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Evaluation of Feeding and Ovipositing Responses of Three Phytoseiid Mites to Amounts of Kanzawa Spider Mite Eggs (Acari: Phytoseiidae, Tetranychidae) 【Research report】

三種捕植蟎對不同數量葉蟎的取食與產卵反應評估【研究報告】

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*通訊作者E-mail : phytoseiid, response, food amount.

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Abstract

Amblyseius womersleyi Shicha is common in Taiwan and feeds on spider mites, providing good control of Tetranychus kanzawai Kishida. A. fallacis (Garman) and Phytoseiulus persimilis Athias-Henriot were exotic phytoseiids imported from the United States and/or Australia to Taiwan for the control of T. urticaeKoch. To compare their abilities to control spider mites, daily food consumption and fecundity of these phytoseiids when provided with 0, 2, 5, 10, 20, 40, 80, 120 Kanzawa spider mite eggs were studied at 28 ℃ and a photoperiod of 13:11 (L: D) in an incubator. These predators responded differently to food availability. With a food supply as low as 2 spider mite eggs per day, A. womersleyi would remain on the leaf disc and finish the food; A. fallacis tended to finish the food and leave; while P. persimilis might have left without feeding. Escape behavior of A. fallacis and P. persimilis decreased after 10 or more spider mite eggs were provided daily. With a supply of 20 or more spider mite eggs, P. persimilis ate more than the others did. A. womersleyi and A. fallacis reached their normal fecundity after 20 or more spider mite eggs were provided per day, indicating that this is likely to be their daily food requirement. P. persimilis reached normal fecundity after 40 spider mite eggs were supplied daily. Its daily food requirement is probably around 30 spider mite eggs. Supplied with 120 spider mite eggs daily, fecundity of all three predators significantly decreased. Compared with P. persimilis, A. womersleyi and A. fallacis can be released into lower spider mite densities. A. womersleyi would stay, feed, and oviposit with low food amounts; it feeds more than A. fallacis does when food is plenty, and is prevalent in Taiwan. More studies should be carried on the utilization of this mite in spider mite IPM systems.

摘要

溫氏捕植蟎(Amblyseius womersleyi Schicha)普遍發生於臺灣各地，捕食葉蟎，對神澤氏葉蟎(Tetranychus kanzawai Kishida)有良好的防治效果。法拉斯捕植蟎(A. fallacis (Garman))及智利捕植蟎(Phytoseiulus persimilis Athias-Henriot)為自美國以及澳洲引進的外來種類，引進目的在防治二點葉蟎(T. urticae Koch)。為比較此3種捕植蟎對葉蟎的抑制能力，本試驗觀察定溫箱中28℃、13:11(L: D)光週期下，每日供給0、2、5、10、20、40、80、120粒神澤氏葉蟎卵時，3種捕植蟎的捕食量、產卵量。三種捕植蟎對食物量的反應不一，低如每日2粒葉蟎卵即可使溫氏捕植蟎停留於葉片，將食物吃光；法拉斯捕植蟎傾向於吃完後離去；智利捕植蟎則可能不吃即離去。供給10粒或更多葉蟎卵時，法拉斯捕植蟎及智利捕植蟎才有相當的安定性。供食超過20粒葉蟎卵後，智利捕植蟎食量躍升3者之冠，溫氏捕植蟎次之，法拉斯捕植蟎最少。自產卵量來看，溫氏捕植蟎及法拉斯捕植蟎每日有20粒葉蟎卵即正常產卵，其每日所需食物量約為20粒葉蟎卵；智利捕植蟎則在每日供40粒葉蟎卵時才達應有產卵量，其每日食物需求可能為30粒葉蟎卵左右。供食120粒葉蟎卵時，產卵量均顯著有下降情形。缺乏食物時，三種捕植蟎均迅速離去。與智利捕植蟎相較，溫氏捕植蟎及法拉斯捕植蟎可在較低葉蟎密度時釋放。溫氏捕植蟎在低食物量時即能定著而取食、產卵，食物豐足時的取食量優於法拉斯捕植蟎，又普遍存在於台灣，應探討其在IPM系統中的應用價值。

Key words: phytoseiid, response, food amount.
關鍵詞: 捕植蟎、反應、食物量

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Evaluation of Feeding and Ovipositing Responses of Three Phytoseiid Mites to Amounts of Kanzawa Spider Mite Eggs (Acari: Phytoseiidae, Tetranychidae)

