Original article KOREAN JOURNAL OF APPLIED ENTOMOLOGY

한국응용곤충학회지
Korean J. Appl. Entomol. 51(4): 343-348 (2012)
DOI: http://dx.doi.org/10.5656/KSAE.2012.08.0.042

pISSN 1225-0171, eISSN 2287-545

복숭아혹진딧물에 기생하는 목화면충좀벌의 발육단계별 온도영향

최용석 · 황인수 · 박덕기[1] · 최광렬[2]*
충청남도농업기술원 농업환경연구과, [1](주)에코솔라텍, [2]충남대학교 농업생명과학대학 농생물학과

Effect of Temperature at Different Performance Stages of *Aphelinus varipes* (Hym. Aphelinidae) Parasitizing the Green Peach Aphid, *Myzus persicae*

Yong Seok Choi, In Su Hwang, Deog Gee Park[1] and Kwang Ryul Choe[2]*
Bioenvironment Research Division, Chungcheongnam-do Agricultural Research & Extension Services, Yesan 340-861, Republic of Korea
[1]Eco Solatec # 203, Growing Venture Support Building, Bio 21 Center, 1033 Munsan, Jinju, Gyeongnam, Republic of Korea
[2]Department of Applied Biology, Chungnam National University Daejon 305-764, Republic of Korea

ABSTRACT: Developmental period, mummification, pupal mortality, and sex ratio of Korean strain of *Aphelinus varipes* Förster parasitizing the green peach aphid, *Myzus persicae* were studied at 20, 25, 30, and 35℃ in controlled climate cabinets. The plastic container with a leaf disc of sweet pepper (*Capsicum annuum* L.) was used as experimental units. Green peach aphids at different developmental stages were reared in four different temperatures and presented to *A. varipes* for 12 hours. A female adult of *A. varipes* was allowed to parasitize for 12 hours in each plastic petri dish. The periods from egg to adult of *A. varipes* were 18.3 days, 14.7 days, 10.4 days, and 9.3 days at 20℃, 25℃, 30℃, and 35℃, respectively. The pupal mortalities of *A. varipes* were 0%, 1.5%, 2.8%, and 10.2% at 20℃, 25℃, 30℃, and 35℃, respectively. The mummifications of *A. varipes* were significantly different in all developmental stages of the aphid. The mummification of *A. varipes* parasitizing green peach aphid was the highest at 1st and 2nd in 20℃ and 25℃, but the highest at 3rd (84.4–85.0%) in 30℃ and 35℃. The host feedings of *A. varipes* were 20℃ (12.5%), 25℃ (17.3%), 30℃ (16%), and 35℃ (10.9%), respectively. The sex ratios of *A. varipes* female were 20℃ (49%), 25℃ (46%), 30℃ (69%), and 35℃ (60%), respectively.

Key words: *Aphelinus varipes*, *Myzus persicae*, Developmental characteristics

초 록: 복숭아혹진딧물에 기생하는 목화면충좀벌의 발육기간, 머미율, 번데기 사망률, 성비를 20, 25, 30, 25℃ 인큐베이터에서 수행하였다. 실험을 위하여 피망잎이 놓인 콤팩트샤레를 사용하였다. 각각의 4개 온도에서 발육단계별로 복숭아혹진딧물을 사육하였고 기생을 유도하기 위하여 12시간 동안 목화면충좀벌에 제공하였다. 목화면충좀벌의 알에서 성충까지 발육기간은 20℃ 18.3일, 25℃ 14.7일, 30℃ 10.4일, 35℃ 9.3일 이었다. 복숭아혹진딧물에 기생한 목화면충좀벌의 머미율은 20℃와 25℃, 1령과 2령에서 가장 높았으나 30℃와 25℃에서는 3령충에서 84.4~85.0%로 가장 높았다. 목화면충좀벌의 기주섭식률은 20~35℃까지 각각 12.5%, 17.3%, 16.0%, 10.9%였다. 목화면충좀벌 암컷의 성비는 온도별로 각각 49%, 46%, 69%, 60% 였다.

