 1983).

In order to understand the ecological tactics of parasitengone mites, it is necessary to examine their life history and interactions with their specific environment; this is also the first step in checking the role of these species as agents of biological control. Not much information is available on the biology of the Parasitengonae and, for the terrestrial species in particular, little has been published on the parasitic phase.

Larvae of both the species under investigation, *Centrotrombidium schneideri* Kramer, 1896 and *Valgothrombium major* (Halbert) 1920, recognize only the larval and pupal instars of their specific hosts, but only parasitize the imagines (previously unknown for terrestrial Parasitengonae). Furthermore, they display high host-specificity. Details on habitat restriction and life history will be given here.

**Material and methods**

Adult mites from the field were kept in groups of 3-15 individuals in polystyrene boxes (25 x 25 x 20 mm) filled up to a third of its volume with mould taken from their habitats. For laboratory rearing experiments plaster-charcoal filled polystyrene boxes (25 x 25 x 20 mm) were used. Saturated air humidity was maintained by adding appropriate amounts of water to the substrate. Individuals were kept in a light-thermostat at 20°C (± 1°C) with a 12h/12h light/dark cycle. For parasitism experiments 10-20 larvae kept in a rearing box were exposed to 2-3 potential hosts for a period of 4 days. All boxes were checked daily.

Larvae of both species were tested for phototactic responses the day after hatching. Glass tubes were used (10 cm long, 2.5 cm in diameter) and were illuminated with a light source from alternating positions.

Hygro-preferences : The abundance of adults for both species was determined with a humidity gradient apparatus at levels of 33 %, 55.5 %, 76 %, 93.5 % and 100 % rh (relative air-humidity) (Barlow & Nicholls, 1961, modified). Abundance was defined as the actual distribution of the individuals at these respective humidities in 10 min intervals over a period of 4 hours. Experiments were carried out in a light-thermostat at 20°C (± 1°C) in light and without any food supply.

The osmotic haemolymph concentration [mosm/kg] of adults of both species was determined
micro-cryoscopically shortly after capture according to the method of Weigmann (1973). Conditions prior to measurements were: no food supply, refrigerated at 9-14°C (except for the time lapsed during transfer) and saturated air humidity.

Specimens used for taxonomic descriptions were laboratory-reared, unfed larvae obtained from eggs deposited by females captured on 10 June 1992 at lake “Wittensee”, Northern Germany (54°20’20” N, 09°45’12” E). Drawings and measurements were made from cleared and mounted specimens using a microscope (BH-2, Olympus) with interference phase-contrast and a camera lucida. Terminology follows Vercaumen-Grandjean & Cochrane (1974).

RESULTS

1. Taxonomy

a) Centrotrombidium schneideri Kramer 1896; larva (Tables 1, 2, figures 1, 2).

Idiosoma: Length 156-158 μm, colour reddish in life.

Dorsum (Fig. 1a): Propodosoma with a single scutum and one pair of eyes. Scutum nearly

Fig. 1: Centrotrombidium schneideri Kramer, 1896, larva.

a — Dorsal aspect. b — Ventral aspect. Palps omitted beyond femur, legs omitted beyond trochanter.
triangular (length 51-55 μm, width 37-46 μm) with a projecting naso bearing a pair of barbed setae (38-39 μm long, 10-12 μm apart) and a pair of trichobothria posteriorly. Trichobothria (34 μm from the tip of naso, 22 μm apart) each consisting of a basal stalk (13 μm long) which widens to form a globular tip (13 μm long).

Posterior to scutum are 26 barbed setae (47-55 μm long) inserted on ovoid plates (16 μm long) arranged in rows of 6/6/6/6/2 setae (anterior to posterior).