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ABSTRACT

Amblyseius womersleyi Shicha is common in Taiwan and feeds on spider mites, providing good control of *Tetranychus kanzawai* Kishida. *A. fallacis* (Garman) and *Phytoseiulus persimilis* Athias-Henriot were exotic phytoseiids imported from the United States and/or Australia to Taiwan for the control of *T. urticae* Koch. To compare their abilities to control spider mites, daily food consumption and fecundity of these phytoseiids when provided with 0, 2, 5, 10, 20, 40, 80, 120 Kanzawa spider mite eggs were studied at 28 ℃ and a photoperiod of 13:11 (L: D) in an incubator. These predators responded differently to food availability. With a food supply as low as 2 spider mite eggs per day, *A. womersleyi* would remain on the leaf disc and finish the food; *A. fallacis* tended to finish the food and leave; while *P. persimilis* might have left without feeding. Escape behavior of *A. fallacis* and *P. persimilis* decreased after 10 or more spider mite eggs were provided daily. With a supply of 20 or more spider mite eggs, *P. persimilis* ate more than the others did. *A. womersleyi* and *A. fallacis* reached their normal fecundity after 20 or more spider mite eggs were provided per day, indicating that this is likely to be their daily food requirement. *P. persimilis* reached normal fecundity after 40 spider mite eggs were supplied daily. Its daily food requirement is probably around 30 spider mite eggs. Supplied with 120 spider mite eggs daily, fecundity of all three predators significantly decreased. Compared with *P. persimilis*, *A. womersleyi* and *A. fallacis* can be released into lower spider mite densities. *A. womersleyi* would stay, feed, and oviposit with low food amounts; it feeds more than *A. fallacis* does when food is plenty, and is prevalent in Taiwan. More studies should be carried on the utilization of this mite in spider mite IPM systems.

Key words: phytoseiid, response, food amount.

Introduction

Amblyseius womersleyi Schicha is a native phytoseiid mite of Taiwan. Incorporated into biological control programs, it has provided good control of *Tetranychus kanzawai* Kishida on strawberry, tea, and mulberry (Lo *et al.*, 1984; Chen,

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1988; Ho and Chen, 1991). However, it did not work in an attempt to control *T. urticae* (Koch) on strawberry (Lo *et al.* 1984). To fortify this deficiency, two phytoseiid mites, *Phytoseiulus persimilis* Athias-Henriot and *Amblyseius fallacis* (Garman), that have been used worldwide in spider mite biological control or IPM programs, were imported to Taiwan to control spider mites on various crops (Lo *et al.*, 1990; Shiau *et al.*, 1993; Hao *et al.*, 1996).

Laboratory life cycle studies of *A. womersleyi* showed a daily food consumption rate and fecundity similar to those of *P. persimilis* and *A. fallacis* (Ho *et al.*, 1995). *A. womersleyi* therefore should be a good biological control agent against spider mites. But how does it compare to *P. persimilis* and *A. fallacis*? To learn more about their performance in suppressing spider mites, the feeding and ovipositing responses of these three phytoseiids to various amounts of food were studied.

Materials and Methods

A plastic plate, 250×190×3 mm, set on polyvinyl foam and fringed with a 1-cm cotton strip saturated with water to restrain mites, was used to rear the stock colony of phytoseiid mites. Soybean (*Glycine max* L.) seedlings infested with *Tetranychus kanzawai* Kishida were served every 2-3 days for food.

The leaf-arena method described by Lo and Ho (1979) was applied to study the response of phytoseiid mites to Kanzawa spider mite eggs. Adult female phytoseiids were transferred from the stock colony onto a new leaf arena to oviposit for 4 h, and were then removed. Hatched immature phytoseiids were reared individually on fresh leaf arena. After emergence, the 2- to 3-day-old adult female mites were well fed for 1 day, and then their individual responses were tested with a daily offering of 2, 5, 10, 20, 40, 80, or 120 spider mite eggs. Adult female mites offered no food served as the control. For each food amount offered, the responses of 10 adult female phytoseiids were observed daily for 5 days. The amount of food consumed and the number of eggs laid were recorded. When replenishing food, hatched spider mite larvae or matured spider mite eggs were removed and replaced with fresh spider mite eggs.

