BIOLOGY AND PREDATION OF *PHYTOSEIULUS MACROPILIS*[1] ON *TETRANYCHUS URTICAE*[2,3]

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ABSTRACT

Phytoseiulus macropilis (Banks) was studied in the laboratory to determine its potential rate of population increase when fed on eggs of *Tetranychus urticae* Koch. The shortest developmental period was 4.7 days for males, and 5.8 days for females reared at 27 ± 2°C and 90% ± 5% RH under 12L:12D. Mean generation duration was 14.2 days with an average reproductive rate of 1.89 eggs per female per day. Predation of *P. macropilis*, expressed as the number of prey eggs consumed per individual, was 5.9 eggs for the immature stages and 194.1 eggs for the adult or 7.9 eggs consumed per adult per day. Mean adult longevity was 25.3 days. For each predator egg produced, 4.3 prey eggs were consumed. The intrinsic rate of predator population increase (r_m) was calculated as 0.27 individuals per female per day.

Phytoseiulus macropilis (Banks) is the most common phytoseiid predator of spider mites in south Florida (Saba 1974). Its life history is described by Smith and Summers (1949) and its life cycle duration by Prasad (1967). No details of the reproductive rate or predation of *P. macropilis* at specific prey densities are given in these studies; data are not adequate to determine the intrinsic rate of increase, sex ratio, or influence of prey density on individual life history studies for the predator or its host, *Tetranychus urticae* Koch (Watson 1964, Laing 1969, Shih et al. 1976). The objective of this paper is to provide data on the biology, potential rate of population increase, and predation of *P. macropilis* fed on *T. urticae*.

MATERIALS AND METHODS

The life history of *P. macropilis* was studied at the University of Florida Agricultural Research and Education Center, Bradenton, Florida. Environmental chamber conditions were 27 ± 2°C, 90 ± 5% RH and 12L:12D. The initial colony of *P. macropilis* was collected from among twospotted spider mite populations on celery, statice (*Limonium* sp.), chrysanthemum, and blackberry in a greenhouse at Bradenton, in August 1973. Predators were reared continuously on spider mites fed on 'Henderson Bush' lima beans (*Phaseolus*) grown from seed in 6 in pots. Each pot was set in a 6 in diameter (1 in deep) pot saucer, which served to supply water for the plants and to confine the mites to the unit. Eggs from the collected predators were used to start 23 individual colonies. Eight days after establishing each stock colony, all second generation (F_1) *P. macropilis* adults were transferred

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[1]Acarina, Phytoseiidae.
[2]Acarina, Tetranychidae.
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to 14 petri dishes containing excised leaf cultures of spider mites. Each culture contained at least 3 females and 2 males of *P. macropilis*. A leaf culture was prepared as follows: twospotted spider mites were transferred onto dwarf 'Henderson Bush' lima beans 2 days after primary leaves had expanded. After 24 hours a spider mite infested leaf was excised and placed upside down on a 70 x 70 mm piece of cheese cloth in a 100 mm diameter petri dish. Water was added to soak the cloth but not flood the leaves. Lanolin applied to the leaf periphery helped confine mites to the leaves. A No. 00 brush was used to manipulate mites.

After 24 hours on the 14 leaf cultures, surviving *P. macropilis* adults were transferred to 9 fresh leaf cultures for another 24 hours before being returned to the stock colony. The 23 (14 and 9) excised-leaf cultures were kept until the *P. macropilis* eggs had hatched, after which the young predator mites were transferred to fresh leaf cultures. Thereafter, the predators were transferred to fresh leaf cultures every 24 hours until the colony died. To ensure mating, male predators of the same generation were added to cultures where no males developed or where males died during the first 14 days.

Mites were transferred to separate leaf cultures after each molt. All mites in a subculture were thus in the same developmental stage. Daily prey consumption, durations of developmental stages, preoviposition period and daily egg production were recorded every 12 hours (0.5 day). When a developmental stage was not observed between 2 successive observations, the duration of the missed state was assumed to be 0.25 day.