Venter (Fig. 1b) : Hysterosoma with approximately 28 setae behind coxae III and a further pair at level of coxae III. All setae smooth (20-25 μm long), inserted on ovoid plates (8 μm long). Urstigmata between coxae I and II, at the lateral margins of body. Anal opening median (22-24 μm long), posterior to level of coxae III. Coxal setae formula : 2,1,1, I 29-31 μm, II and III deeply bifurcate, 20-24 μm long.

Gnathosoma : Palp (Figs. 1a, 2a) with a single dorsal, barbed seta on femur and genu each. Palptibia with three smooth setae and a strong, slightly curved claw. Palptarsus with 3 normal, nude setae and 3 barbed setae; terminally with a strong spatulate, barbed seta; posteriorly with one solenidium. Tip of tarsus sharply pointed, extending beyond basis of spatulate seta. Gnathobase (Fig. 1b) with two pairs of setae, the anterior one 6-8 μm, the posterior one 18-22 μm long. Velum oval in outline, reticular in appearance. Movable digit of chelicera smooth and strongly curved.

Legs (Fig. 2b-d) : all with partly divided femur, the ventral and lateral joint being accordion-like. Leg segmental formula : 6,6,6 (including coxae). All claws falciform, posterior claws on all legs bent rectangularly at mid-length. Anterior claws of legs I and II bifid. Claws of legs III significantly larger than others. Measurements and setation as given in tables 1 and 2.

b) *Valgothrombium major* (Halbert) 1920 ; larva (Tables 1, 2 ; figures 3, 4).

Idiosoma : Length about 178 μm ; colour red in life.

Dorsum (Fig. 3a) : with two shields and two pairs of eyes. The anterior shield (scutum, length 54-56 μm, width 55 μm) bearing 3 pairs of barbed setae and one pair of trichobothria. The anterior setae (32-35 μm long, 23-24 μm apart) located at the anterior margin of the scutum. Trichobothria (32 μm long, 24 μm apart) 26-30 μm behind the tip of scutum, located between levels of the mid setae (31 μm long, 41 μm apart) and the posterior setae (54 μm long, 47 μm apart). Distance between anterior and posterior setae 44 μm. Scutum with a posteriorly protruding ridge (width at top 5 μm) along its median axis, which overlaps the mid anterior part of the second dorsal shield (scutellum). The scutellum (55 μm long, 65-67 μm wide) with one pair of barbed setae (58 μm long, 25 μm
With a ridge along its median axis, which flattens posteriad to the level of the shield. Laterally to the scutellum are 3 barbed setae on each side; posteriorly are 16 barbed setae (55-63 μm long), each inserted on a circular plate (14-20 μm diameter), arranged in rows of 4/6/4/2 setae (anterior to posterior).

Venter (Fig. 3b) : 3 rows of barbed setae posterior to coxae III (2,2,2; 24 μm long) on almost spherical plates (9-10 μm). Urostigmata between coxae I and II at the lateral margins of body. Anal opening (9-12 μm long) behind coxae III. Coxal setae formula : 2,1,1. All setae bifurcate, 28-31 μm long.

Gnathosoma : almost entirely hidden dorsally by the scutum. No setae on palpfemur and genu. Palptibia (Fig. 4a) with one normal, nude seta and two short, spine-like setae on each side of the terminal, bifurcate claw. Palptarsus (Fig. 4a) with two normal, nude setae, one externobasal solenidium, and four spine-like setae terminally. Movable digit of chelicera strongly curved, with a minute hook on the blade close to its tip. One pair of minute protorosstral setae (2 μm long), no further setae detected on gnathobase (oil immersion).

Legs (Fig. 4b-d) : segmental formula 6,6,6 (including coxae). Measurements and setation as given in tables 1 and 2. All legs bear two falciform claws, with a trifurcate tip. Leg III additionally with a thin, terminal empodium.

