

Functional responses and parasitoid success rate of aphelinid *Eretmocerus sp.* (Hymenoptera: Aphelinidae) on *Bemisia tabaci* Genn. (Homoptera: Aleyrodidae)

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Abstract

Poinsettia (*Euphorbia pulcherrima* Willd Ex Koltz) is an important ornamental and medicinal plant. One of its major insect pests is sweetpotato whitefly, *Bemisia tabaci* Genn. (Homoptera: Aleyrodidae). *Eretmocerus sp.* (Hymenoptera: Aphelinidae) is an important natural enemy agent on sweetpotato whitefly, which mainly parasitizes 2nd and 3rd instar nymphs of *B. tabaci* and often feeds the nymphs. With poinsettia (*Euphorbia pulcherrima* Willd Ex Koltz) as the host plant, the present study showed that the functional responses for parasitization of *E. sp.* on 2nd and 3rd instar nymphs of *B. tabaci* coincided with Holling-III equation. The handling time against the 2nd and 3rd instar nymphs were 76.2 min and 117.2 min respectively. The maximum parasitization against the 2nd and 3rd instar nymphs were 18.9 per day and 12.3 per day respectively. The functional responses for host feeding of *E. sp.* on 2nd and 3rd instar nymphs of *B. tabaci* coincided with the Holling-II equation. The handling time against the 2nd and 3rd instar nymphs were 201.7 min and 298.8 min respectively. The maximum host feeding against the 2nd and 3rd instar nymphs was 7.1 per day and 4.8 per day respectively. The parasitoid success rate of *E. sp.* against *B. tabaci* reached 86.5%. The result suggested that the host feeding of *E. sp.* was a significant component in the natural control of *B. tabaci*.

Keywords *Eretmocerus sp.*; *Bemisia tabaci* Genn.; functional responses; parasitization; host feeding; parasitoid success rate.

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1 Introduction

Poinsettia, *Euphorbia pulcherrima* Willd Ex Koltz, is an important ornamental plant (Chong et al., 2014; Olberg and Lopez, 2016). In addition, it is a traditional Chinese herbal plant (Zhang, 2017a, b). Sweetpotato whitefly, *Bemisia tabaci* Genn. (Homoptera: Aleyrodidae), is a significant foliar insect pest damaging on cotton, tomato, poinsettia and some other crops (Mound, 1965; Sundaramurthy, 1992; Minkenberg et al., 1994;

McKenzie et al., 2014). Biological control is a powerful tool for the control of sweetpotato whitefly. *Eretmocerus sp.* (Hymenoptera: Aphelinidae) is an important natural enemy agent on sweetpotato whitefly, which mainly parasitizes 2nd and 3rd instar nymphs of *B. tabaci* and often feeds the nymphs (McKenzie et al., 2014). Previous studies focused on the natural parasitism, oviposition, and searching behavior of this parasite (Bellows, et al., 1988). Host feeding on some whiteflies were also recorded for other aphelinid parasites (Arakawa, 1981; Sharaf, 1985). Up till now, the functional response of this parasite has not yet been studied in detail. To examine the potentiality of *E. sp.* as a natural enemy on *B. tabaci* and provide the necessary parameters for population simulations (DeGrandi-Hoffman et al., 1994), we try to analyze the types and parameters of the functional responses of *E. sp.* on *B. tabaci* based on parasitization and host feeding on poinsettia, and conducted the experiment to determine the parasitoid success rate of *E. sp.* against *B. tabaci*. *sp.*

2 Materials and Methods

In the experiment for functional responses, five treatments, i.e., 1, 5, 10, 25, and 50 of the 2nd instar nymphs of *B. tabaci* (N2) for each plant, 4-8 replicates for each treatment, were used for parasitoid release. In addition, there was a control treatment of 4 replicates, 50 N2 for each treatment. The plant poinsettia were raised from 4-5 leaves of seedlings in the pots, then moved into laboratory with 25°C and received artificial lights (eight 40 watt Gro-Lux plant florescent tubes). After then, plant received different densities of whitefly adults to deposit eggs. On one leaf for each plant, adults were limited with clip cage. After 24hs of depositing eggs, all adults and clip cages were removed from plants. While the eggs developed into N2, the surplus nymphs were removed off to obtain the N2 densities indicated above. Then one female *E. sp.* was released for each treatment on a single plant with cage (25.5cm height and 24.5cm diameter for cage and 231cm² of total leaf area for each plant). After 24hs of parasitizing and feeding, the parasites were removed from each plant. At pupae stage, examine the parasitism of the whitefly pupa and host feeding number for each treatment.