Due to the overlap of developmental stages and the active nature of spider mites, the predatory capability of *P. macropilis* was evaluated on the basis of spider mite egg consumption rather than on predation of all prey stages. The number of spider mite eggs on each leaf culture always greatly exceeded actual daily egg consumption of *P. macropilis*. With food supply ample and laboratory microenvironment uniform, the influence of these factors was not considered in this study. The sex ratio of *P. macropilis* was determined in both the laboratory study and in samples taken twice weekly from 2 field plots of strawberries at Bradenton, Florida from January through March 1974.

Phytoseiulus macropilis prey consumption was established as the number of prey consumed per predator in each age class. The intrinsic rate of natural increase (r_m) or the number of offspring produced per female per day was determined as a fundamental statistic to explain the predator mite capacity for numerical increase under laboratory conditions. The increase of *P. macropilis* was estimated using the method proposed by Birch (1948).

Results and Discussion

I. Development, Predation, and Potential Rate of Increase of *P. macropilis* Immature Stages. Appearance and behavioral characteristics described for *P. persimilis* by Laing (1968) were found to be very similar to *P. macropilis*. *Phytoseiulus macropilis* egg mortality was 2.9%, but no losses were recorded for the other juvenile stages. The average duration of the juvenile period was 2.2 days for eggs, 0.7 days for larvae, 1.0 days for protonymphs and 0.6 and 0.1 days for female and male deutonymphs, respectively (Table 1).

TABLE 1. DURATION OF THE IMMATURE STAGES AND CUMULATIVE TIME REQUIRED FOR DEVELOPMENT OF *Phytoseiulus macropilis* FED *Tetranychus urticae* EGGS AT 27 ± 2°C, 90 ± 5% RH, AND 12L:12D.

Stage of development	Number observed	Days duration			Mean cumulative days*
		Mean	SD	Min.-Max.	
Egg	174	2.2	—	—	—
Larva	169	0.7	0.5	2-5	2.2
Protonymph	169	1.0	0.5	3-6	2.9
Active deutonymph					
Female	122	0.6	0.6	3-7	3.9
Male	47	0.1	—	—	0.1
Quiescent deutonymph					
Female	122	1.3	0.7	4-10	4.5
Male	47	0.7	0.3	3-7	4.0
Adult					
Female	122	—	0.9	4-10	3.8
Male	47	—	0.8	3-7	4.7

*Duration of each active stage is recorded at the beginning of each stage and then added to the cumulative duration of all preceeding stages.

Adult stage. The deutonymphal quiescent period was 1.3 days for females and 0.7 days for male deutonymphs. Development time from egg through the quiescent deutonymph was 4-10 days for females and 3-7 days for males (Table 1). Males lived approximately 23 days; females lived an average of 27 days (Table 2). The mean oviposition period was nearly 25 days with an average total production of 49.1 eggs per female (Table 2). Fifty percent natural mortality was reached at 26.7 days for females and 22.6 days for males. Male to female ratios determined from field samples and the laboratory study were 1:5 and 2:5, respectively.

Prey Consumption. The number of *T. urticae* eggs consumed per individual *P. macropilis* is shown in Tables 2 and 3. Each immature stage required more prey than the preceding one: 0.4, 1.5, and 4.0 eggs per mite larva, protonymph, and deutonymph, respectively. The daily predation potential of adults was 7.9 eggs per individual per day (Table 2).

II. BIOLOGY OF *P. macropilis.*

Influence of predator age on predation. Daily predation by adult *P. macropilis* increased rapidly to a peak the 4th day after ecdysis, then decreased gradually until death (Fig. 1). The only exception to this general trend was an abrupt increase near the end of the life span observed in the few mites (6) surviving on days 33 and 34. The mean daily consumption rate for all individuals used in this experiment (44 females and 23 males) was 7.9 eggs per adult per day.

