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COMPARATIVE BIOLOGY OF *Goniozus nephantidis* (MUESBECK) ON *Galleria mellonella* L. AND *Corcyra cephalonica* (STAINTON)

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ABSTRACT
Goniozus nephantidis (Muesbeck) is a gregarious ecto-larval parasitoid of *Opisina arenosella* (Walk.) having high demand in coconut growing areas. Present study shows biological parameters of *G. nephantidis* on two laboratory hosts *viz*., *Galleria mellonella* L. and *Corcyra cephalonica* (Stainton) *cephalonica*. The results revealed the incubation period of eggs of *G. nephantidis* 2.90 ± 0.64 and 2.60 ± 0.68days with 75.39 ± 8.58 and 78.19 ± 9.33 per cent hatching on *G. mellonella* and *C. cephalonica*, respectively. Larval period was found significantly (t = 2.30*) shorter (2.55 ± 0.60days) on *G. mellonella* compared to *C. cephalonica* (3.05 ± 0.76days). Pupal period was 4.95 ± 1.05days (*G. mellonella*) and 5.20 ± 0.62days (*C. cephalonica*). Pre-oviposition, oviposition and post-oviposition periods were 5.10 ± 0.91, 14.95 ± 2.31, 3.20 ± 1.24days (*G. mellonella)* and 4.85 ± 0.75, 16.65 ± 3.08, 3.60 ± 1.14days (*C. cephalonica*). The sex ratio (M:F) was achieved 1:5.23 (*G. mellonella)* and 1:5.69 (*C. cephalonica*). Highly significant difference (t = 3.30**) was recorded in adult emergence on both hosts. Significant variations were observed in adult longevity (t = 2.12* male and t = 2.13* female) and fecundity (t = 2.10*) on both hosts. Total life cycle of males remained significantly similar while, it was significantly (2.78*) longer (37.65 ± 3.23days) in *C. cephalonica* than *G. mellonella*.

INTRODUCTION

The coconut black headed caterpillar, *Opisina arenosella* Walker (Lepidoptera: Cryptophasidae) is one of the serious and endemic pest of coconut in India. One of the major factors that contributes to the loss in coconut production and productivity is damage due to *O. arenosella*. The pest can cause serious damage to palmyrah (*Borassus flabellifer*), talipot (*Corypha umbraculifera*) and wild date (*Phaoenix sylvestris*) however, lower damage observed on oil palm (*Elaeis guineensis*). In case of severe outbreak of this pest, whole affected plantation presents a burnt up appearance due to drying of leaves. The infested leaves droop, the bunches buckle and the immature nuts heavily shed. During 2000, about 1.6 million coconut palms were affected with this pest in Karnataka. While, In 2013, nearly 200ha of coconut plantations were affected in Andhra Pradesh (Rao *et al*., 2018).

The caterpillar lives on the lower surface of leaflets within the galleries made of excreta and silken web and feeds on parenchymatous tissues. Due to continuous feeding, removal of superficial tissues of the abaxial leaf surface leaving only the top layer and the leaf lamina which observes white. Dried patches appearing on the upper epidermis of leaves and the presence of larval galleries and pupal cases on the lower surface of leaves are the major symptoms of infestation. In severe outbreaks, it even feeds on green surfaces of petioles, spathes and nuts (Howard, 2001).

The chemical management of the pest is not practicable, as the application of the insecticides is quite difficult because of the huge height of the palm. Even if a power sprayer is used, the spray fluid does not reach the larvae easily due to the galleries surround by them. Aerial spraying is also not effective and desirable as the pest is found only on the undersurface of the leaflets. Considering these conditions, biological control is living weapon and excellent strategy over chemical control. The *O. arenosella* is attacked by many entomophagous insects during its developmental stages. Among them, *Goniozus nephantidis* (Muesbeck) (Hymenoptera: Bethylidae) is a gregarious larval ectoparasitoid and responsible for the reduction in the population of pest under field conditions (Cock and Perera, 1987; Venkatesan *et al*., 2004 and Rao *et al*., 2013). The field releases made for three years revealed that the overall recovery was 30.97 per cent parasitism of *O. arenosella* (Kapadia and Mittal, 1993).