![Table 1: Centrotrombidium schneideri Kramer, 1896, Valgothrombium major (Halbert) 1920, larvae. Lengths of legs (μm).](image)

![Table 2: Valgothrombium major (Halbert) 1920, Centrotrombidium schneideri Kramer, 1896, larvae. Setation of legs. Abbreviations: E = eupathidium; F = famulus; N = normal seta; P = pretarsal seta; S = solenidium; S2 = club-shaped solenidium; ST = subterminal seta; FT = pretarsal seta; V = vestigialum.](image)
FIG. 3: *Valgothrombium major* (Halbert) 1920, larva.
a — Dorsal aspect. b — Ventral aspect. Palps omitted beyond femur, legs omitted beyond coxa.
FIG. 4: *Valgothrombium major* (Halbert) 1920, larva.
a — Tibia (left) and tarsus of palp; ventral aspect. b — Leg I. c — Leg II. d — Leg III. All legs in dorsal (above) and ventral (below) aspect, coxae not drawn. Lower scale refers to b-d.
2. Phenology

Adults of *Centrotrombidium schneideri* (Johnstonianidae) were found during June 1992 on the surface of the litter layer within the reed belt located close to the shore of lake “Wittensee”. Characteristic for this habitat was a high air humidity level of 100% rh and a wet substrate. An adult was found parasitized by a larva of *Johnstoniana parva* Wendt 1994. Adults of *Valgothrombium major* (Microthrombidiidae) were captured during August/September 1991 and June 1992 in the same biotope. They were found to be active on the substrate and sometimes preyed on small nematocerous larvae. It was observed that several individuals often preyed on the same insect larva. Furthermore, adults were also found at the bottom of a partially dried-up ditch in Bremen (Northern Germany) in June 1992. Only a single deutonymph was found in July 1991 at lake “Wittensee”. Tritonymphs were found in June 1992 at this location. Unfed larvae and protonymphs were also found from late June to early July 1992 at the bottom of the above mentioned ditch.

3. Laboratory observations

a) *Centrotrombidium schneideri*

With an average adult body weight of 0.15 mg (n = 10), *C. schneideri* is one of the smaller johnstonianid species. Adults were observed to feed exclusively on small larvae of Chironomidae and Ceratopogonidae. Larvae of *Drosophila* sp., other insects and oligochaets were never accepted. When searching for food, the adults displayed a very special form of behaviour: using the tarsi of leg I, they firmly poked all over the ground, especially inside fissures and cavities of the substrate. Using their palps, pieces of substrate were turned over to expose any prey hidden underneath. Ceratopogonid larvae were pierced by the mites with their chelicerae and the body contents sucked out. They behaved aggressively towards conspecifics disturbing them during their search for prey and drove them away by striking them with legs I. Adults consumed one ceratopogonid larva every 1-2 days. When kept for two or more days without food, they sometimes preyed on conspecifics and even spermatothores were sucked dry. However, eggs were never eaten.

The adults were mainly active on the surface and only occasionally did they enter cavities and fissures of the substrate. No burrowing was observed. Adults moving through narrowing cavities were observed to press their bodies outwards by means of peristaltic body motions, with the backwardly-arranged body setae also assisting the forward movement of the body. The adults preferred humidity levels of 100% rh (Fig. 5) and had an average osmotic haemolymph concentration of 206 ± 5.6 mosm/kg, with no significant differences between the sexes being observed (females 209 ± 3.4 mosm/kg (n = 5), males 200 ± 3.5 mosm/kg (n = 2)). Immediately after capture, males deposited spermatothores on the ground. The same day the first females were observed to lay eggs. Eggs were deposited individually beneath the mould-surface and were observed to be reddish-brown in colour with a diameter of 140 μm. All females died within 14 days after terminating their oviposition (by which time all males had already died). The larvae hatched 12-13 days after egg deposition. They explored the surface of the substrate using their palps and were observed to carefully examine cavities and fissures on the substrate. They displayed negative phototactic responses. When kept in boxes filled with mould taken from their habitat they were observed to sometimes enter cavities and fissures of the substrate. However, active burrowing was not observed. If no adequate hosts were available, the larvae survived for 7-9 days. No aggressive behaviour between larvae was observed.

