Host-Parasitoid Relationship Between the Parasitoid, *Anagyrus kamali* Mourse (Hymenoptera: Encyrtidae) and the Pink Hibiscus Mealybug, *Maconellicoccus hirsutus* (Green), (Homoptera: Pseudococcidae)

Ahmed[*], S. A.; A. A. El-Saedi[**]; H. M. Ahmed[**] and A. M. Sayed[***]

[*]Faculty of Environ. Agric. Sci., Suez Canal Univ., El-Arish, Egypt

[**]Faculty of Agric.., El Azahr Univ., Cairo, Egypt

[***] Plant Protection Research Institute, Agric. Res. Center, Giza, Egypt

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ABSRATCT

The encyrtid parasitoid, *Anagyrus kamali* Mourse (Hymenoptera: Encyrtidae) females parasitizes all stages of the pink hibiscus mealybug (PHM), *Maconellicoccus hirsutus* (Green), (Homoptera: Pseudococcidae). Mean number of hosts parasitized, total number of eggs laid and average number of deposited eggs/ adult female and third nymphal instar of PHM differed significantly than all other stages. Thus, *A. kamali* prefers older nymphal instars and seemed to be more efficient on adult females. Duration periods and number of the emerged parasitoids from the 1st and 2nd nymphal instars were more than that from 3rd nymphal instar and adult females. Developmental periods of 3rd nymphal instar and adult females were 8.1 days faster than that of 1st and 2nd nymphal instars. Time spent for oviposition significantly decreased with increasing host age. In contrast was the time spent for preening. Also, the results strongly suggest that the *A. kamali* has perfect discrimination capabilities. Studied females showed a reproductive period of 11.9±1.46 days. The mean total number of eggs was 98.4±8.64 eggs/female. Daily number of eggs/female laid was 8.5±0.41 eggs. Longevity of unmated females was generally longer than that of the mated females.

Key Words: *Maconellicoccus hirsutus*, *Anagyrus kamali*, Searching behavior, Reproductive capacity, Longevity

INTRODUCTION

Maconellicoccus hirsutus (Green) (Homoptera: Pseudococcidae) commonly named the hibiscus or pink mealybug (PHM), has become a major pest on several crops. It injects a toxin at the site of feeding, causing severe distortion of leaves, new shoots, and fruits (Williams 1996). *M. hirsutus* was the most injurious mealybug species occurring in Egypt, following its introduction to Egypt about 1908, presumably from India, and by 1926 it was generally distributed all over the country (Mousa *et al.*, 2001).

Because of its wide host range and rapid geographical expansion, not only to agricultural lands but also to home gardens and forest areas, biological control should be an important tactic to mange the hibiscus mealybug populations.

The parasitoid, *Anagyrus kamali* Moursi (Hymenoptera: Encyrtidae) is a solitary endoparasitoid, prefers the host hibiscus mealybug (Moursi, 1948a) and attacks; *Nipaecoccus viridis* (Meyerdirk *et al.*, 1988) and *Ferisia virgata* (Cross and Noyes, 1996). In Egypt, *A. kamali* was recorded as one of 8 primary parasitoids attacking PHM on *Hibiscus* plants (Mousa *et al.*, 2001). Few studies have been published on the behavior of the encyrtid parasitoid, *A. kamali*.

Understanding parasitoid-host interactions is useful not only for mass production of this parasitoid, but also for optimization the timing of field releases. In nature, parasitoid frequently encounters mixed populations of mealybugs and must have evolved an array of behavioral, ecological, and physiological adaptations to discriminate among susceptible and preferred host stages (Boavida *et al.*, 1995 and Bokonon Ganta *et al.*, 1995). Hence, it might be important for implementation in biological and integrated control programs.

Objectives of the present study were determination of susceptible mealybug's stages for parasitization with *A. kamali*, host preference and preferred host stages for oviposition, development and mass production.

MATERIALS AND METHODS

Maconellicoccus hirsutus culture

PHM was reared on sprouted potatoes in aluminium cheesecloth cages (60x 60 x 100 cm.) away from any pesticides contamination or insect infestation. Culture of PHM was kept under the controlled greenhouse conditions at 25 ± 2°C and 65±5 % R.H. Three weeks after infestation, the potatoes had PHM individuals; consisted mainly of 1st nymphal instar (NI) (6-8 days), 2nd NI (10-12 days), 3rd NI (15-20 days) and adult females. This procedure minimized quality differences due to the

instar size and guaranteed that all hosts of each particular instar were of approximately have the same length.