The experiment with 3rd instar nymph of *B. tabaci* was all the same as for N2.

In the experiment for parasitoid success rate of *E. sp.*, the plant poinsettia were raised in the pots, and moved into laboratory. Two treatments, i.e., releasing *E. sp.* on plant inside cage and without cage, were used. Several adult *B. tabaci* were placed on the leaves for each plant to lay eggs. While *B. tabaci* developed into 2nd or 3rd instar nymphs, several *E. sp.* were released on leaves of each plant to parasitize. After *B. tabaci* have puparized, record the percentage of emerged *E. sp.* from parasitized *B. tabaci*. Each treatment was replicated 11 times in different periods.

3 Results and Discussion

3.1 Functional responses for parasitization

The experimental results, indicated as in Fig.1, show that the functional responses for parasitization of *E. sp.* on 2nd and 3rd instar nymphs of *B. tabaci* coincide with the Holling–III equation (1965)

$$N_a = bTN^2 / (1 + cN + bT_h N^2) \quad (1)$$

where c and b are constants, N is the number of the host, N_a is the parasitized number of the host, T_h is handling time, and T is the total time ($T=1$ in present study).

The parameters for eq. (1) are indicated in Table 1. According to Table 1, the handling time for the 3rd instar nymph (117.2 min) is longer than that for the 2nd instar nymph (76.2 min). The maximum parasitization, which is the reciprocal of the handling time (days), for the 2nd instar nymph is 18.9 per day and for the 3rd instar nymph is 12.3 per day. It seems that the larger nymph body will take much more parasite's time to

parasitize.

3.2 Functional responses for host feeding

The results in Fig. 2 show that the functional responses of host feeding of *E. sp.* on 2nd and 3rd instar nymphs of *B. tabaci* coincide with the Holling-II equation (Holling, 1965)

$$N_a = a'TN / (1 + a'T_hN) \quad (2)$$

where N_a , N , T_h , and T are the same as in eq. (1), a' is attack rate, $T=1$. The parameters for eq. (2) are listed in Table 2. Obviously the maximum host feeding against 2nd instar nymph of *B. tabaci* is 7.1 per day and for 3rd instar nymph is 4.8 per day. The larger nymph body will provide much more body fluid for the parasite to suck.