All studies were carried out in an incubator maintained at 28℃ with a photoperiod of 13:11 h (L:D).

Results

Ten adult females tested for 5 consecutive days should yield 50 data points for both daily food consumption and daily fecundity for each treatment. However, some females escaped from the testing leaf arena in some treatments. This resulted in fewer than 50 data points for those treatments. For each food-provision treatment, these data points were assessed separately to calculate the mean, standard error, and ratio of standard error over mean, for food consumption (Fig. 1) and fecundity (Fig. 2) on a daily base.

I. Feeding responses

Feeding rates of all three phytoseiids were steady in all tested food-provision schemes. Variations among individuals or testing days were low. The ratio of standard error over mean was always within 0.1, mostly not exceeding 0.05. The only exception was *P. persimilis* at the two lowest food-providing rates, in which some mites did not eat.

Daily feeding amounts of the tested predators all increased significantly with increasing food supply (Fig. 3). At the three lower rates of food supply, *A. womersleyi* depleted almost all food. Its feeding rate reached a plateau of around 24 spider mite eggs at supply rates of 40

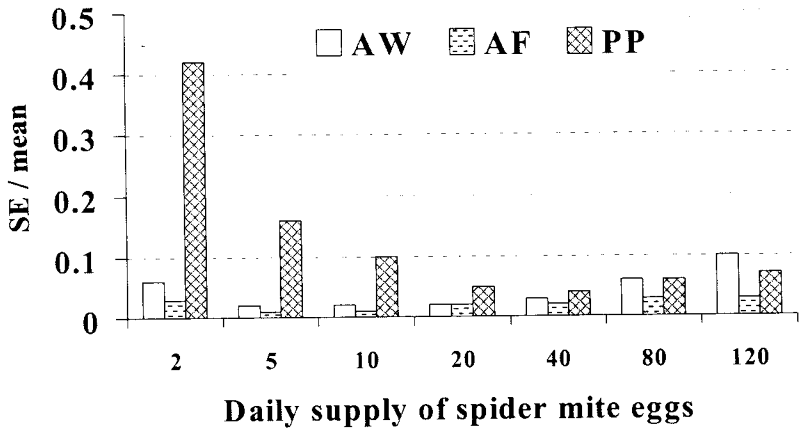

Fig. 1. The ratio of standard error (SE) over the mean of the daily feeding amount of three phytoseiid mites with various *T. kanzawa* egg provision schemes. AW: *Amblyseius womersleyi*, AF: *A. fallacis*, PP: *Phytoseiulus persimilis*.

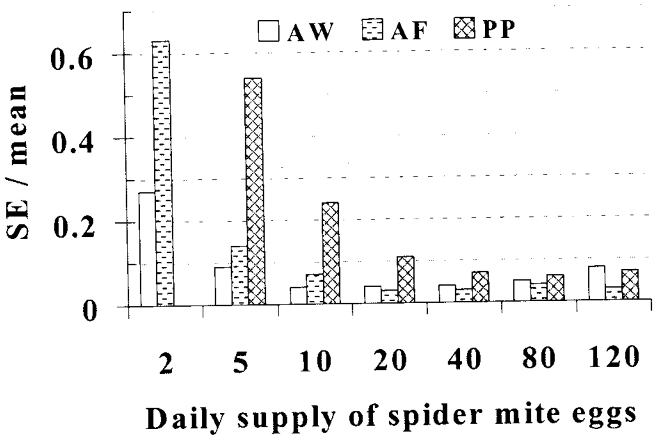

Fig. 2. Ratio of standard error (SE) over the mean of the daily fecundity of three phytoseiid mites with various *T. kanzawai* egg provision schemes (see Fig. 1 for footnotes).

and 80 spider mite eggs a day. The feeding rate jumped to a significantly higher number, 38 spider mite eggs, when offered 120 spider mite eggs daily. Daily feeding amounts of *A. fallacis* were similar to those of *A. womersleyi*, except that *A. fallacis* ate less than *A. womersleyi* did at the three higher food-supply rates, and its feeding rate decreased significantly when the daily supply of spider mite eggs increased from 80 to 120. *P. persimilis* ate significantly less than *A. womersleyi* and *A. fallacis* did when food was scarce. A few individuals did not eat at all, resulting in a higher SE/mean ratio (Fig. 1). Its feeding rate increased rapidly with an increase of food supply, and surpassed the feeding rates of *A. womersleyi* and *A. fallacis* when 40 or 80 spider mite eggs were offered. Then, the feeding rate of *P. persimilis* dropped slightly, not significantly statistically, at