Anagyrus kamali culture

A. kamali was obtained from samples collected from different areas infested with PHM in Ismailia Governorate and was reared on sprouted potatoes as outlined by Fisher (1963). The culture was kept in cages (60x60x100 cm.) covered with cheese cloth away from pesticides contamination under the laboratory conditions of 26°C ± 2 and 65±5 % R.H., and 12 hrs daily illuminations by using fluorescent tubes of 40 watt. Adult females of the parasitoid were released weekly into the cages containing infested sprouted potatoes supporting 3-week old individuals of PHM. Two-day old mated females of the parasitoid were used for experiments. Parasitoid rearing was maintained at 25 ± 2°C and 65±5 % R.H. and a photoperiod of LD 12:12 using fluorescent tubes of 40 watt. Emerged parasitoid adults were collected after 20-25 days.

Searching behavior of *A. kamali*

Choice and non-choice experiments were carried out in the morning to avoid possible differences in foraging behavior arising from the wasps' daily rhythm. Before each observation, Petri dishes (9 cm diameters) were left upside down for 24 h to allow settlement of PHM and to avoid excessive accumulation of honeydew on the leaf. The Petri dish lid was replaced by a clean one and a diagram identifying each mealybug and its location on the leaf was made to facilitate observations on frequency of host encounter and stinging. Under artificial light of a stereomicroscope started with introduction of one female parasitoid into the arena. Each parasitoid was continuously observed for 30 min. and the duration of each type of behavior was recorded. Observations on the parasitoids spent more than 10 consecutive min. walking on the lid were discontinued. For each sting, any defensive reaction by the host was observed, and stung hosts were not removed.

1. Host stage susceptibility (No-choice experiment)

Host stages of PHM were transferred from the culture to hibiscus leaf, (*Hibiscus rosasinensis*), placed into a 9-cm diameter glass petri dish on the top of a moistened cotton bottom. Its edges were sealed with cellotape to prevent the insects from crawling underneath and thus escaping observation. In this experiment, a single parasitoid female was introduced into each dish. Ten PHM at the same stage were offered to the parasitoid. Ten batches of each mealybug stage were exposed to individual parasitoid females (total of 40 parasitoid tested). Adult parasitoids were removed. Each host was immediately dissected in a drop of saline solution (Ringer's solution). Number of encounters, ovipositor probing, hosts parasitized by each *A. kamali* female, total number of eggs laid per parasitoid female and numbers of parasitoid eggs per accepted host were used as the criteria for determining host susceptibility.

2. Host stage preference (Choice experiment)

A simultaneously exposed five hosts from two different PHM stages on a hibiscus leaf was placed into a 9-cm diameter glass Petri dish. The following combinations of mealybug stages were used in the two-choice-tests: L1 vs L2, L1 vs L3, La vs adults, L2 vs L3, L2 vs adults, and L3 vs adults. One parasitoid female was introduced into each dish. Each host was immediately dissected in a drop of saline solution (Ringer's solution). The number of eggs in each host was recorded. Ten parasitoid females were used for each combination (total of 60 parasitoids tested). Number of encounters, probing, and hosts parasitized per female, total number of parasitoid eggs laid per replicate and numbers of parasitoid eggs per accepted host were used as the criteria for determining host preference. Host discrimination was analyzed by comparing the number of attacks resulting from encounters with hosts not parasitized before with the one resulting from encounters with hosts that had been parasitized. In the previous experiments after dissections, PHM were mounted on slides and examined under a microscope to ensure that all eggs were counted. Also, encounter rates were calculated for each instar by dividing the number of individuals observed in each replicate by the total visits of the wasp during searching in the replicate, multiplied by 100. Also, various parasitoid behaviors as well as developmental times and adult life span were used for analysis of variances. Time allocated by each female wasp to different behaviors was calculated by treatment as a mean of the time per replicate. Means were separated at the 5% probability level with the least significant difference (LSD) test.

3. Host stage suitability

Twenty PHM, at the same stage were transferred onto a sprouted potato and placed into a glass jars (8 cm diameter covered with nylon mesh). Two adult female parasitoids were introduced into the jar for a period of 24 h. The glass jars were kept at 25 ± 2°C and 65±5 % R.H. The mealybugs were observed on a daily basis to record parasitoid emergence. Parasitoids were collected and sexed. The criteria used to determine host suitability were the number

of emerged parasitoids per replicate, the sex ratio (number of males divided by the total progeny number) and the durations of development.