In parasitism experiments, imagines of *Limonia phragmitides* Schrank (Tipulidae), *Drosophila* sp. (Brachycera), *Culicoides* sp. (Ceratopogonidae), *V. major* (adult) and *C. schneideri* (adult) as well as larvae and pupae of *Drosophila* sp. and an undetermined chironomid species were never recognized as hosts and never parasitized, though contact between larvae of *C. schneideri* and the potential hosts took place from time to time. However, when the pupae and larvae of *Culicoides* sp. (Ceratopogonidae) were placed in the same rearing box, a
larva of *C. schneideri*, upon making contact with a ceratopogonid pupa, would climb onto it, examine it with its palps and thereafter remain motionless on the body (preferring the head region of the pupa). Only when disturbed (e.g. touched by other larvae) did they again become active. They then either (1) soon resumed their previous state of motionlessness elsewhere on the pupa or (2) abandoned their host and searched for a new one. Resting on the pupae, the mite-larvae survived up to 23 days. They never started their parasitic phase when on the pupae (n = 30). In three cases, larvae of *Culicoides* sp. (Ceratopogonidae) were accepted as resting places and only in two cases were empty exuviae of ceratopogonid pupae selected. When the ceratopogonid imago emerged, the waiting larvae of *C. schneideri* climbed onto it and started their parasitic phase. Imagines of *Culicoides* sp. were chosen only during this phase and never during a later contact with searching larvae of *C. schneideri*. The average parasitic load per host was found to be 4 larvae (maximum 13, n = 26 hosts). Obviously the number of larvae per host was dependent on the number of available ceratopogonid pupae in the rearing box. In all cases, the larvae attached themselves to the thorax of the imaginal hosts. The lateral regions were preferred (n = 67); the dorsal (n = 28) and the ventral (n = 12) sites being less often chosen. In one case, a host was found to be parasitized by 13 larvae of *C. schneideri* and additionally by 2 larvae of *V. major*. In the event of host death, all larvae left shortly thereafter. Two days on the host was not enough time for the larvae to reach the protonymphal stage so that the partially engorged larvae restarted their search for a new host pupa. On average, the parasitic phase lasted 4 days (3-5, n = 52) at 20°C. After 5 days all larvae were observed to be fully engorged and, in due course, left their hosts. Only occasionally did the hosts die (maybe as a result of rearing conditions) — usually they survived parasitism (even one *Culicoides* sp. parasitized by 15 larvae). Other
effects in the host (e.g. fertility or longevity) were not checked. Immediately after leaving the host, the engorged larvae sought refuge in cavities. Within 24 hours they started the calyptostatic protonymphal phase \((n = 47)\). After two days the deutonymph was visible inside the protonymphal instar. On average, the protonymphal stage lasted 4 days \((3-6, n = 39)\). The deutonymph required only 2-4 minutes time to leave the protonymphal exuvia, with the gnathosoma and the legs I first being visible. Lastly, the remaining legs were brought out, followed by the rest of the idiosoma, which was pressed out by means of peristaltic body movements. The deutonymphs avoided light and at most times hid in cavities. Some started to feed on ceratopogonid larvae and behaved in a similar way to that described for the adults. However, all deutonymphs died within 29 days.

b) *Valgothrombium major*

*V. major* belongs to the smaller Microthrombidiidae and has an average adult body weight of 0.1 mg \((n = 9)\). The modes of feeding of deutonymphs and adults were found to be similar to those of *C. schneideri*. When kept in groups of 10 individuals for 7 days without food supply, they displayed the same searching behaviour, while no cannibalism or aggression towards conspecifics was observed. Sometimes, under conditions of starvation, spermatophores were sucked dry. The adults preferred a humidity level of 100 % rh \((\text{Fig. 5})\) and females had an osmotic haemolymph concentration of 233 ± 6.1 mosm/kg.

