Studies on Lasioseius scapulatus, a Mesostigmatid mite predaceous on nematodes

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Abstract: The life history and feeding habits of *Lasioseius scapulatus,* an ascid predator and potential biocontrol agent of nematodes, was examined. Reproduction was asexual, and the life cyc'e was 8–10 days at room temperature. Life history consisted of the egg, protonymph, deutonymph, and adult. Both nymphal stages and the adult captured and consumed nematodes. Two fungal genera and eight genera of nematodes were suitable food sources. Second-stage root-knot nematode juveniles were eaten, but eggs and adult females were not. The mite fed voraciously on nematodes and drastically reduced *Aphelenchus avenae* populations in vitro. It is suggested that mites are of considerable importance in the ecology of certain nematodes. *Key words:* Mesostigmata: Ascidae, biological control, predation, *Meloidogyne.*

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Although it is well known that nematodes are used as food by soil-inhabiting mites, little quantitative data has been published. Sharma (9) demonstrated the ability of the mite, *Lasioseius penicilliger,* to feed on and reduce numbers of *Tylenchorhynchus dubius* in soil. The feeding habits and food preferences of mites feeding on nematodes have been reported by others (1,6,7, 8). We quantitatively describe here the life history, feeding habits, and predacity of *Lasioseius scapulatus* Kennett on soil-inhabiting nematodes. A portion of the data has been published previously as an abstract (5).

MATERIALS AND METHODS

Origin, culture, and identification of mite: Potato dextrose agar petri dishes were inoculated with *Rhizoctonia solani;* 7 days later, *Aphelenchus avenae* were added to the dishes. Three weeks later, *L. scapulatus,* obtained from citrus grove soil by the method of Mankau (3), were added to the dishes. The cultures were maintained at room temperature and were transferred monthly. Dr. D. C. Coleman, Natural Resource Ecology Laboratory, Colorado State University, identified the mite.

Life cycle, reproduction, and feeding habits: One adult mite was placed on each of 10 *A. avenae/R. solani* cultures. The plates were sealed with plastic tape, held at room temperature (about 24 C) for 10 days, and examined daily for mite development and predatory activity. The sequence of development and reproduction was determined by placing a single egg on each of four *A. avenae* cultures. Development was monitored daily for 2 weeks thereafter.

Rate of egg production: One *L. scapu-*

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latus protonymph was added to each of nine replicate 3-week-old *A. avenae/R. solani* cultures. Eggs were counted daily and oviposition calculated as follows: Daily oviposition = total number of eggs + number of nymphs – number of eggs produced in the previous 24 hours.

Relationship of initial mite population to subsequent mite and nematode populations: Four initial mite inoculum levels (1, 2,4, and 10 adults) were added to five *A. avenae-R. solani* cultures, and mite numbers and stages were determined daily for 10 days. After the last observation, the agar was removed and the nematodes were extracted for 48 hours on a Baermann Funnel and counted. Cultures not inoculated with mites served as controls.

L. scapulatus and A. avenae population dynamics: Two adult *L. scapulatus* were placed on each of 50 *A. avenae-R. solani* cultures. Mite development was determined and the nematodes were extracted on Baermann Funnels from five inoculated and five control plates each day for 10 days. Fifty uninoculated cultures served as controls.

Food consumed: Eight genera of nematodes were examined for suitability as a food source. An aqueous suspension containing about 500 nematodes was pipetted onto each of five 3% water agar (WA) petri plates. Two adult mites were placed in each plate 24 hours later. The plates were observed daily for mite development and predation. Predation of *Meloidogyne incognita* adult females and eggs in egg masses was determined by placing small pieces of tomato root (< 2 cm long) containing the nematodes and eggs in situ on WA plates. Mites were added and examined for feeding and development.

Mites occurred in relatively large numbers on WA plates contaminated with fungi and bacteria. To determine if mites reproduce with only fungi and bacteria as a food source, the microorganisms were isolated in pure culture and tested for suitability as a food source. The fungi were grown on one-quarter strength cornmeal agar (Difco) and the bacteria on nutrient agar for a few days; five mites were added to each plate and feeding and development determined for about 7 days.