검색어: 목화면충좀벌, 복숭아혹진딧물, 발육특성

The cotton aphid, *Aphis gossypii* and the green peach aphid, *Myzus persicae* are major pests on cucumber and sweet pepper in greenhouses (Van Schelt, 1993), and these occurrences in other greenhouse crops are increasing (Van Steenis, 1995). As the cotton aphid and green peach aphid have developed resistance to many commonly used pesticides (Gubran *et al*., 1993), exploring natural enemies that can be used in the biological control of these aphids is quite an interesting study. The purpose of this study is to determine whether *A. varipes*

***Corresponding author:** yschoi92@korea.kr
Received July 6 2012; **Revised** August 8 2012
Accepted October 5 2012

could supplement the aphidiinae species (Braconidae) that are used in the biological control of cotton aphid and green peach aphid in greenhouses today.

Few aphelinids are known to parasitize the cotton aphid and the green peach aphid successfully. Only *Aphelinus asychis* and *A. abdominalis* have been used for biological control of the cotton aphid (Wyatt, 1967). Van Steenis (1995) collected life history data from a strain of *A. varipes* from Cameroon with the cotton aphid as host. The data concluded that *A. varipes* could be useful in biological aphid control programs, especially when used together with *Aphidius colemani* Viereck (Hym., Aphidiidae).

Different strains of one parasitoid species can have different life history parameters. Due to intraspecific variability, choosing the right strain is of crucial importance for the success of biological control (Haardt and Holler, 1992). In this study, some important life history traits of a Korean strain of *A. varipes* parasitizing the green peach aphid are described. The traits studied were host feeding, mummification, pupal mortality, developmental period, and sex ratio when green peach aphids in different stages were presented to *A. varipes*. Green peach aphids are large and dark green at lower temperatures, but they are smaller and light green (Blackman and Eastop, 1984; Aldyhim and Khalil, 1993) at higher temperatures. The experiment was performed at 20℃, 25℃, 30℃, and 35℃ to find out whether this morphological variation had any influence on the traits studied.

Materials and methods

Host plants

Sweet pepper (*Capsicum annuum* L.) were grown in a greenhouse at 25±5 ℃ and moderately fertilized. We inoculated aphids on the plants cultured for 3-5 weeks (about 10-15 cm). The plants inoculated were maintained in acrylic cage (500 mm^3) and transferred to the controlled climate room. To avoid contamination of other pests to the plants, the plants were cultured in net cages (1,000 × 2,000 × 1,500 mm).

Host aphid

We collected the green peach aphids on greenhouse peppers at Yuseong, Daejeon, Republic of Korea in year 2000. They were transferred to laboratory and were reared successively under the described conditions. To avoid their contamination by other natural enemies, they were isolated with acrylic cages (500 × 500 × 500 mm). The acrylic cage had the draft hull with a net (80 mesh).

Parasitoid

Aphelinus varipes is distributed in Korea (Paik, 1978). This species was collected from the colonies of wheat aphid, *Rhopalosiphum padi* L. on barley field, Yuseong, Daejeon, Republic Korea in March 2000. They were transferred to green peach aphids and cultured on sweet pepper. The experiments were performed 4 years later.

The rearing of *A. varipes* was held in cages at 25±2℃ temperature, 16L:8D light. The parasitoids used in the experiments were 24-hour-old mated females placed in emergence vials (Ø1.6 cm × H6.3 cm). They had some host experiences from green peach aphids placed in the emergence vials for host feeding (2-3 aphids per parasitoid) the day before the experiments.