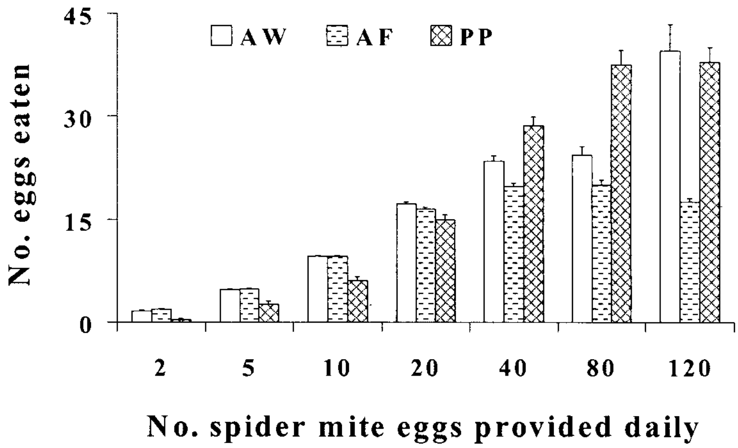

Fig. 3. Daily food consumption of three phytoseiid mites with various *T. kanzawai* egg provision schemes (see Fig. 1 for footnotes).

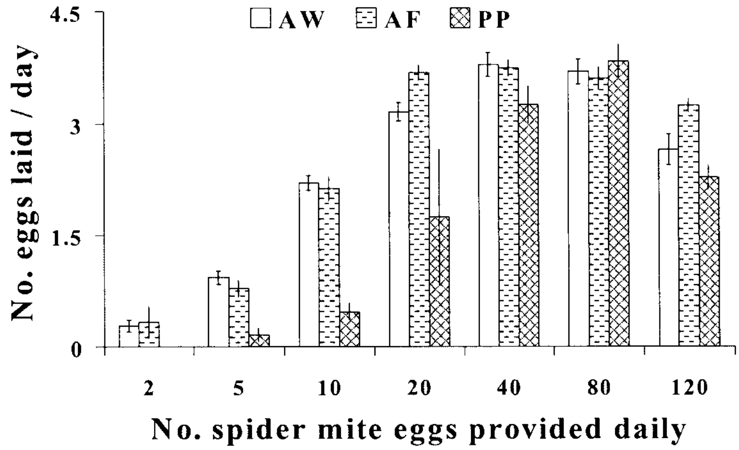

Fig. 4. Daily fecundity of three phytoseiid mites with various *T. kanzawai* egg provision schemes (see Fig. 1 for footnotes).

the daily provision of 120 spider mite eggs.

II. Ovipositing responses

When provided with no food, all of the tested phytoseiid mites escaped from the leaf arena on the first day of testing. However, some individuals laid eggs before leaving. This occurred for all three phytoseiid species. To exclude the influence of food intake previous to the test on egg laying, eggs laid on day 1 were not used in the analyses of results.

Daily fecundity of *A. womersleyi* stabilized, i.e., SE/mean ratio less than 0.1, after 5 spider eggs were provided (Fig. 2). Those of *A. fallacis* and *P. persimilis* stabilized after 10 and 40 spider mite eggs were provided, respectively.

Fecundity of *A. womersleyi* increased with the amount of food supplied (Fig. 4), reaching a plateau after being offered 20 spider mite eggs, then dropping significantly with the provision of 120 spider mite eggs. *A. fallacis* showed the same fluctuation in oviposition rate as did *A.*

womersleyi. *P. persimilis* laid no eggs when provided 2 spider mite eggs a day. Supplied with 5-20 spider mite eggs a day, it laid significantly fewer eggs than did *A. womersleyi* or *A. fallacis*. Its fecundity caught up with those of *A. womersleyi* and *A. fallacis* when provided 40 or 80 spider mite eggs. Like *A. womersleyi*, it laid significantly fewer eggs when provided 120 spider mite eggs.