Relationship of nematode size to number consumed: Three different size nematodes were used to determine the relationship of nematode size to number consumed. *Diplenteron* sp. (1,500 × 32 μm) *A. avenae* (800 × 29 μm) and *Acrobeloides* sp (400 × 28 μm) suspensions containing approximately 500 individuals/ml were prepared and 0.1 ml. (≅ 50 nematodes) were added to ten 3% WA plates for each nematode; one adult mite was placed in each plate. Forty-eight hours later, the agar was removed and placed on a Baermann Funnel for 2 days; the numbers of extracted nematodes were determined.

RESULTS

Life cycle, reproduction, and feeding habits: Aphelenchus avenae-R. solani PDA medium is suitable for culture of L. scapulatus. The mite moved about the surface of the agar and climbed aerial hypal strands. The anterior pair of legs are held up and forward and apparently used as tactile sensors. When a nematode is found, it is quickly captured with the chelicera and ingested. The process of capture and ingestion takes less than a minute, but the mite is usually motionless for several minutes thereafter. No cannibalism was observed, even in plates lacking suitable prey. When prey was exhausted the mites attempted to migrate from the plate but became trapped on the adhesive tape seal.

Movement of the mites was confined to the agar surface and *R. solani* aerial hyphae. They were never seen in the agar and when placed on a soft agar substrate (< 1.5 %) they became mired and died.

Life cycle stages differed in size, number of legs, and pigmentation. A six-legged protonymph hatched from 3-day-old eggs. About one day later, the protonymph molts to the eight-legged deutonymph which molts to the adult in approximately 24 hours. When young, the adult is unpigmented, but it becomes light brown in about 1 day. Oviposition begins approximately 1 day after the adult matures. Eggs were sometimes deposited on the surface of the agar but more frequently were placed in aerial fungal hyphae. The nymphs and adults use the anterior pair of legs to explore their surroundings and walk on the remaining legs. All of the motile stages captured and consumed nematodes. Since copulation was never observed, the mite ap-

parently reproduced asexually. Single eggs placed in *A. avenae* cultures matured, and the resulting adults produced eggs which hatched and completed development to gravid adults.

Rate of egg production: When daily egg production was determined for 6 days, the first eggs were produced within 1 day, then production increased to 4 or 5 eggs per day for the next 5 days (Table 1). Each adult has the ability to produce at least 23 progeny in 6 days and probably produces many more during its life span. Experimental design did not permit determination of the full reproductive potential, since at 7 days second generation mites were producing progeny.

Initial mite inoculum and subsequent population development: Initial inocula of 4 or 10 mites rapidly increased to a maximum number on the 8th day followed by a rapid decline (Fig. 1). Apparently as the number of mites increased, the nematode populations declined precipitously, and as the food was reduced, the mites migrated from the plates. Lower inoculum levels resulted in a more gradual increase in mite numbers, which had not peaked at 10 days (Fig. 1). The maximum number of mites observed was greatest with the higher initial population, but the maximum progeny per mite produced was much lower (Table 2). Where initial inoculum was 1 mite, the progeny produced per mite exceeded that of the 10-mite group by four times. The magnitude of the reductions in the numbers of nematodes in the cultures paralleled the initial mite populations (Table 2).

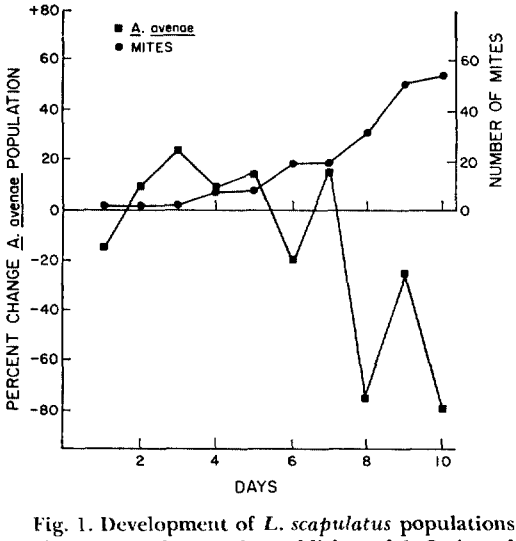

Fig. 1. Development of *L. scapulatus* populations on *A. avenae* cultures after addition of 1, 2, 4, and 10 mites.

