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【Research report】

智利捕植蟎 (Phytoseiulus persimilis) 的生殖特性【研究報告】

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Abstract

摘要

本研究報告的實驗材料智利捕植蟎 (Phytoseiulus persmilis) 係省農試所於民國七十六年夏由美國加州進口的生物防治工具。為瞭解該溫帶種在濕熱的亞熱帶氣候下的生殖特性，於是將其培養於32℃，相對濕度80%的恆溫箱。並於此條件下 (非智利捕殖蟎的最適培養條件) 觀察其生殖特性。結果顯示，智利捕植蟎之生殖特性與其他捕植蟎有極大的差別，例如：智利捕植蟎只須一次成功的交尾即可持續產卵而其他大多數的捕植蟎必須多次交尾才得以持續產卵；在求偶過程中雌成蟎奔向雄蟎而其它種類多為雄蟎主動尋找成雌成蟎或準備作最後一次蛻皮的雌性個體。此外，子代性比與母蟲日齡成正比。

Key words:
關鍵詞: 交尾習性、智利捕植蟎。

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SOME ASPECTS ON THE REPRODUCTION OF *PHYTOSEIULUS PERSIMILIS*

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Abstract

Phytoseiulus persimilis was imported from California during the summer of 1987 as a biological control agent. In order to understand whether the hot and humid subtropical environment is still suitable for the species from the temperate zone, it has been reared in the laboratory under the condition of 32±0.5°C (which is far from the optimum temperature for this species) and 80%±5% RH. Unlike most of the phytoseiid species, one successful mating for the *P. persimilis* females is probably sufficient for their lifetime egg production. Evidence also showed that during courtship, females moved toward males. In other words, male attracts female. The sex ratio in the offspring is influenced by the age of their mother. Older females produce more daughters than sons.

(Key words: mating behavior, *Phytoseiulus persimilis*)

Introduction

Phytoseiulus persimilis, a famous biological control agent for spider mites, was introduced into Taiwan from Riverside, California, USA during the summer of 1987. Although the life history, life cycle duration, and the predation of *P. persimilis* have been intensively studied (Mori and Shinkaji, 1977), the details on the reproduction of this species are still far from complete. To understand the reproduction of *P. persimilis* under the local environment is of fundamental importance to use this organism as a biological control agent. In this communication, we investigated the reproductive behavior of *P. persimilis* at the hot and humid subtropical conditions.

Materials and Methods

Maintenance of mites

The population of *Phytoseiulus persimilis* Athias-Henriot investigated in the present study was obtained in 1987 from a culture maintained at the University

of California at Riverside, California. It has been reared at room temperature for a year, and then transferred into incubators under the condition of 30±0.5°C, 80%±5% RH and 12L:12D and stayed in there for two months. Finally it was maintained under the condition of 32±0.5°C, 80%±5% RH and 12L:12D. The mites were placed on a plastic plate surrounded by water-filled cotton, and fed with multiflora bean (*Phaseolus coccineus* L.) leaves full of spider mites (*Tetranychus kanzawai* Kishida). The whole apparatus was covered by a plastic cover in order to insure high humidity suited for these predacious mites.

Moving direction of ***Phytoseiulus persimilis*** *adults*

In a 10-cm diameter petri dish, 3 leaf discs (approx. 3.5-4.5 cm^2) full of spider mites were layered on damped cotton about 5 mm thick. The cotton was pressed to form a flat surface in order to avoid trapping mites in loose cotton fibers. These 3 leaf discs were firmly attached on the surface and equally spaced by a 1-cm gap. On a flat and damped cotton surface, adult *P. persimilis* could run across the space between discs without any problem in our experimental device. In order to examine the moving direction of adults, one adult, smashed 5 adults of one sex, or nothing as a blank was inoculated on each disc for observation. Thus, there were six combination, including one male-two blanks, one female-two blanks, one male-two females, one female-two males, one female-5 smashed males-one blank, and one male-5 smashed female-one blank in each petri dish. For each combination, 5 replicates were used. Either virgin or mated one day old adults were used in this experiment which was performed in the laboratory at a room temperature of 25°C. The movement of *P. persimilis* was observed under a binocular microscope (15×) with a fiber optics bifurcated illuminator.

Egg production under different situations

Each one day old mated females or each polyandrous female with three adult males were transferred onto a leaf disc. One day old mated female was obtained from pairs of mites after the copulation was completed. The leaf disc was kept on wet cotton and surrounded by a barrier made of canada balsam and castor oil (1:1). Eggs produced by these females were collected and counted everyday separately during the whole experimental period. These eggs were incubated at 32°C and allowed to develop until they could be sexed. The sex ratios in the offspring of individual females were recorded.

Results and Discussion

Moving direction of ***Phytoseiulus persimilis*** *adults*

In the presence of enough food, males or females alone in the device described above did not show intention to leave the original disc. If both male and female adults were inoculated in the same petri dish, female always ran toward male, i.e. unidirectional movement. All of five virgin females moved to males within one day. However, the running of mated females toward males was occurred at the fourth day (1 out of 5) and the fifth day (2 out of 5).