Experimental units

At first, petri dishes (Bock, Art. Nr. 41113, 31 mm in height; 77 mm in diameter) that Van Schelt (1993) indicated were used despite the insignificant diameter and height. Therefore, we used petri dishes with a diameter of 90 mm and a height of 50 mm for the experiments. Nets (80 mesh, 40 mm in diameter) were incorporated into the lids for air exchange. In order to adhere to leaf disc for each petri dish, Van Schelt (1993) and Röhne (2002) used water agar but the moisture was not maintained in petri dish. Therefore, we used square absorbent cotton (40 mm × 40 mm) instead of water agar. Square absorbent cotton wetted with distilled water was adhered to bottom of each petri dish and a punched sweet pepper leaf disc was placed upside down on the square absorbent cotton. The petri dishes were placed upside down on shelves (with ventilation hole) to simulate a more natural condition for the aphids and prevent the leaf from being contaminated by honeydew and mold (Van Schelt, 1993).

Experimental procedure

Experiments were carried out in all five host stages and at four different development temperatures: 20℃, 25℃, 30℃, and 35℃. The climate cabinets with 16L: 8D were used. Ten adult green peach aphids were placed in each petri dish for 24 hours. When the offspring of these aphids had reached the desired stages, 50 aphids per dish were selected, while the surplus was removed. Three replicates (dishes) were found for each of the 20 combinations of aphid stages and temperatures.

Two female parasitoids were allowed to host feed and parasitize in each petri dish for 12 hours at different temperatures. The parasitoids were then removed from each petri dish. The proportion of aphids mummified was used to measure the host acceptance of *A. varipes* and the suitability of the host in a no-choice situation. Host feeding, pupal mortality, sex ratio, and development time from egg to mummy (pupa) and from mummy to adult were measured. The mummies were transferred to glass vials (50 mm height; 20 mm diameter) for enclosure.

Data analysis

The data were examined using a two-way analysis of variance (ANOVA) and checked for interaction. Data on development time were analyzed using the averages for each petri dish. Multiple comparisons were made using an LSD-procedure (α= 0.05) with Bonferroni adjustment (Reimer, 1959).

Results

The total developmental period from egg to an emergence of *A. varipes* adult parasitizing the green peach aphid was 20℃ (18.3 days), 25℃ (14.7 days), 30℃ (10.4 days), and 35℃ (9.3 days) while the shortest is at 30℃ and 35℃ (Table 1). The developmental period for Korea strain of *A. varipes* was in accord with the Norwegian strain parasitizing the cotton aphid (Röhne, 2002) and was about a day longer than the African strain (Van Steenis, 1995). The pupal mortality of *A. varipes* was 20℃ (0 %), 25℃ (1.6 %), 30℃ (2.8℃), and 35℃ (10.4 %), and the highest at 35℃ (Fig. 1). These results were in accord with many experiments where the pupal mortality of *Aphelinus* species was not influenced by temperature of up to about 32℃ (Force and Messenger, 1964a; Tang and Yokomi, 1995). Therefore, the optimum temperature of development of *A. varipes* parasitizing the green peach aphid was inferred from 30℃ to 35℃.

Table 2 shows that the mummification rate of *A. varipes* parasitizing the green peach aphid at different developmental stages and at different temperatures was significantly different. The experiments indicated that *A. varipes* like other aphelinid

Table 1. Developmental Periods of *A. varipes* Parasitized from 1st to 4th Instar of *M. persicae* at Four Different Temperatures