After three months of parasitoid release, the larval and pupal population of *O. arenosella* decreased by 34.08-75.88 and 33.33-94.52 per cent, respectively with 8.30-26.92 per cent recovered paralysed larval population. While, after six months, the larval and pupal population decreased up to 59.65-100 and 92.77-100 per cent, respectively with 18.68 to 34.61 per cent paralysed larval population recovery. Thus, the impact of inundative release of *G. nephantidis* for suppression of *O. arenosella* was prominent, after six months providing impetus to the role of biological control in pest management. The assumed overall economic loss prevented due to this intervention was 192.6 million rupees (Rao *et al*., 2018).

Dharamaraju (1952) reported *Corcyra cephalonica* (Stainton) (Lepidoptera: Pyralidae) as an alternate host for the laboratory rearing of *G. nephantidis*. Moreover, Venkatesan *et al*. (2002) reported that Galleria mellonella Linnaeus (Lepidoptera:

Pyralidae) could be used as an alternate host for laboratory rearing of *G. nephantidis*. In general adult parasitoids produce progeny with respect to the size of host. Looking to the size of the laboratory hosts, the larvae of *G. mellonella* is bigger than the larvae of *C. cephalonica*. Based on this assumption, we can get maximum number of progeny on *G. mellonella*. Since, the biology of parasitoids differs in different hosts (Landge *et al.*, 2009), it becomes imperative to determine the most suitable host for its mass rearing programme. Despite the great potency of this important larval parasitoid, investigation on the biological attributes and potential factitious host for mass production, the comparative biological parameters of *G. nephantidis* on *G. mellonella* and *C. cephalonica* have been carried out.

MATERIALS AND METHODS

The experiment conducted at Biocontrol Laboratory, Department of Entomology, N. M. College of Agriculture, Navsari Agricultural University, Navsari is situated at 13 km away in the East, from the great historical place, Dandi on the Arabian seashore at 27º57 N latitude, 72º 54 E longitude and at an altitude of 10m above the Mean Sea Level (MSL). The experiment was carried out under the laboratory condition at 30.45 ± 2.57ºC temperature and 57.75 ± 2.75 per cent relative humidity.

The nueleous cultures of *Galleria mellonella* L. and *Corcyra cephalonica* (Stainton) were obtained from Biocontrol laboratory, N. M. College of Agriculture, Navsari Agricultural University, Navsari the same cultures were maintained in the laboratory.

The grater wax moth, *G. mellonella* reared on an artificial diet by using wheat flour 100g, wheat bran 100g, maize flour 200g, milk powder 100g, yeast powder 50g, honey 175ml and glycerol 175ml were used. The dry ingredients were mixed with liquid ingredients for uniform distribution of liquid ingredients over dry ingredients. The *G. mellonella* larvae reared in the laboratory by using above artificial diet. The egg mass was transferred in plastic jar (1-liter capacity) along with an artificial diet to facilitate the egg hatching. Initially larvae were reared in a plastic jar (1-liter capacity) containing artificial diet for first one week of larval development because they require little space. Then, larvae were transferred to a round plastic container (7-liter capacity, 22cmX23cm) with artificial diet. The containers were arranged in metal shelf. The ant well was also provided to ant avoid crawling to ants. During this period, fresh diet was provided for healthy growth of larva. Healthy late instar larvae were transferred into a separate plastic container (7-liter capacity, 22cmX23cm) with the artificial diet for pupation. Larvae were not disturbed and allowed them to pupate in the artificial diet. The pupae were transferred into a separate plastic container (7-liter capacity, 22cmX23cm) for adult emergence. The folded accordion wax paper (A4 Size; 100GSM) placed in a plastic container for egg laying. The egg masses were collected carefully by replacing the accordion wax paper once in two days for the next six days with fresh paper (Anon., 2007).

The rice moth, *C. cephalonica* reared on an artificial diet by using the milled (by making two to three pieces of each grain) grains of sorghum and heat sterilized in hot air oven at 55ºC for 30 minutes to make free from any secondary infestation. The same was conditioned in room temperature for gaining ambient moisture for one day. The material was treated with streptomycin sulphate @0.2g per kg to prevent the bacterial infection, crushed raw groundnut @250g added to one kg of sorghum and kept in pre-sterilized circular galvanized trays (35cmX12cm). Trays were arranged in a metal shelf. The ant well was also provided to avoid ant crawling. Each tray inoculated with 1000 eggs of *C. cephalonica* (0-1 hour old) and thoroughly mixed to have uniform distribution of eggs in food material. These trays were covered with white muslin cloth tied with a two-fold rubber band so as to avoid escape of larvae. The trays were kept undisturbed. The emerging adults were transferred to oviposition cage for egg laying Naganna and Shinde (2017).