Five smashed males could replace a male to attract females, whereas five smashed females did not result any directional movement of the male. Five smashed males were more effective than a single male in stimulating the move-

ment of virgin females. All of five virgin females ran toward smashed males within an hour. The movement of mated females toward smashed males was the same as that the male was used. Furthermore, it was noticed that the females, either virgin or mated, would stay on the disc occupied by the male after they reached there, but hovered from disc to disc in the other device after they reached the disc with smashed males.

Laing (1968) reported that the female was active and kept running around until encountered and mated with a male. The unidirectional movement from female to male showing in our results is in agreement with Laing's finding. This unidirectional movement of female toward male or smashed males suggests that the sex pheromone, if it exists, is released from males to attract females in *P. persimilis*. However, it has been reported that sex pheromones were produced by females in *Typhlodromus occidentalis* and *Amblyseius fallacis* in the family Phytoseiidae (Hoy and Smilanick, 1979; Rock, *et al.*, 1976; Tanigoshi, 1982). The reason for this difference remains to be investigated.

Comparison of single-mated and multiple-mated females

The duration of oviposition was represented by the number of days a female actually ovipositing eggs. The frequencies of oviposition duration for two groups of females were showed in Table 1. The A group consists of females individually polyandrous with three males for the whole experimental period and the B group 45 mated females without male around. The duration of oviposition of the B group did not fit normal distribution according to χ^2 analysis, indicating that it might be a bimodel distribution with a main peak and a smaller one. The average

Table 1. Test of the goodness of fit to normal distribution. A, the distribution of the total length of egg production of 45 females accompanied with 3 males; B, 45 single mated females; and B′, 41 females from the main peak of the B distribution. The statistical analysis was according to the methods of Wardlaw, 1985.

Oviposition duration (days)	A		B		B′	
	obs.	exp.	obs.	exp.	adj.	exp.
1	2	1.71	1	2.48	1	1.56
2	3	2.52	7	2.52	3	1.85
3	8	4.64	3	3.96	3	3.16
4	9	6.80	8	5.44	8	4.59
5	9	8.15	9	6.44	9	5.82
6	3	7.88	7	6.70	7	6.31
7	5	6.16	3	5.98	3	5.90
8	4	3.92	0	4.72	0	4.76
9	1	2.03	2	3.20	2	3.32
10	0	0.86	2	1.89	2	2.01
11	1	0.27	2	0.99	2	1.01
12	0	0.09	1	0.40	1	0.46
	n=45		n=45		n=41	
	avg.=4.84		avg.=5.24		avg.=5.56	
	s.d.=2.16		s.d.=2.66		s.d.=2.58	
	χ^2=10.07		χ^2=19.88		χ^2=13.59	
	$p>0.1$		$p<0.05$		$p>0.1$	

duration of the small peak in the bimodel distribution was around 2 days. If this small peak was removed by artificially substracting 4 from the second category, the new distribution of the B′ group fits normal distribution, and is statistically indistinguishable from that of the A group (t=1.38, p>0.10). These results suggest that one successful mating is sufficient for the majority of females. Thus, *P. persimilis* is unlike other parahaploid phytoseiid mites in which females need repeated mating to avoid the cease of oviposition (Putman, 1962; McMurtry and Scriven, 1964). The second small peak with oviposited eggs for only 2 days in the bimodel distribution may represent a small portion of unsuccessfully mated females.

If a female produced eggs for more than three days, it was considered to have received a successful mating. Among the 41 successfully mated polyandrous females, six of them (15%) did not produce an egg at the first day after mating. All of the 37 successfully mated females in the other group produced eggs from the first day after mating. These results implied that these six polyandrous females received an unsuccessful copulation at the first time and got a second mating for producing eggs. However, the multiple mating were not essential for continued egg production and oviposition. These results are consistent with the finding that total egg production by females of *P. persimilis* was not increased by multiple matings, while that of another phytoseiid species, *Amblyseius andersoni*, did (Amano and Chant, 1978).

Egg production at 32°C

At 32°C, the average oviposition rate is 4.34 eggs per female per day (n=386). The age-dependent oviposition curve is showed in Fig. 1. As reported by Dosse (1958), the oviposition rates were 0.4, 1.2, 4, 4.2, 5.2 eggs per female per day at 10, 15, 25, 30, 35°C, respectively. The oviposition rate observed at 32°C in this study is basically in agreement to that reported by Dosse (1958). Laing (1968) reported

