Biological Studies of *Typhlodromips sessor* (Acarina: Phytoseiidae)[1]

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ABSTRACT

Typhlodromips sessor DeLeon, reared upon *Tetranychus urticae* Koch at 25°C and 90% RH, showed an average duration of 61.5, 53.0, 42.0, 25.5, and 56.0 h for the egg, larval, protonymphal, deutonymphal and preoviposition stages, respectively. Higher temperatures produced more rapid development; at 90% RH the temperature variables of 20°, 25°, and 30°C led to average egg-to-adult developmental times of 146, 184, and 272 h, respectively. The mites were susceptible to desiccation and none developed to maturity at 64% RH and very few at 75% RH.

T. sessor was able to utilize a variety of foods of plant and animal sources. Reproductive rates of mites fed *T. urticae, Aculus schlechtendali* Nalepa, *Thrips tabaci* Lindeman, *Haplothrips subtilissimus* Haliday, pollen from *Cirsium vulgare*, or a tarsonemid mite averaged 0.79, 0.70, 0.51, 0.23, 0.15 and 0.13 eggs/female/day, respectively. In comparison with most other phytoseiids studied, the developmental time of this species was longer and the reproductive rate lower. However, such differences might be rendered less important by its adaptation of parthenogenicity.

Typhlodromips sessor DeLeon was established in our surveys as the numerically dominant phytoseiid in early successional communities within the piedmont area of New Jersey. Horsburgh and Asquith (1968) reported *T. sessor* to be a predator of *Panonychus ulmi* Koch in south-central Pennsylvania. Poe and Enns (1969) list it as a litter-inhabitant in Missouri apple orchards. Since several species of the Phytoseiidae are economically important as biological control agents in agriculture, we made the biology of *T. sessor* the object of a field and laboratory study. The present paper concerns its life history, the influence of temperature and relative humidity on its development, and the interaction of the species with certain aspects of its biological environment, namely, food and predators.

MATERIALS AND METHODS

Stock Cultures.—We reared *T. sessor* in the tops of 35×10 mm plastic petri dishes circumscribed at the rim with Stikem Special (Michel and Pelton Co., Emeryville, Calif.) to prevent escape of the mites. These petri dish tops were cemented, bottom down, to the bottoms of 100×15 mm petri dishes to form double-chambered containers, allowing the introduction of humidity-controlling solutions. We supplied prey as needed by brushing twospotted spider mites, *Tetranychus urticae* Koch, from infested lima bean leaves into the center chamber. The chambers were held in constant-temperature incubators at 25±1°C and 16L:8D.

Test Methods.—We used petri dish chambers to study effects of temperature and humidity upon total developmental time of *T. sessor.* We maintained temperatures of 20±1°C, 25±1°C, and 30±1°C, in separate incubators; and we provided constant relative humidities with saturated solutions of the following salts: $NaNO_2$, 64%; NaCl, 75%; BaCl, 90%; and K_2SO_4, 97%.

A leaf disc method was employed in some studies of food habits or natural enemies of *T. sessor.* Since this phytoseiid was frequently collected in sizeable numbers from rough-stemmed goldenrod, *Solidago rugosa,* we felt that leaves from this plant provided a suitable microhabitat. Leaf discs of 18 mm diam were cut from *Solidago rugosa* and placed, ventral side up, on water-soaked paper toweling in the bottoms of 100×15 mm plastic petri dishes. Water was added periodically to prevent migration and provide high humidity.

In the life history and ovipositional rate study, we used 175×7.5×0.6 cm Plexiglas® plates, containing 20 depression cells. The dimensions of the cell were 20 mm diam and 6 mm deep with the opening encircled by Stikem Special. Temperature and humidity were held constant at 25±1°C and 90% RH, respectively.

In the developmental study, 40 freshly deposited eggs of *T. sessor* were removed from stock cultures with a fine dental probe and transferred to individual cells. Development was recorded at 3-h intervals or less. Prey (all stages of *T. urticae*) were supplied as needed to provide an excess of food at all times. Also, for this aspect of the study measurements were taken of stock specimens of *T. sessor,* mounted at various stages of development.