In June, soon after capture, the females started laying eggs while the males deposited spermatophores at the same time. The eggs were deposited in clusters of 27-43 eggs \((\text{mean 32, } n = 14)\). On substrates from the field, egg-clusters were deposited within cavities and fissures just beneath the surface. The highest number of eggs deposited by a single female was 145 \((\text{in four clusters})\). The eggs were spherical, reddish, with a diameter of 125 µm. In one instance a female died during the oviposition period. When clearing and mounting it a few days thereafter, hatched larvae were found inside her body. However, no vivipary was observed to have taken place in the laboratory. All adults died within 23 days after terminating reproduction \((\text{the females usually later than the males})\). At 20°C, larvae hatched 8-11 days \((\text{mean 9, } n = 9 \text{ clusters})\) after egg-deposition. The larvae displayed no phototactic orientation. Without hosts, the larvae survived up to 8 days. The same types of potential hosts as described for *C. schneideri* were offered to the larvae and, once again, only the pupae of *Culicoides* sp. were recognized. The larvae of *V. major* remained with the host, as described for *C. schneideri*. When the host emerged to the imaginal instar, parasitism took place. Later contact between imaginal hosts and unfed larvae of *V. major* never led to parasitism. In the laboratory, imagines of *Culicoides* sp. were parasitized by 1-3 larvae of *V. major* \((n = 4)\) which attached themselves ventrally on the thorax between the coxae of their hosts. The parasitic phase lasted 4 days \((n = 2)\) and, within 24 hours after leaving the host, the larvae started the calyptostatic protonymph within cavities in the ground. This lasted for 5 days \((n = 1)\) at 20°C. A deutonymph found at lake "Wittensee" in July reached the calyptostatic tritonymph \((\text{which lasted for 8 days at 20°C})\) one day after capture.

**DISCUSSION**

1. Taxonomy

For Europe, two species of *Centrotrombidium* have, to date, been described in the adult instar only (*C. schneideri, C. motasi* Feider 1945) and two further species have been described as larvae only (*C. culicoides* Vercammen-Grandjean 1957, *C. romaniensis* Vercammen-Grandjean & Feider 1973). *C. distans* Newell 1957 \((\text{from California})\) is the only species described in the larval and adult instar, though without correlation by laboratory rearing. Adults of the species found at lake "Wittensee" were identified as *C. schneideri* according to Thor & Willmann (1941). Its larva is different to those of *C. culicoides* and *C. romaniensis* in that it possesses only one seta on the palp femur. It can be distinguished from all known species by its divided setae, situated on both coxae II and III.

Adults of *Valgothrombium* could be identified as *V. major* according to Thor & Willmann (1941).
and SCHWEIZER & BADER (1963). No larval instars of this genus have, so far, been described.

2. Habitat

The postlarval instars of both species prefer concealed places within their habitats. All species of Centrotrombidium and Valgothrombium seem to inhabit wet biotopes (THOR & WILLMANN, 1941, SCHWEIZER, 1951, NEWELL, 1957, VERCAMMEN-GRANDJEAN, 1957, VERCAMMEN-GRANDJEAN & COCHRANE, 1974), especially the borders of limnic waters. The few published data and our results obtained for C. schneideri are consistent. The assumption that V. major and C. schneideri are restricted to wet biotopes is supported by the following facts:

a) Failure to find any populations of these species in more xeric biotopes.

b) Their preference for high levels of aerial humidities as observed in the laboratory. The same has been reported for some Johnstoniana species inhabiting the same type of biotope. These species also have low drought resistances (WENDT, in press).

c) The comparatively low haemolymph concentration regulation level, peculiar to both species, is known to be characteristic for species restricted to extreme hygric conditions. This feature must have evolved at least thrice convergently within the Parasitengonae: the stem line of the Hydrachnidia (OLOMSKI, 1991), the Johnstonianidae (WENDT, in press) and V. major. Other Parasitengonae, as well as species of the probable sister group of the Parasitengonae within the anystoid stock (LINDQUIST, 1976, WITTE, 1991) inhabiting true terrestrial habitats, have higher haemolymph concentrations (300-400 mosm/kg; OLOMSKI, 1991, WENDT, 1991).