Mating and daily oviposition rate. Copulation occurred immediately after female ecdysis. The first eggs were laid 2 days after mating. Unmated females did not oviposit. Female *P. macropilis* reached their peak oviposition rate of 3.18 eggs per female per day on the 7th day after ecdysis. The rate

TABLE 2. LONGEVITY, REPRODUCTION AND PREDATION OF ADULT *Phytoseiulus macropilis* FED *Tetranychus urticae* EGGS AT 27 ± 2°C, 90 ± 5% RH, AND 12L:12D:

Characteristic	Number observed	Mean	SD	Min.-Max.
Longevity (days)				
Female	44	26.7	6.4	12-40
Male	23	22.6	5.1	14-32
Oviposition period (days)	44	24.6	5.3	12-36
Fecundity				
Total number of eggs laid per female	44	48.3	9.5	24-68
Total number of eggs laid per female per day	44	1.9	0.9	0.4-3
Predation				
Total number *T. urticae* eggs consumed per predator	67	194.1	43.3	134-228
Total number *T. urticae* eggs consumed per predator per day	67	7.9	3.0	0-16
Total number *T. urticae* eggs consumed per predator egg laid	44	6.1	1.5	3-8

TABLE 3. TWOSPOTTED SPIDER MITE EGG CONSUMPTION BY *Phytoseiulus macropilis* DURING EACH ACTIVE DEVELOPMENTAL STAGE IN A 27 ± 2°C, 90 ± 5% RH, AND 12L:12D CHAMBER.

Stages of *P. macropilis*	Number observed	Number of eggs consumed per mite stage		
		Mean	SD	Min.-Max.
Larva	79	0.4	0.4	0-1
Protonymph	76	1.5	0.9	0.3-3
Deutonymph	75	4.0	1.9	1-9
All immature stages	75	5.9	3.2	2-15

Potential Rate of Increase. The intrinsic rate of increase, (r_m) was calculated to be 0.27 individuals per female per day. The predator population was estimated to increase (R_o) 47 times in a mean generation time (T) of 14.2 days.

remained fairly constant for 3 days, then declined gradually to 0 at 1-2 days before death. Fluctuations in daily oviposition rate occurred in cycles of 2 to 3 days during the latter half of the oviposition period, usually from days 14 to 28 (Fig. 2).

The relationship between *T. urticae* eggs consumed and predator eggs produced is noteworthy. During the first 4 days after ecdysis, the ratio of

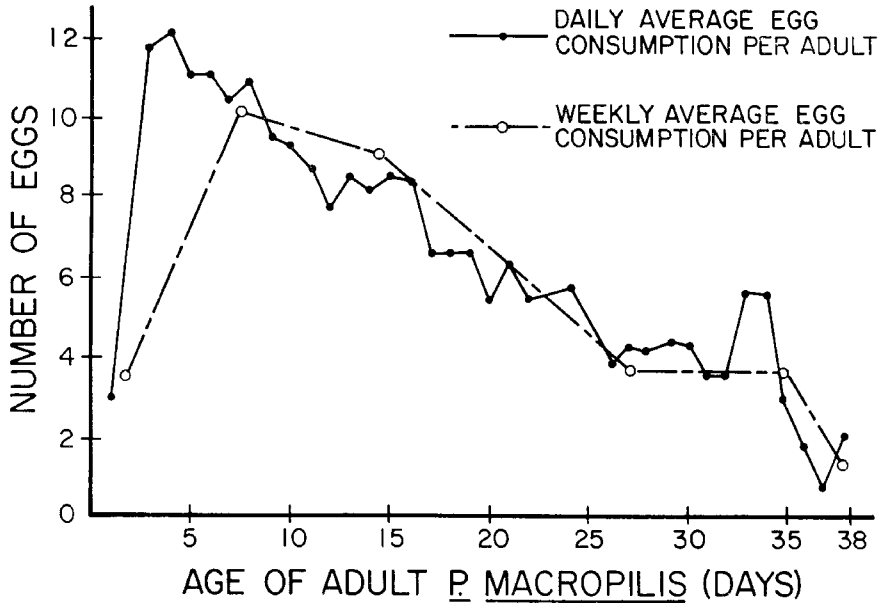

Fig. 1. Predation of *Tetranychus urticae* Koch eggs by *Phytoseiulus macropilis* (Banks).