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RESULTS AND DISCUSSION

T. sessor is parthenogenic, which eliminates the need for mating and separate sex studies. The durations (in hours) of the developmental stages were as follows [mean ± standard deviation (range)]:

Stage	N	% Mortality	Duration
egg	40	10	61.5±0.89 (53–72)
larva	36	42	53.0±1.12 (46–63)
protonymph	21	33	42.0±1.20 (36–47)
deutonymph	14	0	25.5±1.03 (21–32)
preoviposition	14	0	56.0±1.85 (38–62)
Totals	14	35	236.7±3.62 (211–262)

Eggs were laid singly, and adhered to the sides of the petri dish or in the webbing formed by the prey. They became more elliptical as they aged, and they changed from colorless and translucent to off-white and crystalline, owing to embryological development. Ninety percent of the eggs were viable. Failure to hatch could be attributed largely to injury incurred during transfer. The eggs averaged 156 μ long and 104 μ wide.

Larvae of *T. sessor* began to emerge by thrusting their first pair of legs through a split in the eggs' shell. Gradually, with the use of the other legs, the larvae pried themselves from their shells within an hour. Upon emergence, the 6-legged larvae were colorless, fragile, and sluggish. Over half of these larvae did not feed upon tetranychids and died, suggesting that this prey was not entirely suitable. The remaining larvae fed mostly upon larval tetranychids and then turned orangish in color. The average length of the dorsal shield of 10 well-fed larvae was 182 μ and the width, 117 μ. After a short period of quiescence molting occurred.

Some larvae that had not fed developed to the protonymph stage but soon died. Protonymphs fed readily on 2-spotted mite larvae, but had difficulty with the other stages. Some mortality occurred. After feeding, a noticeable change in shape was seen from an "8-legged" larva type to a "small adult" type. The dorsal shields of 10 well-fed protonymphs had an average length of 221 μ and width of 130 μ. A rapid ecdysis to the next stage occurred.

The deutonymph was more vigorous than the previous larval states and fed largely upon prey larvae and early instar nymphs. Prey eggs and adults were infrequently attacked, never with success. Activity increased during this stage. Average length of the dorsal shields of 10 well-fed deutonymphs was 300 μ and width, 168 μ. Mortality did not occur at this stage and a rapid ecdysis occurred.

From egg to adult, the average developmental time was 182 h or ca. 7.5 days. All adults were females. These mites developed a wide, rounded posterior when gravid. The mean length of the dorsal shields of 10 gravid mites was 344 μ, and width, 213 μ. All stages of prey were probed by the predator, but feeding attempts were rarely successful upon eggs or female adults. These adult predators turned a reddish orange after feeding. The preovipositional period averaged 56 h and ranged 38–62. The total mortality of *T. sessor* through its development to this stage was 35%. The preoviposition period was followed by egg-laying and established an average egg-to-egg cycle of 236.7 h, or ca. 10 days. During the 1st 5 days of oviposition the daily ovipositional rate was 0.8 eggs/female/day, after which it dwindled to only an occasional egg laid at intervals of several days.

Influence of Temperature and Humidity on Developmental Time.—We transferred 5 recently-deposited eggs to a petri-dish test chamber, and recorded the development of the mites. Six replicates of 5 eggs each were used for each combination of temperature and relative humidity. Table 1 presents the results of an analysis of variance in relation to temperature and humidity variables as well as provides the total mortality incurred at the various treatments.

Relative humidities of 64% and 75% were inadequate for proper development of *T. sessor* at the three temperatures tested. At these levels, almost complete mortality of the eggs occurred through desiccation. The few mites that survived the 75% RH at 25°C had the longest developmental time of all treatments. This response presents an obvious physical limit in determining distribution. Humidities of 90% and 97% were adequate for development at all 3 temperatures.

The average length of the life cycle at 30°C was almost one-half that found at 20°C. Mortality during development was lowest at 25°C. At the highest temperature, increased activity of the mites caused some entrapment in the sticky barrier, thus artificially increasing larval mortality at this temperature. At 20°C the mites were lethargic and failed to pursue and capture prey, many dying because they could not function effectively at this temperature.