Parasitoids were collected and each one was transferred to a plastic tube (1cm diameter). The tubes were checked daily. Drop honeybees were placed inside them until adults' death. The adult life span was recorded.

RESULTS AND DISCUSSION

Host stage susceptibility

Obtained results are given in Tables (1 and 2). In the no-choice experiment, encounter (examining, antennation and attacking the PHM), stinging and ovipositional rates were calculated for each nymphal instar (NI). The encountered and ovipositional values were highest (57.53 and 32.70) for PHM, respectively. The values were 8.12, 5.43 and 3.09 for the 1st NI, 24.30, 19.0 and 12.67 for the 2nd NI and 45.47, 44.53 and 30.46 for the 3rd NI, respectively.

No differences were found between 3rd NI and adult female in the number of examining, stinging and ovipositing. Also, significant differences were found between the mean numbers of examining, stinging and ovipositing in 1st and 2nd NIs. However, fewer eggs were laid in the 1st and 2nd NIs.

It was observed that, all the four PHM stages were parasitized by *A. kamali* (Table 2). Adult female and 3rd NI showed significant differences than all other stages. The mean no. of hosts parasitized by adult female and 3rd NI was not significantly different from each other, with 7.7 and 7.5 hosts parasitized, respectively. The 1st NI was the least parasitized stage 1.4 %.

The total number of eggs laid was higher in adult female (15.4± 1.11), followed by 3rd NI 13.2± 1.16, 2nd NI 7.1± 0.71 and then the 1st NI 1.6± 0.40. In the 1st NI of PHM, the average number of eggs/female deposited was 1.12± 0.13 eggs per host. This was significantly fewer than that laid in the 2nd NI (1.49 ± 0.09), the 3rd NI 1.78 ± 0.08) and the adult female (2.02± 0.10).

Host stage preference

In the choice experiment, the 1st NI of PHM encountered, stung and oviposited by the parasitoid, *A. kamali* was significantly less often than other NIs and adult female stage offered simultaneously. In contrast, adult female was significantly high in encountering, stung and oviposition than the other NIs (Table 3 and 4). It was noted that the wasp encountered larger mealybugs instar significantly more often than smaller ones. The reproductive success on the first NI host was significantly low (Table, 3). When offered a choice between two stages of PHM, parasitoid females showed significant preference for 3rd NI and the adult female compared to the 1st and 2nd NIs (Table 4). First NI was the least preferred.

The total number of deposited eggs in adult female was significantly higher than that in the 3rd NI, which was preferred than the 2nd NI. The 1st NI was the least preferred stage in terms of total number of eggs laid. Based on the number of deposited eggs per parasitized host, preference to 3rd NI and adult female were not significantly different and those stages had the highest number of eggs per parasitized host.

Table (1): Percentages of the indicated pink hibiscus mealybug (PHM) stages in oviposition sequence by *A. kamali* female

PHM stages	Encounter	Stinging	Oviposition
Adult female	57.53a	40.51a	32.70a
3rd NI	45.47a	44.53a	30.46a
2nd NI	24.30b	19.00b	12.67b
1st NI	8.12c	5.43c	3.09c

Within columns, pairs of means followed by the same letters are not significantly different.

Table (2): Oviposition of *A. kamali* on pink hibiscus mealybug (PHM) *M. hirsutus* stages

PHM stages	Mean no. hosts parasitized (X± S.E.)	Mean no. parasitoid eggs (X± S.E.)	Mean no. parasitoid egg / parasitized host (X± S.E.)
Adult female	7.7 ± 0.52 a	15.4±1.11 a	2.02 ± 0.10 a
3rd NI	7.5 ± 0.65 a	13.2±1.16 a	1.78 ± 0.08 a
2nd NI	4.7 ± 0.40 b	7.1 ±0.71 b	1.49 ± 0.09 b
1st NI	1.4 ± 0.22 c	1.6 ±0.40 c	1.12 ± 0.13 c

Within columns, pairs of means followed by the same letters are not significantly different.