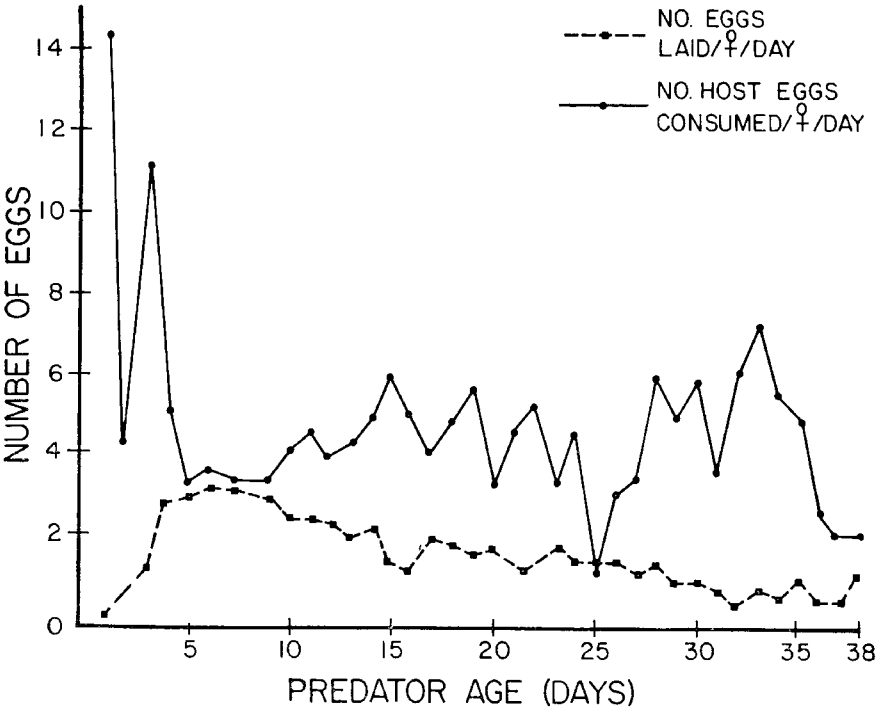

Fig. 2. Daily egg production by *Phytoseiulus macropilis* and its consumption of *Tetranychus urticae* eggs.

prey egg consumption to predator eggs laid was much higher than that of the subsequent 7 days. Feeding cycles of 3 to 5 days appeared on days 13 to 26 (Fig. 2). Females older than 26 days consumed slightly greater numbers of prey but laid fewer eggs. Initial fluctuations might be attributed during the first 5 days to the need for building nutritional reserves and completing ovarian development during a period of high food intake and low oviposition rate. A highly active female at this period may also need greater quantities of food to meet energy requirements; later (days 5-25) the cycling may be due to the periodic build-up and depletion of nutritional reserves as eggs are laid; after day 27, the differences may be due to senility or biased data since fewer than 8 females were alive at 28 days.

The data reported here for *Phytoseiulus macropilis* differ only slightly from those provided by Laing (1969) for *P. persimilis*. The life cycle of *P. macropilis* appears to be more rapid at each stage of development, a difference which might be attributed to the low and fluctuating temperature used in the *P. persimilis* study. *P. persimilis* oviposited an average of 2.4 eggs per day compared to 1.8 eggs per day for *P. macropilis*. The intrinsic rate of increase for *P. persimilis* was 0.219 individuals per female per day and the population multiplied 44.4 times in a mean generation time of 17.32 days (Laing 1969). In contrast, *P. macropilis* had an intrinsic rate of increase of 0.271 individuals per female per day and the population multiplied 47 times in a mean generation time of 14.2 days. Since both species are apparently of tropical origin and frequent similar habitats it is not surprising that their life histories are similar.

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