Table 2.—Influence of temperature and humidity on the egg to adult developmental time and mortality of *T. sessor*.

Temperature °C	RH	Total % mortality	Average development time in hours	Range (hours)
30	97	26.6	148.0 a	136–160
30	90	33.3	146.0 a	136–168
30	75	100.0	—	—
30	64	100.0	—	—
25	97	20.0	181.3 b	160–192
25	90	16.6	184.0 b	168–200
25	75	66.6	280.0 c	248–312
25	64	100.0	—	—
20	97	33.3	262.0 c	232–296
20	90	43.3	272.0 c	248–296
20	75	100.0	—	—
20	64	100.0	—	—

[a] Means followed by the same letter(s) are not significantly different at the 1% level of probability according to LSD test.

Suitability of Food Sources.—We studied the ability of *T. sessor* to feed and reproduce on various animal and non-animal foods. All studies were 5 days in duration. We investigated non-animal foods sources separately by introducing potentially nutritive materials into 35×10 mm petri dishes, each containing one 10-day old starved mite. Plant species were selected from among those likely to be available to *T. sessor* in the field. Feeding observations were noted and daily oviposition recorded. These tests included rainwater, plant juices from mascerated leaves, leaves and pollen of *Solidago rugosa, S. graminifolia, Convolvulus arvensis, Solanum carolinense*, and *Cirsium vulgare*, and pollen of *Solidago juncea* and *Linaria vulgaris*. All leaves were washed thoroughly and oozing cuts were sealed with Stickem Special. We field-collected animal food sources and transferred them to floating leaves for the 5-day studies. The animal foods that were evaluated included the mites *T. urticae (Tetranychidae), Amblyseius fallacis* (Phytoseiidae), a tarsonemid mite collected from *C. vulgare,* and *Aculus schlechtendali* Nalepa (Eriophyidae), as well as all stages of *Thrips tabaci* Lindeman and *Haplothrips subtilissimus* Haliday, aphids and their honeydew collected from *C. vulgare* and *Asclepias syriaca,* syrphid larvae, and foliage-inhabiting nematodes.

Direct observation, gut coloration, or increase in body size showed that *T. sessor* fed upon rainwater, all plant juices and plant leaves, pollen of *C. arvensis* and *S. rugosa,* larvae *of A. fallacis,* nematodes, newly-born aphids, and small syrphid larvae. No oviposition occurred upon these food sources, although they may be valuable in maintaining natural populations during periods of food scarcity. Recently, Porres et al. (1975) reported that *Amblyseius hibisci* Chant could extract sap from intact avocado leaves and that plant juices may provide nourishment and/or moisture for this phytoseiid species.

The results of all food sources that led to oviposition are summarized in Table 2. Low ovipositional rates of 0.13, 0.15, and 0.23 eggs/female/day were obtained with tarsonemid mites, pollen of *C. vulgare,* and all stages of *H. subtilissimus,* respectively. Of particular interest was the ability of this phytoseiid to puncture pollen grains and ingest the germ cell contents. The predator evacuated as many as 16 grains in 5 min, after which these grains were either lighter in color or collapsed. The use of pollen as an alternate food source has been noted for some phytoseiids (McMurtry and Scriven 1964, Knisley and Swift 1971).

Higher oviposition rates of 0.51, 0.70, and 0.79 eggs/female/day were obtained upon all stages of the preys *Thrips tabaci, A. schlechtendali,* and *T. urticae,* respectively. *T. sessor* readily attacked and fed along the abdomen of the thrips, preferring smaller individuals. Few cases of phytoseiids feeding and reproducing upon thrips as prey have been reported (MacGill 1939, Swirski et al. 1970). All stages of the eriophyid mite were attacked, but the largest ones were the easiest to capture in the pubescent micro-habitat of the leaf surface. As many as 13 prey were consumed within 5 min by the predator. The predator also showed marked feeding preferences when given all stages of the twospotted spider mite. The preference breakdown for all stages of *T. urticae* was as follows: eggs—0.4%, larvae—73%, nymphs and males—25.5%, and adult females—1.1%. Numerous attempts made to penetrate the eggs of the prey were almost always unsuccessful. The larvae were highly preferred as prey since they were observed to be more easily subdued and consumed. Nymphs and males were frequently consumed but often succeeded in evading the predator. Female adults were infrequently consumed as the predator had difficulty in attacking or penetrating this prey. The female adults that were successfuly consumed may have been individuals weakened through age or injury. The oviposition rate on *T. urticae* was 0.79 eggs/day over 4 days of egg laying, which was a lower rate upon this prey than that of other phytoseiids studied (McMurtry et al. 1970).