The nucleus culture of *Goniozus nephantidis* (Muesbeck) obtained from AICRP on Palm, Horticulture Research Station, University of Horticulture Science (UHS), Arsikere, Bagalkot-587101 (Karnataka). Rearing of *G. nephantidis* carried out with standard method suggested by Venkatesan *et al*. (2008) with slight modification. The parasitoid adults were maintained on the healthy larva of *C. cephalonica* under laboratory condition. Male and female of *G. nephantidis* were released into small plastic vials (5cmX2cm) for mating under diffused light. Males and females were differentiated as female are larger in size with the prominent ovipositor and males are smaller with blunted abdominal tip. The droplets of honey solution (50% diluted) on a wax coated paper stripes and water were provided as adult food. After pre-oviposition period, the females were separated and kept in small plastic vials (5cmX2cm) and covered with cotton plug to avoid escape of the adults. Later on, kept individually as there was contest behaviour among females, this involves aggressive postures, rapid chases and violent flights in which contestants attempt to bite and sting each other. The female was transferred at every 24 hrs to a similar small plastic vial (5cmX2cm) containing another fresh full-grown larva for eggs deposition. The parasitized larva containing eggs of *G. nephantidis* were removed regulary at 8:00 AM from the vials till the death of the female such larvae were kept in accordion type paper in plastic boxes for successful completion of lifespan. The developed cocoons were utilized in further investigation on comparative biology of *G. nephantidis* on *G. mellonella* and *C. cephalonica*.

The biological parameters of *G. nephantidis* ascertained by exposing healthy *G. mellonella* and *C. cephalonica* larva to freshly emerged individual *G. nephantidis* pair in plastic vials (5cmX2cm). Each mated female (after completion of pre-oviposition) was exposed to *G. mellonella* and *C. cephalonica* 5th (Av. weight of larva 3.94 ± 0.68mg) and 3rd (Av. weight of larva 2.68 ± 0.19mg) instar larva respectively.

The various stages of *G. nephantidis* on *G. mellonella* and *C. cephalonica* were studied under stereo-trinocular microscope by using a very fine needle and moistened brush to determine the size shape and duration of each stages. The length and breadth of various stages of *G. nephantidis* were measured under stereo-trinocular microscope (Make: Olympus. SZ 61) fitted with Brand Catcum-130 camera having software Power Scope Photo (Version 3.1). The data thus obtained were

analysed by two sample 't'- test.

RESULTS AND DISCUSSION

The results revealed that the maximum number of eggs were laid by female *Goniozus nephantidis* (Muesbeck) on dorso-lateral side of 5th and 6th abdominal segments of both host larvae and there were no any eggs laid on the first and last segment of abdomen and thorax. The eggs were loosely attached to the host's integument and deposited parallel to the longitudinal axis of the body. The present results are in close accordance with the observations Naganna and Shinde (2017) and Gurav *et al*. (2018).

Freshly laid eggs of *G. nephantidis* on *Galleria mellonella* L. and *Corcyra cephalonica* (Stainton) were creamy white in colour and became translucent later. The deposited eggs were spindle shaped or sometimes also pear shaped, slightly curved, hyaline colourless and loosely attached to the surface of the larval body. The data (Table 1) revealed that the average length and breadth of eggs of *G. nephantidis* 0.44 ± 0.06 and 0.19 ± 0.04mm on *G. mellonella* whereas, it was 0.49 ± 0.06mm and 0.20 ± 0.04mm on *C. cephalonica*, respectively. There was significant difference (t = 2.35*) observed in length *G. nephantidis* eggs on both hosts. The maximum length (0.49 ± 0.06mm) of *G. nephantidis* eggs observed on *C. cephalonica* as compared to *G. mellonella*. The present observations showed similarity to the earlier