Developmental Period	Temp. (℃)	Nymph (days, Mean±SD)								Adult		AVE	
Developmental period	Temp. (℃)	1st Instar		2nd Instar		3rd Instar		4th Instar		Adult		AVE	
From egg to mummy	20	7.4±0.6	(31)	8.4±1.0	(35)	8.3±0.5	(18)	8.2±0.4	(16)	7.4±0.6	(17)	7.9±0.8	(117)*
	25	6.5±0.7	(35)	6.6±1.1	(25)	6.2±0.4	(12)	5.7±0.9	(17)	6.3±0.8	(12)	6.3±0.9	(101)
	30	4.4±0.5	(44)	4.2±0.5	(30)	4.6±1.3	(49)	4.7±0.9	(27)	5.1±1.1	(38)	4.6±1.0	(188)
	35	4.6±0.5	(14)	4.1±0.4	(22)	3.9±0.4	(48)	3.5±0.8	(20)	4.3±0.5	(17)	4.0±0.6	(121)
From mummy to adult	20	10.9±0.6	(31)	10.1±1.1	(33)	10.8±0.4	(18)	10.8±0.5	(16)	9.7±0.8	(17)	10.4±0.9	(115)
	25	8.5±0.6	(35)	8.4±0.6	(25)	8.4±0.7	(11)	8.2±0.7	(15)	8.0±0.5	(11)	8.3±0.6	(97)
	30	5.9±0.4	(35)	6.0±0.4	(23)	5.9±0.6	(43)	5.7±0.6	(25)	5.7±0.6	(29)	5.8±0.5	(155)
	35	5.7±0.8	(14)	5.3±0.5	(21)	5.3±0.5	(36)	5.2±1.0	(18)	5.1±0.4	(17)	5.3±0.7	(106)
From egg to adult	20	18.3±0.6	(31)	18.4±1.4	(33)	19.1±0.2	(18)	18.9±0.3	(16)	17.1±1.0	(17)	18.3±1.1	(115)
	25	15.0±0.6	(35)	15.0±1.3	(25)	14.5±1.0	(11)	14.0±1.3	(15)	14.4±0.9	(11)	14.7±1.1	(97)
	30	10.3±0.5	(35)	10.2±0.5	(23)	10.5±1.0	(43)	10.4±0.8	(25)	10.6±0.9	(29)	10.4±0.8	(155)
	35	10.3±0.9	(14)	9.4±0.5	(21)	9.1±0.4	(36)	8.7±1.0	(18)	9.4±0.6	(17)	9.3±0.8	(106)

* No. of observed aphids

species (Stary, 1988; Tang and Yokomi, 1966) have the highest parasitization rate for the earlier host instars. In case of 20℃, the mummification rate of *A. varipes* parasitizing the green peach aphid was 1st (52.2 %), 2nd (58.3 %) at 20℃ and 1st (60.0 %), 2nd (48.9 %) at 25℃. The result in 30℃ (df = 14, F = 36.60, P < 0.0001), *A. varipes* shown the higher oviposition compared with other temperatures and was the highest at 3rd (85.0 %). In 35℃ (df = 14, F = 206.85, P < 0.0001), *A. varipes* preferred 3rd (84.4 %) instar to the other stages. This Korean strain of *A. varipes* preferred 1st and 2nd in low temperatures (20 and 25℃), but 3rd in high temperatures (30 and 35℃). These results were in accord with the Norwegian strain of *A. varipes* (Röhne, 2002).

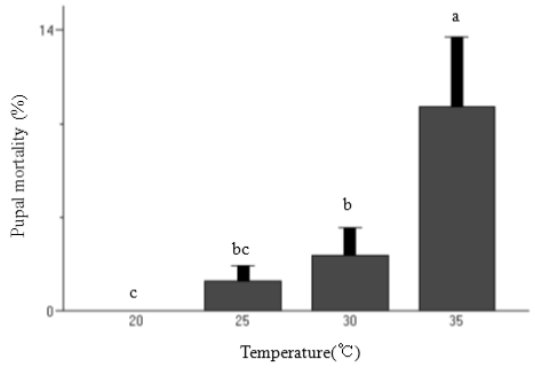

Fig. 1. The mortality of *Aphelinus varipes* parasitizing *Myzus persicae* at four different temperatures.