T. sessor can be considered a facultative predator or general feeder, since it can consume not only small animals, but also products of plant and animal origin. Huffaker et al. (1969) discussed the divergence of the Phytoseiidae into specialized and generalized feeding strategies. Apparently, *T. sessor* has evolved along the line of polyphagy. This foraging strategy seems to be associated with a low biotic potential in this species, relative to some other members of the family, as evidenced by the relatively low fecundity and slow developmental rate found in this study. In the field, this low biotic potential is partially offset by the uniparental nature of this phytoseiid.

Table 2.—Ovipositional rates of *T. sessor* utilizing various food sources.

Food source	Rearing chamber	No. obs.	% mortality	Eggs/♀/day
T. urticae	petri dish	43	25.6	0.79
A. schlechtendali	petri dish	16	25.0	0.70
Thrips tabaci	petri dish	15	20.0	0.51
Haplothrips subtilissimus	petri dish	15	60.0*	0.23
Cirsium vulgare pollen	leaf disc	10	0.0	0.15
Tarsonemidae	petri dish	5	60.0	0.13

* Partially due to predation by *H. subtilissimus.*

Natural Enemies.—The procedure for collecting and testing possible natural enemies of *T. sessor* was similar to that of the tests for animal food sources. The following results only include positive tests in this area.

In the animal-feeding study we noted that *H. subtilissimus* could prey upon *T. sessor,* and vice versa. Competition studies were set up between these mutual predators by placing 6 wingless adult thrips on a leaf of *S. rugosa* with 6 adults of the mite. Eight leaves distributed among 3 petri dishes were checked daily through 3 days of this confrontation. Each species attacked the abdomen of the other and many attacks were unsuccessful. A defense mechanism of the thrips was to vigorously shake its abdomen, which often circumvented the attack. *T. sessor* would escape attack by immediately reacting to the probing mouthparts of the thrips and fleeing successfully because of its greater speed. Occasionally, either species fell prey. Over the 3 days confinement, 44% of the thrips' and 33% mites' mortalities were attributed to predation by the other.

The other natural enemy was an *Orius* sp. (Anthocoridae). We placed two of these predators on each of 5 leaves of *S. rugosa* that bore 15 adults of *T. sessor,* and we observed them for 3 days. To determine if this predation was specific, we placed 8 adults each of *T. sessor* and *T. urticae* with 3 anthocorids on a leaf of *S. rugosa;* four such leaves were placed in petri dishes. It was difficult to keep these higher-level and larger-sized predators confined upon the leaves due to their high mobility. Nonetheless, these bugs rapidly consumed any mite encountered. Once impaled on the elongated, piercing mouthparts of the predator, escape by the mite was virtually impossible. Where *T. sessor* was offered alone, mortality of 41 adults of the mites, or 55%, was attributable to predation. In the mixed prey test, this bug consumed any mite it randomly searched out; since the phytophagous mites were slower and bulkier, they were subject to more frequent attack.

Autopredation was another cause of mortality in *T. sessor* and was checked through observation of the laboratory colonies. Autopredation occurred even in the presence of ample tetranychid prey, although the rate was higher when the relative prey supply was limited. Apparently, the principal cannibalistic stage is the adult; 62.9% of all feedings were by adult mites. The 2 nymphal stages contributed a total of 31.4% of all feedings. Larvae were rarely cannibalistic, but were often the prey; 67.9% of all feedings were on the larvae. By comparison, 25.0% of the feedings were on protonymphs, and none on deutonymphs or eggs. Adults were preyed upon occasionally, probably because of old age, weakened condition, or injury. This cannibalistic trait, not reported as common in other phytoseiids, may be a density-dependent mechanism of population regulation.

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