III. Retainment

All three phytoseiids left the testing leaf arena the first day when provided no food. With food present, more mites stayed on the leaf arena when offered additional food. As few as 2 spider mite eggs could induce *A. womersleyi* to stay on the leaf arena. The number escaping was low, significantly lower than that of *A. fallacis* or *P. persimilis*, and their leaving was delayed to the second day of experiment, which was recorded on the third day (Fig. 5). At least 10 or more spider mite eggs were needed to hold the same proportion of *P. persimilis* or *A. fallacis* on the leaf arena. Although *A. fallacis* has a similar food requirement as *A. womersleyi*, it tended to vacate the leaf arena on the first day, as indicated in the record of the second day, when food was deficient. Like *A. fallacis*, *P. persimilis* tended to vacate the leaf-arena in the low food supply scheme. With 40 or more spider mite eggs, no *A. fallacis* left the leaf arena, but some *A. womersleyi* and *P. persimilis* still showed escape behavior.

Discussion

Studies on feeding and ovipositing responses to food amount customarily emphasize the functional and numerical responses of the tested animal. We have tried to view the obtained data differently by judging the true food requirements of the tested animal, and its responses to both extra and insufficient food.

Various authors have studied the functional and/or numerical responses of *A. womersleyi*, *A. fallacis*, and *P. persimilis*. The highest numbers of prey eggs consumed in each study are listed in table 1. Probably because the testing temperatures were lower than that used in this study, the consumption rates recorded

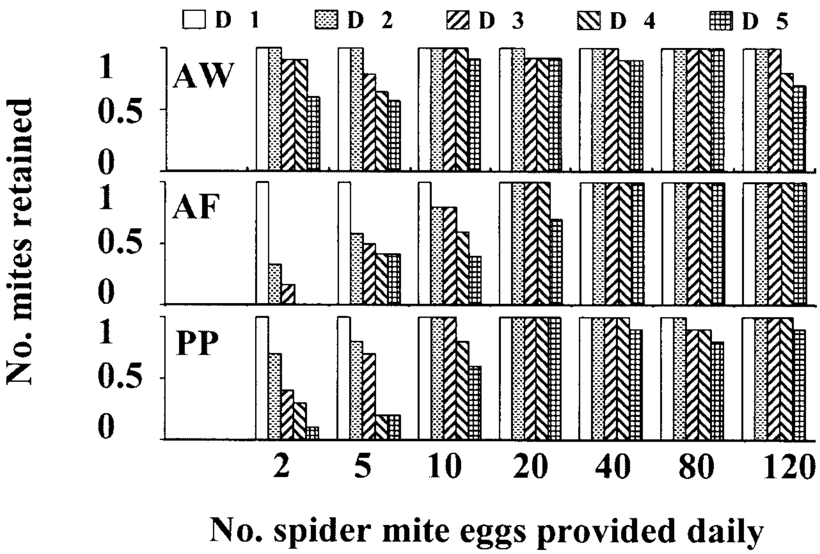

Fig. 5. Retainment of three phytoseiid mites over 5 consecutive days with various *T. kanzawai* egg provision schemes (see Fig. 1 for footnotes).

Table 1. Highest food consumption rates in some functional response studies (data are approximated from original drawings)

Mite	Temp. (℃)	Prey	Prey eggs consumed daily	Daily supply of eggs	Source
P. persimilis	22.2	*T. urticae*	11	32	Takafuji and Chant, 1976
P. persimilis	25	*T. pacificus*	22	30~60	Takafuji and Chant, 1976
A. fallacis	25	*T. urticae*	14	40	Santos, 1975
A. womersleyi	25	*T. kanzawai*	7.5	64	Shih and Huang, 1991
A. womersleyi	25	*T. kanzawai*	16	32	Kim and Lee, 1996
A. womersleyi	25	*T. kanzawai*	18	128	Kim and Lee, 1996

P. = *Phytoseiulus; A.* = *Amblyseius; T.* = *Tetranychus.*

in these other studies are always less than that in this study. We therefore make judgements with our own data only.