Population dynamics of L. scapulatus and A. avenae: Changes in nematode populations appeared to be related to mite number and stage of development. During the first 3 days, the mites oviposited, eggs were developing, and nematode numbers increased (Fig. 2). For the following 2 days, the mite eggs began hatching and nematode numbers decreased, and as the numbers of predaceous stages increased, nematode populations declined precipitously. At the end of the experiment, nematode populations had been reduced in the plates containing mites to 22% of that in the control plates. There were reductions in both the juvenile and adult nematode counts, but the greatest reduction was in adults. Reductions were 76.8% and 95.1% for juveniles and adults, respectively. Many of the juveniles were second stage and may have hatched in the Baermann Funnel from eggs in the agar, suggesting that the actual reduction of vermiform stages may have been greater than the indicated 78%.

Food consumed by L. scapulatus: The mite consumed and completed its life cycle with all the nematodes tested as food sources (Table 3). When placed in WA plates with root-knot nematode infected tomato roots, the mite was observed feeding on second-stage juveniles as they

Table 1. Rate of egg production by *Lasioseius scapulatus*

	Day						
	0	1	2	3	4	5	6
Eggs/day*	0	1.4 ± 0.9	3.8 ± 2.1	5.9 ± 2.7	4.0 ± 1.5	4.2 ± 3.0	3.4 ± 3.3
Total	0	1.4	5.2	11.1	15.1	19.3	22.7

*Egg production by one adult mite on *Aphelenchus avenae* cultures. Mean of nine replications ± one SD.

Table 2. Effect of initial number of *Lasioseius scapulatus* adults on mite development and *Aphelenchus avenae* populations.

Initial no. *L. scapulatus*	Mite development: Maximum number mites observed*	Mite development: Days to peak population	Mite development: Number of progeny produced/mite†	Nematodes: Recovered‡	Nematodes: Percent reduction
0	0	0	0	26552 ± 7171 a	0
1	48.0 ± 7.4	10	80.0	7732 ± 3862 b	70.9
2	56.4 ± 46.3	10	44.6	4184 ± 1697 b	84.2
4	82.6 ± 39.8	8	29.5	181 ± 78 c	99.3
10	126.2 ± 55.7	8	17.3	568 ± 398 c	97.9

*Predaceous stages ± one SD (n = 5).
†Calculated as [maximum no. all stages – initial inoculum]/initial inoculum.
‡Number of *A. avenae* juveniles and adults ± one SD (n = 5). Number followed by different letters are significantly different using Duncan's multiple-range test ($P = .05$).

emerged from the eggs, but the eggs and mature female nematodes were apparently not consumed. Neither *Rhizoctonia solani* nor an unidentified bacterium were suitable as food for the mite, but *Cephalosporium* sp. and *Aspergillus* sp. were. The mite was observed foraging in the conidiophores, and when the mite was crushed on slides, the gut was observed to contain many conidia.

Relationship of nematode size to number consumed: Aphelenchus avenae and an *Acrobeloides* sp. appeared to be equally suitable prey in spite of the size difference (Table 4). However, *Diplenteron,* which is about twice the size of *Aphelenchus* and nearly four times as large, as *Acrobeloides,* was not consumed as readily. Mites were observed attempting to feed on the Diplogasterid, but when captured, the nematode would move violently and frequently escape. The other nematodes exhibited a similar behavior, but usually they could not extricate themselves. Predaceous Mesostigmata, of which *L. scapulatus* is a member, are fluid feeders. They grasp their prey