3. Life history

Both species under investigation have comparatively short development times — particularly concerning the calyptostatic instars (ROBAUX, 1971, WENDT et al., 1994, WOHLTMANN et al., 1994, EGGERS, in press, WOHLTMANN, in press). This rather rapid development could mean that both species pass through more than one generation per year. However, studies of the habitats of both species over a period of two years yielded nothing to suggest the occurrence of more than one generation per year. We therefore assume univoltine life cycles for both species.

4. Oviposition

The mode of egg deposition is different in each case. The laying of eggs in clusters, as in V. major, is typical for most Parasitengonae (SOKOLOW, 1924, 1925, ROBAUX, 1971, THEIS, 1974, WOHLTMANN, in press), whereas the mode of laying single eggs (as in C. schneideri) is only known to occur in trombiculid and johnstonianid species (EVERETT et al., 1973, EGGERS, in press, WENDT et al., 1994, WOHLTMANN et al., 1994) and a water mite genus depositing eggs inside plants (Hydrachna spp., BÖTTGER, 1972a, DAVIDS, 1973). The mode of laying eggs in clusters is probably the plesiomorphic state for the Parasitengonae, while laying them individually represents the apomorphic state and may well be a good tactic for a wider distribution of the larvae. Furthermore, it may serve as a protection against egg predators (EGGERS, in press). The discovery of hatched larvae inside the body of a dead female of V. major is, in all probability, not the result of ovovivipary. A more likely explanation is that the hatching inside of the body is exceptional, due to the accidental death of the female. However, this clearly shows that insemination of the eggs takes place within the ovary.

5. Parasitism

The larvae of parasitengon mites use a wide range of hosts (WELBOURN, 1983). Most terrestrial species inhabiting wet biotopes as well as many water mites use Nematocera as hosts (SMITH & OLIVER, 1976, WELBOURN, 1983, WOHLTMANN et al., 1994). Like most Nematocera, Ceratopogonidae appear to be restricted to the same type of biotope. In this way, they serve to reduce the risk of the parasitizing mite being dispersed into unsuitable biotopes (i.e. with temporarily or perpetually dry
conditions), while still allowing for the option of colonizing new localities via flying hosts.

Not much information is available on host recognition for terrestrial Parasitengonae. In most cases, only those host instars which are parasitized are recognized by the mite-larvae (ROBAUX, 1971, WENDT et al., 1992, WENDT et al., 1994, WOHLTMANN, in press). Furthermore, larvae of species which recognize the imagines of those flying insects they use as hosts often display positive phototactic orientation before starting the parasitic phase (ROBAUX, 1971 for Allothrombium spp., Trombi­dium spp.). Larvae of C. schneideri and V. major display no positive phototactic behaviour, but instead search for their hosts on the ground and only recognize the pupal instars of these hosts. However, parasitism is restricted to the imaginal host instar. This special manner of host recognition was hitherto unknown for terrestrial Parasitengonae but known for some later-derived Hydrachnidia (BÖTTGER, 1972b, SMITH & OLIVER, 1976, 1986), which also recognize the imagines of Chironomidae and other parasitengone mites parasitizing short-lived insect instars such as imagines of Ceratopogonidae and other Nematocera.