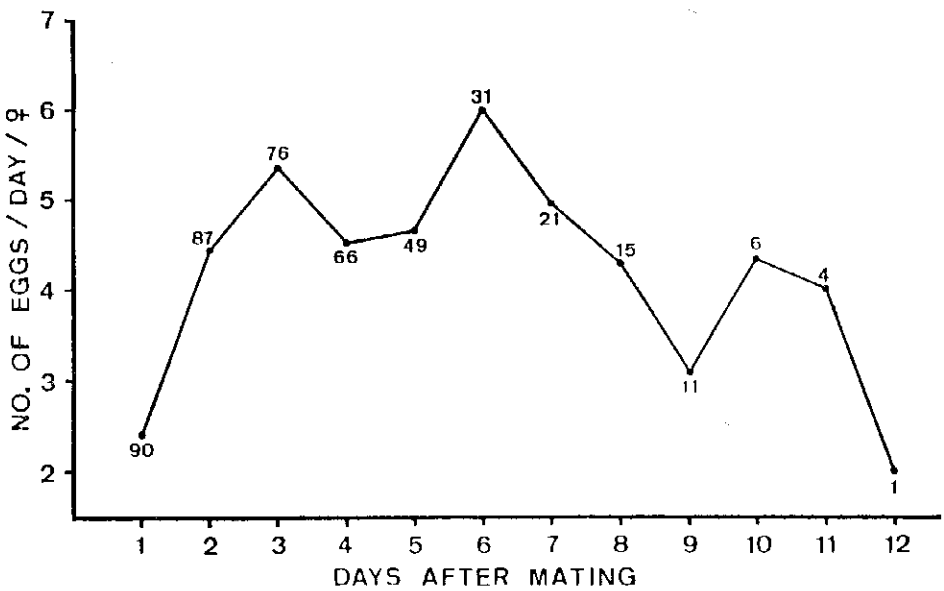

Fig. 1. Age-specific oviposition curves of *P. pesimilis*. Numbers beside plots represent the number of egg producing females.

2.4 eggs per female per day under the condition of 15.5L:8.5D with temperature controlled on a 24-hour cycle from 14.7°C at 3 a.m. to 28.3°C at 1 p.m., and using *T. urticae* as the prey. Takafuji and Chant (1976) reported 3.7 eggs per day at 25°C with *T. pacificus* as the prey. Amano and Chant (1978) showed that to be 3.1 eggs per female per day at 23°C with *T. pacificus* as the prey. The slightly lower oviposition rates in these two reports might be partly due to the lower temperature and partly due to the different prey. Fitness components such as survival rate, mating success and fecundity are under long period of natural selection, and do not have genetic change easily.

Sex ratios in progeny produced by different aged females

Since sex ratios of the offspring produced by mated females alone and by females with males around are statistically insignificant, the data were pooled together. As shown in Table 2, the sex ratio of female/male increased from 1.50 to 3.50 as the age of the female increased. Since the older females have less offspring than the younger ones, the offspring from the older females were arbitrarily merged into two categories, i.e. 7 and 8 days old, and 9 to 12 days old (Table 2). *P. persimilis* was parahaploid rather than arrhenotokous (Helle, *et al.*, 1978; Nelson-Rees, *et al.*, 1980). The higher proportion of male could not be due to the presence of unfertilized eggs. As shown in Table 2, there is no significant difference in the survival rates among different age groups. The high sex ratio (percent female) could not be explained by the differential survival rate. Amano and Chant (1978) suggested that a low sex ratio would be expected in the progeny, if females produced only a few progeny. However, our results showing that the old aged female have low fecundity but high sex ratio in the progeny, disagree to their hypothesis. Therefore, further investigation is needed to understand the mechanism and biological significance of this finding.

Table 2. The tertiary sex ratios of the offspring produced by different aged females

Age of the female (in days)	Number of the eggs	Number of the offspring	Survival rate (%)	female/male
1	191	140	73.82	1.50
2	315	209	66.35	2.07
3	341	273	80.06	2.14
4	253	186	73.52	2.15
5	213	144	67.61	2.20
6	172	127	73.84	2.85
7 & 8	121	85	70.25	3.25
9 to 12	59	45	76.27	3.50

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智利捕植蟎 (*Phytoseiulus persimilis*) 的生殖特性

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本研究報告的實驗材料智利捕植蟎 (*Phytoseiulus persmilis*) 係省農試所於民國七十六年夏由美國加州進口的生物防治工具。爲瞭解該溫帶種在濕熱的亞熱帶氣候下的生殖特性，於是將其培養於32°C，相對濕度 80%的恆溫箱。並於此條件下 (非智利捕殖蟎的最適培養條件) 觀察其生殖特性。結果顯示，智利捕植蟎之生殖特性與其他捕植蟎有極大的差別，例如：智利捕植蟎只須一次成功的交尾即可持續產卵而其他大多數的捕植蟎必須多次交尾才得以持續產卵；在求偶過程中雌成蟎奔向雄蟎而其它種類多爲雄蟎主動尋找成雌成蟎或準備作最後一次蛻皮的雌性個體。此外，子代性比與母蟲口齡成正比。

(**關鍵詞**：交尾習性、智利捕植蟎)