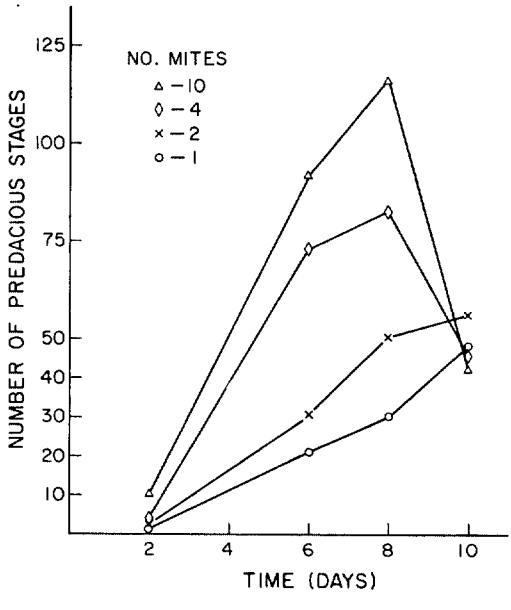

Fig. 2. Population dynamics of *Lasioseius scapulatus* (predacious stages) and *A. avenae* over 10-day period after addition of two mites.

Table 3. Suitability of various nematodes, fungi, and a bacterium as a food source for *Lasioseius scapulatus.*

Food source	Suitability*
Nematodes	
Aphelenchus avenae	+
Paraphlenchus sp.	+
Seinura sp.	+
Caenorhabditis sp.	+
Acrobeloides sp.	+
Diplenteron sp.	+
Mononchus sp.	+
Meloidogyne incognita	
2nd-stage juveniles	+
Adult ♀ ♀	–
Eggs	–
Fungi	
Rhizoctonia solani	–
Cephalosporium sp.	+
Aspergillus sp.	+
Bacterium	–

*Determined by observation of feeding and ability of mite to complete life cycle on food source.

Table 4. Predation efficiency of *Lasioseius scapulatus* on three nematodes.

Nematode	Size (μm)	Number of nematodes recovered/plate*		% consumed
		Control	Mite	
A. avenae	800 × 29	38.7 ± 13.3	3.7 ± 2.2	90.4
Acrobeloides sp.	400 × 28	146.3 ± 25.6	23.1 ± 55.7	84.2
Diplenteron sp.	1500 × 32	55.1 ± 2.5	27.2 ± 13.9	52.5

*Mean of 10 replications ± one SD; initial population was approximately 50/plate.

with the chelicerae and move it towards the gnathosoma where it is punctured by the malae externae (2). It appears, therefore, that prey suitability is partially determined by how well the mite can grasp it; i.e., the size of the prey.

DISCUSSION

Consideration of the biological characteristics of *L. scapulatus* may clarify its potential as a biological control agent. The relatively short life cycle and parthenogenic reproduction allowed the mite population to increase as prey increased, with a lag period of only a few days. This, with the mite's voracious feeding habit and other biological traits, indicate the mite could be useful in the biocontrol of nematode populations. The mite exhibits characteristic density-dependent traits of an effective and somewhat specific predator. The ability of the mite to utilize alternative food sources (fungi) in the absence of nematodes is another advantageous characteristic, as are its relatively great mobility and spatial range. However, its omnivorous nature may also dimish the mite's potential as a biocontrol agent. Because of its nonselective feeding on nematodes, the mite would probably not specifically target phytoparasites as prey. The spatial distribution of the mite also may not coincide with that of many plant-parasitic nematodes. Whereas phytoparasitic nematodes are usually found throughout the root zone of hosts, mites are primarily localized in the uppermost portion of the soil profile and in litter (4). However, the citrus nematode, which occurs in prodigious numbers near the surface feeder roots and is an ideal size, may be vulnerable to the mite.

It is generally accepted that the most effective biological control agents are those that do not initially cohabit with the target organism. Since predaceous mites are common and numerous in most soils (10) and do not seem to be effectively regulating phytoparasitic nematode populations, their potential for exploitation as applied biological control agents may be limited. There has been a lack of attention to the mite-nematode relationship by investigators, however, and the importance of mites in the regulation of nematode populations is unknown and requires more study. Information on factors which favor substantial populations of nematode-destroying mites would be particularly useful.

It is certain that *L. scapulatus* has the potential to exert a tremendous influence on nematode populations, and it and other mites may be very important in the ecology of some nematodes. The mite may have potential as an applied biocontrol agent with specialized uses (for example, in greenhouses or highly organic soils), and it is hoped that the results reported here will stimulate additional work on mite predators of nematodes.

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