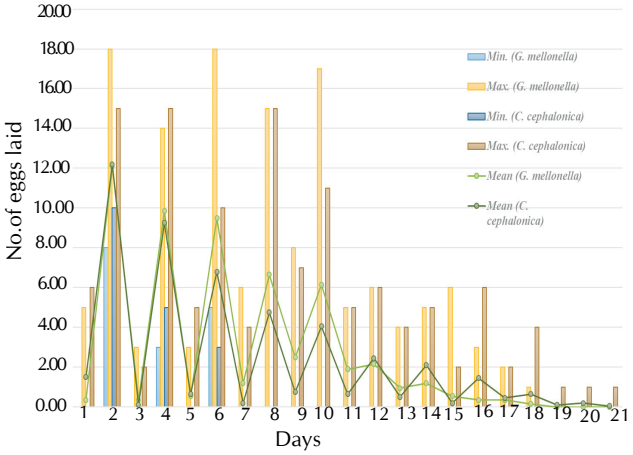
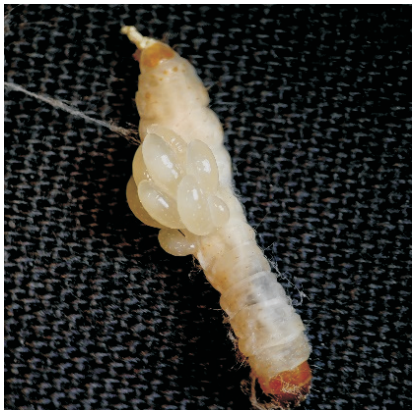


Figure 1: Daily fecundity of G. nephantidis on G. mellonella and C. cephalonica

observations of Naganna and Shinde (2017) who reported that the average length and breadth of *G. nephantidis* eggs were 0.48 ± 0.06 and 0.23 ± 0.03mm, respectively on *C. cephalonica*. However, average length of *G. nephantidis* eggs were 0.47 ± 0.06 and 0.43 ± 0.04mm whereas, the average breadth was 0.23 ± 0.03 and 0.32 ± 0.02mm, respectively on *C. cephalonica* and *O. arenosella* (Gurav *et al*., 2018). The difference in size of eggs might be due to change in host

A. Eggs of *G. nephantidis*



B. Larva of *G. nephantidis*

C. Cocoon of *G. nephantidis*

D. Adult female of *G. nephantidis*

E. Adult male of *G. nephantidis*

Plate 1: Biology of *G. nephantidis* on *G. mellonella*

Table 1: Morphometrics of *G. nephantidis* on different hosts

Stages	Measurements (mm)	*G. mellonella*			*C. cephalonica*			Cal t
		Min.	Max.	Av.± SD	Min.	Max.	Av.± SD	
Eggs	Length	0.31	0.52	0.44±0.06	0.37	0.59	0.49±0.06	2.35*
	Breadth	0.14	0.28	0.19±0.04	0.14	0.28	0.20±0.04	0.35^{NS}
Larva	Length	1.24	2.45	2.09±0.25	0.93	2.24	1.94±0.33	1.67^{NS}
	Breadth	0.3	0.54	0.43±0.07	0.3	0.88	0.49±0.15	1.42^{NS}
Cocoon	Length	3.18	5.12	4.37±0.58	3.19	5.12	4.15±0.57	1.20^{NS}
	Breadth	1.13	2.91	2.03±0.41	1.1	2.93	1.87±0.55	1.04^{NS}
Male adult	Length	1.11	1.64	1.27±0.17	1.11	1.65	1.27±0.17	0.18^{NS}
	Breadth	0.3	0.75	0.46±0.12	0.33	0.8	0.49±0.14	0.62^{NS}
Female adult	Length	1	2.8	1.85±0.44	1.23	2.87	1.84±0.43	0.05^{NS}
	Breadth	0.4	1.2	0.82±0.24	0.38	1.21	0.77±0.26	0.52^{NS}

* = Significant;** = Highly significant; NS = Non significant

Table 2: Comparative biology of *G. nephantidis* on *G. mellonella* and *C. cephalonica* under laboratory condition