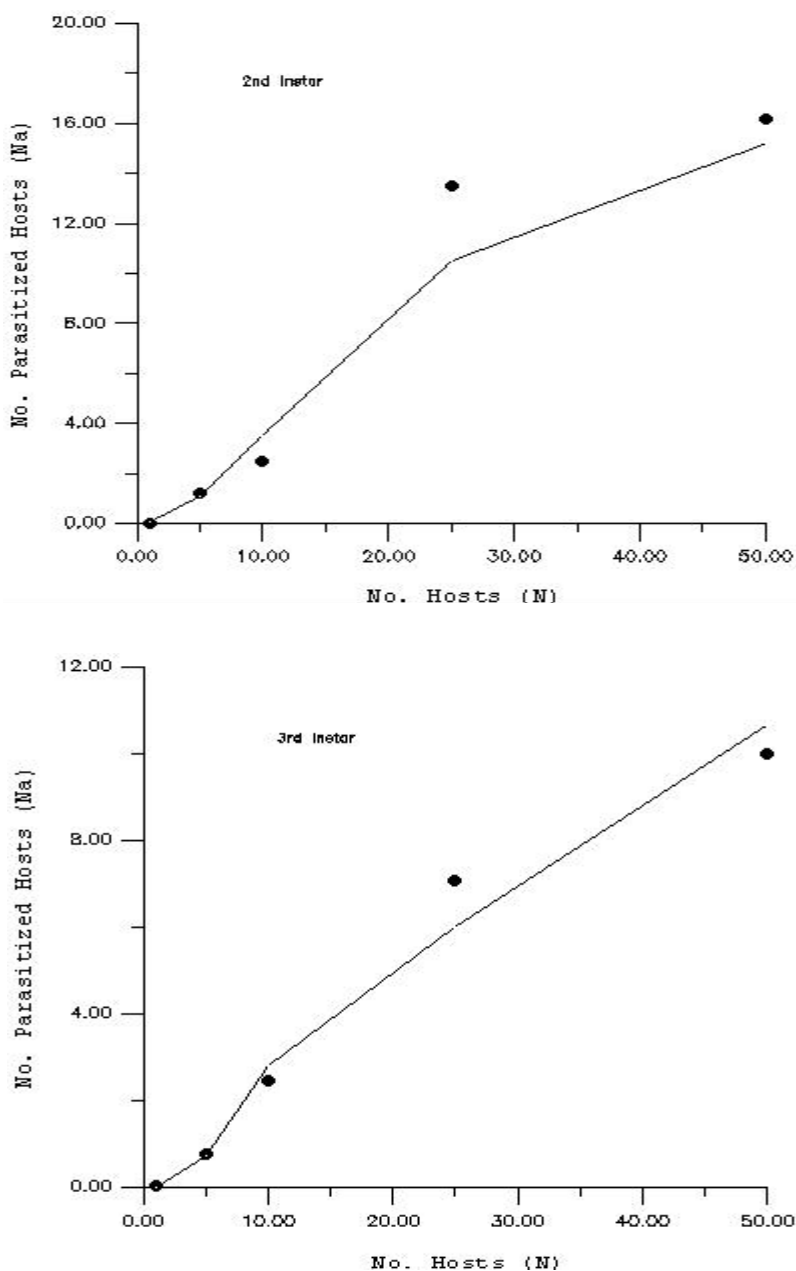


Fig. 1 Functional responses for parasitization of *E. sp.* on 2nd and 3rd instar nymphs of *B. tabaci*, where the real lines represent the simulated results based on eq. (1).

Table 1 Functional responses for parasitization of *E. sp.* on 2nd and 3rd instar nymph of *B. tabaci* based on eq. (1), where c , b are constants and T_h is the handling time(days).

Nymph instars	b	c	T_h	df	F	p
2 nd	0.0482	0.0106	0.0529	3	147.75	<0.01
3 rd	0.0346	0.0118	0.0814	3	147.75	<0.01

F is the F -value for the linear regression between the simulated and observed parasitized number of hosts. $df1=1$, $df2=df$.