Table (3): Percentage of PHM stages (A preferred over B) by a wasp female, *A. kamali*

PHM stages combination offered		Encounter % of A	Stinging % of A	Oviposition % of A
Stage (A)	Stage (B)			
1st NI	2nd NI	12.83	20.48	46.42
	3rd NI	5.36	13.12	31.55
	Adult female	8.25	22.34	24.79
2nd NI	3rd NI	18.19	30.75	49.42
	Adult female	32.96	38.41	39.85
3rd NI	Adult female	73.15	77.01	65.54

Table (4): Oviposition of the parasitoid, *A. kamali* offered a combination of two stages of PHM, *M. hirsutus*

PHM stages combination offered		Mean no. hosts parasitized		Mean no. parasitoid eggs per parasitized host	
Stage A	Stage B	Stage A	Stage B	Stage A	Stage B
1st NI	2nd NI	0.7 ± 0.15 b	3.3 ± 0.30 a	0.40 ± 0.16 b	1.18 ± 0.13 a
	3rd NI	0.5 ± 0.17 b	4.1 ± 0.41 a	0.30 ± 0.21 b	1.65 ± 0.13 a
	Adult female	0.5 ± 0.17 b	4.4 ± 0.34 a	0.40 ± 0.22 b	1.69 ± 0.14 a
2nd NI	3rd NI	1.4 ± 0.22 b	3.4 ± 0.27 a	0.75 ± 0.23 b	1.71 ± 0.14 a
	Adult female	1.9 ± 0.23 b	4.2 ± 0.20 a	1.28 ± 0.18 b	1.76 ± 0.10 a
3rd NI	Adult female	3.6 ± 0.31 a	4.1 ± 0.28 a	1.46 ± 0.13 a	1.85 ± 0.2 a

Within rows, pairs of means followed by the same letters are not significantly different.

Table (5): Percentage of parasitized and unparasitized mealybug examined by *A. kamali* on PHM, *M. hirsutus* stages

PHM	Encountered		Stung		Accepted	
Stages	Unparasitized	Parasitized	Unparasitized	Parasitized	Unparasitized	Parasitized
1st NI	63.0	70.4	37.0	29.6	30.9	11.9
2nd NI	56.2	62.7	43.8	37.3	39.8	18.1
3rd NI	54.1	66.7	45.9	42.6	57.4	41.2
Adult female	53.6	71.2	46.4	46.4	64.9	33.2

In summary, the results showed that *A. kamali* females may oviposit in all NIs of the PHM, but the 1st NI was the least encountered, stung and oviposited. Thus, *A. kamali* prefers older NIs and it seemed to be more efficient on adult females.

In contrast, Nechols and Kikuchi (1985) observed that the 1st and 2nd NIs of *N. viridis* were completely ignored by *A. indicus* in choice experiments when exposed together with the 3rd NI and adult females. However, in *A. kamali*, low rate of parasitism was recorded in 1st NI that might be due to the parasitoid's ovipositor remained stuck within the host. Also, Arai and Mishiro (2004) observed that the parasitism of *Anagyrus subalbipes* Ishii on the 3rd NI and adult females of *Pseudococcus cryptus* was lower than on the 1st and 2nd NIs. Therefore, the 1st and 2nd NIs were considered more suitable host for the parasitoid.

Host discrimination

A. kamali stings occurred more often in unparasitized hosts than in those already parasitized during previously encountered (Table 5).

There was no significant difference in the number of encountering and stinging unparasitized and parasitized host instars, but the total number of encounters in the 1st, 2nd and 3rd nymphal instars and adult female parasitized was significantly more than in the unparasitized. However, the total number of encounters was higher in parasitized host instars than that in unparasitized host instars.

Percentages of accepted unparasitized host instars were 30.9, 39.8, 57.4 and 64.9 % in 1st, 2nd, 3rd nymphal instars and adult female, respectively. While, they were 11.9, 18.1, 41.2 and 33.2 % in 1st, 2nd, 3rd nymphal instars and adult female of previously parasitized host, respectively. It seemed therefore that *A. kamali* discriminates its host after some short attempts of ovipositor insertion, although the number of stings without oviposition lasted much time as efficient oviposition. Although discrimination was perfect and restraint (avoidance of superparasitism) was remarkable, in case of host scarcity, this restraint was broken down and supparasitism occurred. Under forced conditions up to 4 eggs were found in one host, all of them were laid by the same female parasitoid. As it is known that *Anagyrus* spp. are solitary endoparasitoids that means only one individual/host individual is developed.