A. womersleyi, *A. fallacis*, and *P. persimilis* showed a capacity to lay 3.4, 3.3, and 4.6 eggs per day, respectively, in a previous study in this laboratory (Ho and Chen, 1999). *A. womersleyi* reached this fecundity after being provided with 20 spider mite eggs. We believe that approximately 20 spider mite eggs is the daily amount of food required by an adult female *A. womersleyi* to reproduce normally. The daily food requirement of *A. fallacis* is similar to *A. womersleyi*. But 20 spider mite eggs were insufficient for *P. persimilis*. The fecundity of *P. persimilis* recorded in previous studies was not achieved in this study. Studies by Takafuji and Chant (1976) and Ball (1980) also showed a fecundity of less than four eggs per day. Daily fecundity of this mite exceeded three eggs after 40 spider mite eggs were offered. That is, *P. persimilis* requires more food than do *A. womersleyi* and *A. fallacis*. Judged by the amount of food consumed when offered 20 or more spider mite eggs, its daily food requirement is probably between 30 to 40 spider mite eggs.

These three phytoseiids also showed different food utilization strategies in addition to the different food amount requirements. *A. womersleyi* will utilize a small amount of food, remaining to consume the food and lay eggs. This is good for controlling low spider mite populations. But exhausting the food supply may handicap the establishment and spread of its population, as hatching offspring may find no food available. *A. fallacis* can utilize small amounts of food also, but tends to leave under these conditions. That is, *A. fallacis* tends to start its population at a higher prey density than does *A. womersleyi*. *P. persimilis* does not utilize small amounts of food. It needs more food than either *A. womersleyi* or *A. fallacis* to establish its population. Currently, it is hard to judge which strategy is more successful. However, the above information indicates that, in a biological control program, *A. womersleyi* and *A. fallacis*, especially the former species, can be released at lower spider mite populations than can *P. persimilis*.

The available information shows that *A. womersleyi* eats less and proliferates slower than *P. persimilis*. It is, therefore, less powerful than *P. persimilis* as a spider mite control agent. Though similar to *A. fallacis* in fecundity, *A. womersleyi* eats more than *A. fallacis*. While millions of *P. persimilis* and *A. fallacis* have been released on strawberry (Lee and Lo, 1989) and papaya (Hao *et al*., 1996), there is no evidence of their establishment in Taiwan. In addition, from our field experience, *A. womersleyi* is found prevalently in *Tetranychus* colonies throughout Taiwan, indicating that *A. womersleyi* is more valuable than previously thought. More attention should be paid to the utilization of this predacious mite.

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三種捕植蟎對不同數量葉蟎的取食與產卵反應評估

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摘　　要

溫氏捕植蟎(*Amblyseius womersleyi* Schicha)普遍發生於臺灣各地，捕食葉蟎，對神澤氏葉蟎(*Tetranychus kanzawai* Kishida)有良好的防治效果。法拉斯捕植蟎(*A. fallacis* (Garman))及智利捕植蟎(*Phytoseiulus persimilis* Athias-Henriot)爲自美國以及澳洲引進的外來種類，引進目的在防治二點葉蟎(*T. urticae* Koch)。爲比較此三種捕植蟎對葉蟎的抑制能力，本試驗觀察定溫箱中28℃、13:11(L: D)光週期下，每日供給0、2、5、10、20、40、80、120粒神澤氏葉蟎卵時，三種捕植蟎的捕食量、產卵量。三種捕植蟎對食物量的反應不一，低如每日2粒葉蟎卵即可使溫氏捕植蟎停留於葉片，將食物吃光；法拉斯捕植蟎傾向於吃完後離去；智利捕植蟎則可能不吃即離去。供給10粒或更多葉蟎卵時，法拉斯捕植蟎及智利捕植蟎才有相當的安定性。供食超過20粒葉蟎卵後，智利捕植蟎食量躍升三者之冠，溫氏捕植蟎次之，法拉斯捕植蟎最少。自產卵量來看，溫氏捕植蟎及法拉斯捕植蟎每日有20粒葉蟎卵即正常產卵，其每日所需食物量約爲20粒葉蟎卵；智利捕植蟎則在每日供40粒葉蟎卵時才達應有產卵量，其每日食物需求可能爲30粒葉蟎卵左右。供食120粒葉蟎卵時，產卵量均顯著有下降情形。缺乏食物時，三種捕植蟎均迅速離去。與智利捕植蟎相較，溫氏捕植蟎及法拉斯捕植蟎可在較低葉蟎密度時釋放。溫氏捕植蟎在低食物量時即能定著而取食、產卵，食物豐足時的取食量優於法拉斯捕植蟎，又普遍存在於台灣，應探討其在IPM系統中的應用價值。

關鍵詞：捕植蟎、反應、食物量。

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