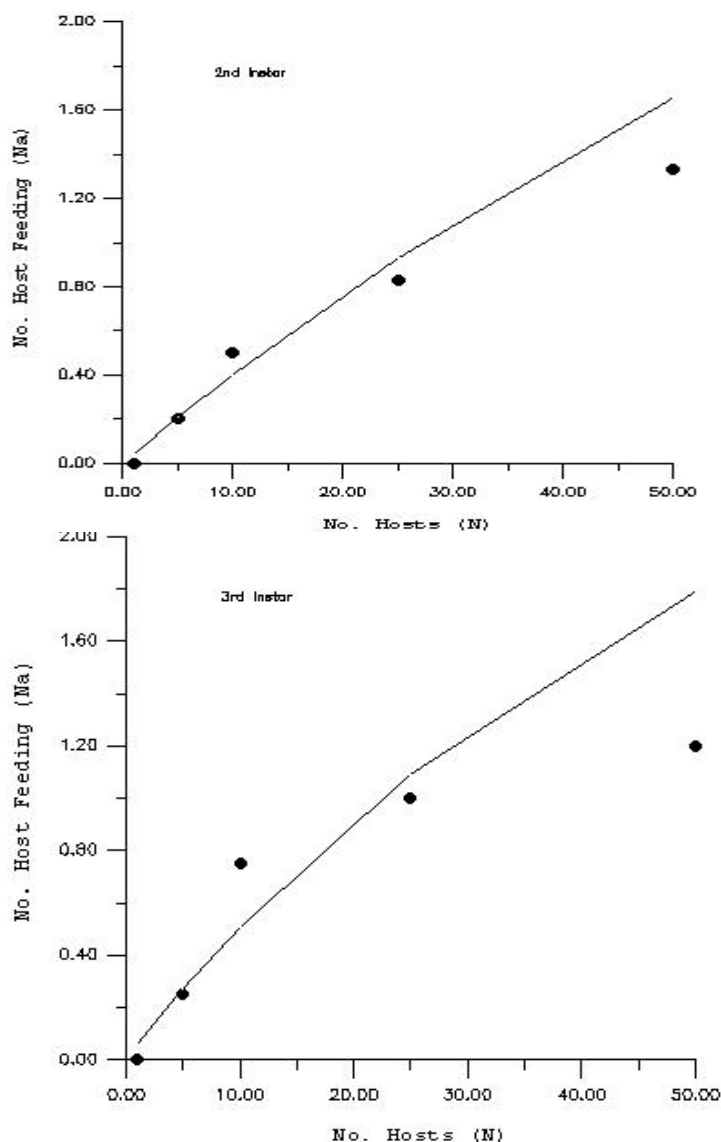


Fig. 2 Functional responses for host feeding of *E. sp.* on 2nd and 3rd instar nymphs of *B. tabaci*, where the real lines represent the simulated results based on eq. (2).

The parameters for eq. (1) are indicated in Table 1. According to Table 1, the handling time for the 3rd instar nymph (117.2 min) is longer than that for the 2nd instar nymph (76.2 min). The maximum parasitization, which is the reciprocal of the handling time (days), for the 2nd instar nymph is 18.9 per day and for the 3rd instar nymph is 12.3 per day. It seems that the larger nymph body will take much more parasite's time to parasitize.

Table 2 Functional responses for host feeding of *E. sp.* on 2nd and 3rd instar nymph of *B. tabaci* based on eq. (2), where a' is the attack rate and T_h is the handling time(days).

Nymph instars	a'	T_h	df	F	p
2nd	0.0429	0.1401	3	147.75	<0.01
3rd	0.0586	0.2075	3	19.2	<0.05

F is the F -value for the linear regression between the simulated and observed host feeding number. $df1=1$, $df2=df$.

Compared the host feeding with parasitization, the former accounts for approximately 37%-39% of the later based on the maximum values, and accounts for approximately 12%-22% based on the average data, which indicates that the host feeding of *E. sp.* is an important factor in the natural control of *B. tabaci*.

3.3 Success parasitization rate of *E. sp.*

The experimental results for parasitoid success rate of *E. sp.* against *B. tabaci* are shown in Table 3. It can be concluded from Table 3 that the parasitoid success rates for all replicates are stable and the average is 86.5%.

Table 3 Success rate (%) of *E. sp.* emerged from parasitized *B. tabaci*.

Replicates	1	2	3	4	5	6	7	8	9	10	11	Mean
Inside cage	88	92	82.6	88.8	74.8	96.3	89.6	91.3	87.7	92.4	75.3	87.2
Outside cage	86	96	75	82.3	74.8	96	89.1	92	92.1	91	71.5	86.0

The functional responses in field situations frequently appeared as Holling-II type. Holling-III type, however, was also commonly occurred in laboratory and field conditions (Lenteren et al., 1978). Collins et al. (1981) observed the Holling-III response for *Aphelinus thomsoni* even in the variable-time experiment. With *B. tabaci* as the host, Lopez Avila (1988) observed a maximum parasitization of 12.8 per day for *Encarsia formosa*. Enkegaard (1992) discovered that the maximum oviposition of *E. Formosa* on *B. tabaci* was 10.4 on poinsettia when the parasite could leave plant. In addition, the handling time in parasitization of *E. Formosa* against *B. tabaci* was reported as 78-120 min (Lopez Avila, 1988; Enkegaard, 1992), which is similar to present study. Compared with the present results, it could be concluded that the *E. sp.* has a greater potentiality in the natural control of *B. tabaci*.

The parasitoid success rate of 86.5% also reveals that *E. sp.* is a parasite with high efficiency, even though a small proportion of parasitized *B. tabaci* will not be useful in the augmentation of *E. sp.*

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