Several factors can lead to superparasitism; gene selection, inexperienced females, high parasitoid/host densities ratio (Van Alphen and Visser 1990) and encapsulation (Sagarra *et al.*, 2000). Moreover, superparasitism can also be due to the physiological need for oviposition linked to the pressure of the mature eggs in ovarioles (Van Baaren and Nenon 1994). In the case of *A. kamali* when competing with *Gyranusoida indica*, the number of encounters and stinging unparasitized host stages were greater than parasitized one. The female did not lay eggs in parasitized host, but it laid eggs in all the unparasitized host stages (William *et*

al., 2006), this strongly suggests that the *A. kamali* has a perfect discrimination capabilities. Discrimination is based on several stimuli which act either simultaneously or successively. The rejection of parasitoid host instars was noticed either after antennal contact, as a result of the defense behavior of the parasitoid host, or after the insertion of the ovipositor. Host discrimination has been found in other encyrtids attacking mealybugs, as *Leptomastix dactylopi* (DeJong and Van Alphen, 1989), *Gyranusoida tebygi* (Boavida *et al.*, 1995) and *A. mangicola* (Bokonon-Ganta *et al.*, 1995).

Host stage suitability

A. kamali developed and emerged successfully from all PHM stages. Parasitoid emergence was significantly higher (46.5 %) from the 1st NI, (40 %) the 2nd NI, (31.5 %) the 3rd NI and (37.5 %) the adult females (Table 6). Sex ratio (0.93 and 0.79) for 1st and 2nd nymphal instars showed a very high proportion of males, whereas it was 0.57 and 0.49 for 3rd nymphal instar and adult females, respectively.

The mean total duration time of the parasitoid (from egg to adult emergence) on its host was greater when oviposition occurred in the 1st and 2nd nymphal instars and males developed and emerged faster than females (Table 6). The males emerged from egg oviposited in 1st nymphal instar lasted 25.3±1.67 days to complete their development, whereas females developed in 27.4±1.63 days. For the eggs laid in 2nd nymphal instar, the males lasted 24.1±0.80 days to complete their developed, whereas females developed in 28.2±1.09 days.

The number of parasitoids emerged from the 1st and 2nd nymphal instars was 1.5 times greater than the number emerged from the 3rd NI and the adult females. Emergence in *A. indicus* from 3rd nymphal instar and adult female was consistently the greatest (Nechols and Kikuchi, 1985). However, Sagarra *et al.*, 2000, mentioned that occurrence of encapsulation for *A. kamali* may explain the differences observed in the total number of adult parasitoids emerged from 3rd nymphal instar and adult females compared to that emerged from 1st and 2nd nymphal instars, that is due to the eggs deposited in 1st and 2nd nymphal instars which were rarely encapsulated by its host.

The sex ratios were in agreement with those observed with other *Anagyrus* species; *A.indicus* (Nechols and Kikuchi, 1985), *A. mangicola* (Bokonon-Ganta *et al.*, 1995) and in contrast with *Anagyrus* sp. nov. nr. *Sinope* (Chong and Oetting, 2007). Sex ratio of the progeny emerged from 1st and 2nd nymphal instars led to mainly males. This could be a problem in mass production of *A. kamali*, which males' impact poorly on the reproductive capacity of the population.

Developmental periods of males and females, emerged from 3rd nymphal instar and adult females were not significantly different. Developmental time of 3rd nymphal instar and adult females was 8.1 days faster than that of 1st and 2nd nymphal instars. Similar results were reported in previous investigations; *A. kamali* (Serrano and Lapointe, 2002), *A. indicus* (Nechols and Kikuchi, 1985) and *A. mangicola* (Bokonon-Ganta *et al.*, 1995) who stated that developmental time was affected by the host stage.

Time budget

The time allocated to different activities during an approximately 30-min observation in the no-choice experiment is given in Table (7). Handling time was measured by antennal contact with a host, until it ended. Handling times (examining, attacking, and stinging the host) invested per host stung significantly decreased with increasing host instar. However, the time spent in preening per host stung significantly increased with host age.

Table (6): Progeny production and sex ratio of *A. kamali* on PHM stages of *M. hirsutus*

Host stage	Average no. of adult parasitoid emerged (X± SE)	Sex ratio (Males/total progeny)	Parasitoid development (egg to adult emergence (days) (X±SE)	
			Male	Female
Adult female	7.5 ± 0.34 bc	0.49	18.3 ± 0.79 b	20.1 ± 0.99 b
3rd nymphal instar	6.3 ± 0.63 c	0.57	19.2 ± 0.92 b	21.4 ± 1.00 b
2nd nymphal instar	8.0 ± 0.42 b	0.79	24.1 ± 0.80 a	28.2 ± 1.09 a
1st nymphal instar	9.3 ± 0.26 a	0.93	25.3 ± 1.67 a	27.4 ± 1.63 a

Within columns, pairs of means, followed by the same letters are not significantly different.