Table 3 shows the life table of *A. varipes*. Aphids killed by host feeding were easily recognized due to a red-brown color and a shrunken appearance. The rates of host feeding by *A. varipes* at different temperatures were 12.5 %, 17.3 %, 16.0 %, and 10.9 %. The host feeding of Korean strain *A. varipes* was higher than Norwegian strain at 10% (Röhne, 2002). The averages of host feeding rates by *A. varipes* at different stages of green peach aphid were 20℃ (12.5 %), 25℃ (17.3 %), 30℃ (16 %), and 35℃ (10.9 %) respectively, and the higher temperature, the higher host feeding rate but it decreased at 35℃. The highest rates of host feeding were 1st at 30℃ (23 and 23.3 %), and 2nd

Table 2. Percentage Mummified Green Peach Aphids

Host Stage	1st Instar MeanSD	n	2nd Instar MeanSD	n	3rd Instar MeanSD	n	4th Instar MeanSD	n	Adult MeanSD	n
20℃	52.2±5.85a	3	58.3±1.67a	3	32.2±2.55b	3	28.3±1.67b	3	28.3±1.67b	3
25℃	60.0±1.67a	3	48.9±6.74a	3	23.3±4.41b	3	31.7±3.33b	3	22.8±2.55b	3
30℃	73.9±5.85ab	3	54.4±4.19dc	3	85.0±4.41a	3	48.3±3.33d	3	65.6±2.55bc	3
35℃	26.1±2.55c	3	37.8±1.92b	3	84.4±4.19a	3	37.2±3.47b	3	29.4±0.96bc	3

Different letters between host stages indicate a significant difference (P < 0.05; LSD with Bonferroni after a two-way ANOVA), n is the number of replicates (dishes with 60 aphids).

Table 3. shows the life history parameters of *Aphelinus varipes* with green peach aphid, *Myzus persicae* as host, parasitized in five different host stages. Two parasitoids were allowed to feed hosts and parasitize in each dish for 6 hours

Temp.	Host Stage	Parameters of Life History (%, Mean±SD)				
Temp.	Host stage	1st	2nd	3rd	4th	Adult
20	Host feeding (%)	16.8±5.68a	17.8±4.1a	15.5±6.47a	8.8±4.25b	3.8±3.93c
	Pupal mortality (%)	0±0.00a	0±0.00a	0±0.00a	0±0.00a	0±0.00a
	Sex ratio (%, fem.)	0.45±0.11a	0.51±0.12a	0.52±0.14a	0.43±0.14a	0.51±0.11a
25	Host feeding (%)	21.3±6.26a	23.5±7.27a	20.3±4.72a	12.5±5.74b	8.8±5.59b
	Pupal mortality (%)	1.5±3.17a	1.7±4.25a	1.5±4.78a	1.7±5.36a	1.4±4.40a
	Sex ratio (%, fem.)	0.52±0.10ab	0.54±0.10a	0.35±0.18c	0.45±0.10abc	0.43±0.13bc
30	Host feeding (%)	23.0±5.94a	23.3±4.06a	15.0±5.62b	11.0±4.17bc	7.8±5.73c
	Pupal mortality (%)	2.7±4.06a	2.8±5.55a	3.0±3.63a	2.8±6.15a	2.6±4.22a
	Sex ratio (%, fem.)	0.45±0.08d	0.88±0.05a	0.60±0.12c	0.73±0.07b	0.80±0.09b
35	Host feeding (%)	14.0±7.00a	15.0±5.62a	11.8±6.34ab	8.3±4.94bc	5.3±4.44c
	Pupal mortality (%)	10.3±14.79a	10.5±10.87a	10.1±7.27a	10.4±13.42a	10.7±11.71a
	Sex ratio (%, fem.)	0.50±0.14c	0.50±0.09c	0.63±0.11ab	0.61±0.10b	0.73±0.09a

The means followed by the same letter in a column for each temperature are not significantly different by LSD at 5%.

at 25℃ (23.5 %). The smaller the side of the aphid, the higher the rates will be for the host feeding in different temperatures. The pupal mortality of *A. varipes* was in proportion with the increase of temperature but increased up to 30℃ and increased rapidly at 35℃. The sex ratios (female) of *A. varipes* at different temperatures were 20℃ (48.5 %), 25℃ (46 %), 30℃ (68.9 %), and 35℃ (59.5 %), respectively. The highest sex ratio of *A. varipes* female was 2nd at 30℃ (87.9%). This result was lower compared with Röhne's result at 74 – 95 %.