The data on parasitism reveals that a host specificity for at least the Ceratopogonidae exists while the food of the deutonymphs and adults may include a broader range of dipteran larvae (probably depending on the prey-size). Nevertheless, it is remarkable that the postlarval instars prey (at least partially) on the same insects that the larvae use as hosts. Similar results have been reported for some other species of parasitengone mites (Tab. 3). Concerning the potential use of the species investigated as agents of biological control, the larvae usually did not kill their hosts. However, it was observed that water mites had a significant influence on their insect hosts in that they reduce longevity and fecundity (LANCIANI, 1983, 1986). The impact on the host population through predation of the postlarval instars is probably of greater significance. This is known to be the case for Balastium murorum (Hermann) 1804 (Parasitengonae), which is the main egg predator of Zeiraphera diniana Guenee (Lepidoptera : Tortricidae) (DELUCCHI et al., 1975) in the field.

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<tr>
<td>Limnesia maculata</td>
<td>Among others, eggs of Chironomidae (BÖTTGER, 1972)</td>
<td>Imagines of Chironomidae (BÖTTGER, 1972)</td>
</tr>
<tr>
<td>Johnstoniana rapax</td>
<td>Larvae of Diptera and other insects (EGGERS, in press)</td>
<td>Larvae of Diptera (EGGERS, in press)</td>
</tr>
<tr>
<td>Johnstoniana tuberculata</td>
<td>Larvae of Diptera and other insects (WOHLTMANN et al., 1994)</td>
<td>Imagines of Limonia spp. (WOHLTMANN et al., 1994)</td>
</tr>
<tr>
<td>Centrotrombium schneideri</td>
<td>Larvae of Ceratopogonidae and Chironomidae (New)</td>
<td>Imagines of Ceratopogonidae (New)</td>
</tr>
<tr>
<td>Valgotherombinus major</td>
<td>Larvae of Ceratopogonidae and Chironomidae (New)</td>
<td>Imagines of Ceratopogonidae (New)</td>
</tr>
<tr>
<td>Estrombium locustarum</td>
<td>Eggs of Aecididae (HUGGENS &amp; BLICKENSTAFF, 1966)</td>
<td>Nymphs and adults of Aecidiae (HUGGENS &amp; BLICKENSTAFF, 1966)</td>
</tr>
<tr>
<td>Allothrombium fuliginosum</td>
<td>Among others, Aphidae (ROBAUX, 1971)</td>
<td>Aphidae (ROBAUX, 1971)</td>
</tr>
<tr>
<td>Calyptostoma velatusius</td>
<td>Larvae of Tipulidae and other Diptera (THIER, 1974)</td>
<td>Imagines of Tipulidae (THIER, 1974)</td>
</tr>
<tr>
<td>Leptus trimaculatus</td>
<td>Larvae of Diptera (WINDT et al., 1992)</td>
<td>Among others, imagines of Diptera (WINDT et al., 1992)</td>
</tr>
<tr>
<td>Caliédosoma metzi</td>
<td>Eggs of Lepidoptera (SHARMA et al., 1983)</td>
<td>Imagines of Geometridae (SHARMA et al., 1983)</td>
</tr>
</tbody>
</table>

Table 3: Hosts of larvae/prey of adults — similarities in the Parasitengonae.

The special pre-parasitic behaviour of the larvae ensures host recognition at a time when the host is able to survive the period needed for food uptake throughout the parasitic phase. This, at very least, is advantageous for Centrotrombium, Valgotherom­bium and other parasitengone mites parasitizing short-lived insect instars such as imagines of Cer­atopogonidae and other Nematocera.

Concerning the potential use of the species investigated as agents of biological control, the larvae usually did not kill their hosts. However, it was observed that water mites had a significant influence on their insect hosts in that they reduce longevity and fecundity (LANCIANI, 1983, 1986). The impact on the host population through predation of the postlarval instars is probably of greater significance. This is known to be the case for Balastium murorum (Hermann) 1804 (Parasitengonae), which is the main egg predator of Zeiraphera diniana Guenee (Lepidoptera : Tortricidae) (DELUCCHI et al., 1975) in the field.
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