Table (7): Mean time in seconds spent per oviposition by a female of *A. kamali* on different PHM *M. hirsutus* stages

PHM stages	Mean time per oviposition in seconds (X± SE)			
	Feeding	Handling	Preening	Total
1st NI	23.3 ± 2.22	26.4±1.27	39.2±3.27	88.9±4.25
2nd NI	19.1±4.05	24.7±1.03	32.3±2.29	76.1±3.19
3rd NI	21.4±1.45	15.3±1.56	58.7±4.93	95.4±5.82
Adult female	14.8±2.21	15.7±0.81	61.3±5.33	91.8±5.89
L.S.D.	7.72	3.48	12.41	

Table (8): Reproductive capacity and durations of life periods in days and longevity of females of *A. kamal.*

No. of female	Reproductive capacity of adult female					Adult female longevity
	Pre- ovipositional period	Ovi-positional period	Post-ovipositional period	No. of deposited eggs/female	Mean daily no. of deposited eggs/female	
1	1	15	2	104	8.0	18
2	1	14	1	106	10.6	16
3	2	5	1	60	10.0	8
4	1	16	2	154	8.11	19
5	2	13	2	121	10.1	17
6	1	12	2	101	7.2	15
7	3	20	5	108	7.2	28
8	1	10	0	88	8.8	11
9	2	7	4	73	7.3	13
10	2	7	2	69	7.7	11
Mean ± SE	1.6 ± 0.22	11.9 ± 0.45	2.1 ± 1.46	98.4 ±10.58	8.5 ± 0.41	15.6 ±1.74

Handling time for oviposition increased significantly with developmental host instar, from 26.4 ±1.27 seconds per egg laid in the 1st NI to 24.7 ±1.03 seconds in the 2nd NI, 15.3 ±1.56 seconds in the 3rd NI and 15.7 ±0.81 seconds in the adult female.

Female wasps preened significantly less time for oviposition when foraging among 1st and 2nd NIs, respectively, 39.2 and 32.3 seconds than among 3rd NI and adult female, namely 58.7 and 61.3 seconds. Handling time decreased with developed host stages, despite the fact that older mealybugs defended themselves much more vigorously than younger ones.

Reproductive capacity and longevity of *A. kamali*

Life span of females of *A. kamali* consists of three successive periods: sexual maturation (pre-oviposition), a very short period that precedes oviposition, the period of reproductive activity (oviposition) characterized by continues, through rhythmical, deposition of eggs and senescence (post-oviposition), prior to death and during which oviposition does not take place. The results of ten females studied for adult longevities are presented in Tables (8 and 9). The pre-ovipositional period was 1.6 ± 0.22 days.

Table (9): Longevity of *A. kamali* parasitoid when fed on different types of food at 25±1°C and 65±5 % R.H.

Type of food	Longevity in days X±SE	
	Female	Male
Starvation	2.1±0.34	1.4±0.26
Water	4.7±0.77	3.1±0.54
Honey	14.4±2.21	9.8±1.16
Honey+water	20.1±2.83	13.3±1.46

The reproductive period was 5-20 days, with an average of 11.9±1.46 days. The total number of eggs ranged from 60-154 eggs, with an average of 98.4±10.58 eggs. The mean daily number of eggs laid through this period ranged between 7.2 to 10.1 eggs, with a general average of 8.5±0.41 eggs per day. The senescence period (post-oviposition) lasted 0-5 days, with the mean of 2.1±0.45 days.

Longevity fluctuated between 8-28 days, with a mean of 15.6 ±1.74 days for mated female fed on honey and water with the host PHM (Table, 9). Longevity of unmated females and males without host was longer than that of mated females with host (Table, 9).

The mean longevity was 20.1±2.83 and 13.3±1.46 for females and males, when fed on honey + water and 14.4±2.21 and 9.8±1.16 days when fed on honey only, respectively. The longevity reduced to 4.7±0.77and 3.1±0.54 days when fed on water only. The shortest longevity was that of the starved females and males, it was 2.1±0.34 and 1.4±0.26 days, respectively.

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