Discussion

The amount of host feeding of *A. varipes* was similar to other *Aphelinus* species (Cate *et al*., 1977; Kuo, 1986; Tang and Yokomi, 1996; Tokumaru and Takada, 1996). In size and color, the variation of green peach aphids that reared at different temperatures only seemed to have an effect on the sex ratio allocation of the egg-laying *A. varipes.* The number of aphids killed by host feeding had no great variation between the rearing temperatures but a great variation of the parasitization rate was observed. The pupal mortality of *A. varipes* increased with the temperature. However, Aphidiinae-species have a higher juvenile mortality at higher temperatures (Force and Messenger, 1964b).

The experiments indicate that *A. varipes*, like other aphelinid species, have the highest parasitization rate for the earlier host instars (Stary, 1988; Tang and Yokomi, 1996). Many Aphidiinae species, on the other hand, show a preference for second and third instar aphids (Hagvar and Hofsvang, 1991), or show no clear host-stage preferences (Völkl *et al*., 1990). The host stage preference and host stage suitability are often correlated with parasitoids (Godfray, 1994). The lower rate of parasitization is more likely in the later host stages due to a more effective defense against parasitoids, thus making successful parasitization of older aphids more difficult (Force and Messenger, 1965; Cate *et al*., 1977; Gerling *et al*., 1990). In *A. asychis*, the host stage did not seem to influence the juvenile mortality of the parasitoid (Cate *et al*., 1977).

Green peach aphids are large and dark green at lower temperatures, while they appear smaller and light green (Blackman and Eastop, 1984; Aldyhim and Khalil, 1993) at higher temperatures. This morphological variation of aphid influences the mummification, the host feeding, and the sex ratio of *A. varipes*.

A. varipes could be a useful supplement to the aphidius species that are used in the biological control of the green peach aphid and cotton aphid in greenhouses today, as *A. varipes.* Unlike Aphidiinaes, host feeds on aphids in addition to parasitization, are less affected by high temperatures. *A. varipes* also prefers earlier aphid stages, and this may reduce potential competition between the parasitoid species if used together. The short developmental period at 20℃, 25℃, and 30℃ and the high proportion of females are properties that make the Korean strain of *A. varipes* an interesting alternative for the biological control of the green peach aphid and cotton aphid in greenhouse.

Literature Cited

Aldyhim, Y.N., Khalil, A.F., 1993. Influence of temperature and daylength on population development of *Aphis gossypii* on *Cucurbita pepo*. Entomol. Exp. Appl. 67, 167-172.

Blackman, R.L., Eastop, V.F., 1984. Aphids on the world's crops: An Identification and Information Guide. John Wiley and Sons, New York, Chichester, pp. 1-373.

Cate, R.H., Eikenbary, R.D., Morrison, R.D., 1977. Preference for and effect of greenbug parasitism and feeding by *Aphelinus asychis*. Environ. Entomol. 6, 547-550.

Force, D.C., Messenger, P.S., 1964a. Duration of development, generation time, and Longevity of three hymenopterous parasites of *Therioaphis maculata*, reared at various constant temperatures. Ann. Entomol. Soc. Am. 57, 405-513.

Force, D.C., Messenger, P.S., 1964b. Fecundity, reproductive rates, and innate capacity for increase of three parasites of *Therioaphis maculata* (Buckton). Ecology 45, 707-715.

Force, D.C., Messenger, P.S., 1965. Laboratory studies on competition among three parasites of the spotted alfalfa aphid *Therioaphis maculata* (Buckton). Ecology 46, 853-859.

Gerling, D., Roitberg, B.D., Mackauer, M., 1990. Instar-specific defense of the pea aphid, *Acyrthosiphon pisum*: influence on oviposition success of the parasite *Aphelinus asychis* (Hymenoptera: Aphelinidae). J. Insect Behav. 3, 501-514.

Godfray, H.C.J., 1994. Parasitoids: behavioral and evolutionary ecology. Princeton, N.J., Princeton University Press, pp. 3-364.

Gubran, E.M.E., Delorme, R., Auge, D., Moreau, J.P., 1993. Pyrethroids and organochlorines resistance in cotton aphid *Aphis gossypii* (Glov.)(Hom. : Aphididae) in the Sudan Gezira. Int. J. Pest Manage. 39, 197-200.

Haardt, H., Höller, C., 1992. Differences in life history traits between isofemale lines of the aphid parasitoid *Aphelinus abdominalis* (Hymenoptera: Aphelinidae). Bull. Entomol. Res. 82,

479-484.

Hagvar, E.B., Hofsvang, T., 1991. Aphid parasitoids (Hymenoptera: Aphidiidae): biology, host selection and use in biological control. Biocontr. News Inform. 12, 13-41

Kuo, H.L., 1986. Resistance of oats to cereal aphids: effects on parasitism by *Aphelinus asychis* (Walker),. *In*: Boethel, D.J., Eikenbary, R.D. (Eds), Interactions of plant resistance and parasitoids and predators of insects. Ellis Horwood Ltd, NewYork, Chichester, pp. 125-137

Röhne, O., 2002. Effect of temperature and host stage on performance of *Aphelinus varipes* Förster (Hym., Aphelinidae) parasitizing the cotton aphid, *Aphis gossypii* Glover (Hom., Aphididae). J. Appl. Ent. 126, 572-576.

Paik, J.C., 1978. A list of Chalcidoidea, Hymenoptera from Korea. Korean J. Pl. Port. 17(3), 167-185.

Reimer, C., 1959. Statistical analysis of percentages based on unequal numbers, with examples from entomological research. Can. Entomol. 91, 88-92.

Stary, P., 1988. Aphelinidae. pp. 185-188. Aphids: Their Biology, Natural Enemies and Control. *In*: Minks, A.K., Harrewjin, P. (Eds.), Vol. 2B. Amsterdam, Elsevier, pp.185-188.

Tang, Y.Q., Yokomi, R.K., 1995. Temperature-dependent development of three hymenopterous parasitoids of aphids (Homoptera: Aphididae) attacking citrus. Environ. Entomol. 24, 1736-1740.

Tang, Y.Q., Yokomi, R.K., 1996. Biology of *Aphelinus spiraecolae* (Hymenoptera: Aphelinidae), a parasitoid of the spirea aphid (Homoptera: Aphididae). Environ. Entomol. 25, 519-523.

Tokumaru, S., Takada, H., 1996. Numbers of eggs deposited and host feeding in *Aphelinus gossypii* Tiberlake (Hymenoptera: Aphelinidae), a parasitoid of *Aphis gossypii* Glover (Homoptera: Aphididae). Jpn. J. Appl. Entomol. Zool. 40, 242-244.

Van Schelt, J., 1993. A fecundity test for the aphid parasite Aphidius sp. *In*: Benuzzi, G.N., Leppla, M.N.C., (Eds.), Proceedings of the seventh workshop of the global IOBC working group 'quality control of mass reared arthropods'. Italy, pp. 191-199.

Van Steenis, M.J., 1995. Evaluation and application of parasitoids for biological control of *Aphis gossypii* in glasshouse cucumber crops. PhD Thesis, Wageningen Agricultural University, Wageningen, The Netherlands, pp. 48-57.

Völkl, W., Stechmann, D.H., Stary, P., 1990. Suitability of five species of Aphidiidae (Hymenoptera) for the biological control of the banana aphid *Pentalonia nigronervosa* Coq. (Homoptera: Aphididae) in the South Pacific. Trop. Pest Manage. 36, 249-257.

Wyatt, I.J., 1967. Parasite control of *Aphis gossypii* on cucumbers. Glasshouse Crops Res. Inst. Littlehampton. Annu. Rep. 1968, 86-87.