Sr. No.	Particulars	*G. mellonella*			*C. cephalonica*			Cal t
		Min.	Max.	Av. ± S.D.	Min.	Max.	Av. ± S.D.	
1	Incubation period (Days)	2	4	2.90±0.64	2	4	2.60±0.68	1.44^{NS}
2	Hatching (%)	62.5	91.76	75.39±8.58	60.87	97.3	78.19±9.33	0.99^{NS}
3	Larval period (Days)	2	4	2.55±0.60	2	5	3.05±0.76	2.30*
4	Pre-cocoon (Days)	1	2	1.50±0.51	1	2	1.70±0.47	1.29^{NS}
5	Pupal period (Days)	4	8	4.95±1.05	4	6	5.20±0.62	0.92^{NS}
6	Pre-oviposition period (Days)	4	6	5.10±0.91	4	6	4.85±0.75	0.95^{NS}
7	Oviposition period (Days)	11	18	14.95±2.31	11	21	16.65±3.08	1.98^{NS}
8	Post-oviposition period (Days)	2	6	3.20±1.24	2	5	3.60±1.14	1.06^{NS}
9	Adult emergence (%)	30	75	52.42±10.55	52.38	70.37	61.24±5.59	3.30**
10	Sex ratio (Male: Female)	01:02.0	01:08.0	01:05.2	01:09.0	01:25.0	01:05.7	0.71^{NS}
11	Adult longevity (Days)							
	Male	10	18	13.00±2.47	8	14	11.60±1.60	2.12*^{s}
	Female	17	30	23.25±2.17	18	30	25.10±3.23	2.13*
12	Total life cycle (Days)							
	Male	21	29	24.90±2.27	22	27	24.15±1.76	1.17^{NS}
	Female	31	40	35.15±2.35	30	42	37.65±3.23	2.78**
13	Fecundity (No. of eggs/female)	34	85	56.80±14.49	36	60	49.05±7.84	2.10*

* = Significant;** = Highly significant; NS = Non significant

larvae and artificial diet as honey to the adult parasitoids and variation in rearing conditions.

The average incubation period of eggs was 2.90±0.64 and 2.60±0.68 days, respectively on *G. mellonella* and *C. cephalonica* (Table 2). In contrast to the present findings, Kapadia and Mittal (1986) noticed that the incubation period was 2.23 days. While, Gurav *et al*. (2018) noted the average incubation period of *G. nephantidis* was 2.10±0.79 days on *C. cephalonica* abd it was 1.80±0.77 days on *O. arenosella*. The slight difference in the incubation period might be due to size of host offered, environmental conditions existing in a particular locality. That average egg hatching of *G. nephantidis* observed 75.39±8.58 and 78.19±9.33 per cent on G. mellonella and *C. cephalonica*, respectively. There was no significant difference observed in per cent egg hatching on different hosts (Table 2). Our findings are more or less similar with Naganna and Shinde (2017), who reported it as 87.03±5.86 per cent on *C. cephalonica* while, Gurav *et al*. (2018) revealed that 84.40 and 85.86 per cent eggs were hatched when *G. nephantidis* reared on *C. cephalonica* and *O. arenosella*.

The colour, shape and size of larva of *G. nephantidis* revealed that the first instar larva was white, apodous, devoid of any sign of external segmentation and distinguished from the egg only by waves of the internal content of gut contraction and the movement of haemolymph within the parasitoid's body. The later instar larvae were whitish yellow and having clear larval body segmentation. The full grown larvae with tapering end and bulge of middle portion of larval body. The average length and breadth of *G. nephantidis* larvae were 2.09±0.25 and 0.43±0.07mm on G. mellonella while, it was 1.94±0.33 and 0.49±0.15mm on *C. cephalonica*, respectively. There was no significant difference observed in morphometrics of parasitoid larvae observed when *G. nephantidis* reared on bothe hosts except slight difference in length of larvae (Table 1). The present studies are in accordance with past workers *i.e*. Naganna and Shinde (2017) observed that the average length and breadth of *G. nephantidis* larvae were 2.17±0.11 and 0.43±0.08mm, respectively. Gurav *et al*. (2018) studied that the average length and breadth of G. nephantidis larvae on *C. cephalonica* were2.15±0.09 and 0.41±0.09mm, respectively while, the average length and breadth of *G. nephantidis* larvae on *O. arenosella* were 2.92±0.26 and 1.24±0.10mm, respectively.

There was significant difference (t=2.30) observed in larval period of *G. nephantidis* on both the hosts. The highest larval period (3.05±0.76 days) observed on *C. cephalonica* as compared to *G. mellonella* (2.55±0.60 days) (Table 2). The observations showed similarity to the earlier observations of Naganna and Shinde (2017) who reported that the average larval period of *G. nephantidis* was 4.03±0.81 days on *C. cephalonica*. The slight difference in larval period might be

A. Eggs of *G. nephantidis*

B. Larva of *G. nephantidis*

C Cocoon of *G. nephantidis*

D. Adult female of *G. nephantidis*

E. Adult male of *G. nephantidis*

Plate 2: Biology of *G. nephantidis* on *C. cephalonica*

due to change in test insect, host insect and prevailing conditions existing in a particular locality.

The final instar larva of *G. nephantidis* stopped feeding and then searched for a suitable place, where it remained stationary. The caudal region was firmly attached to the substrate; the body shrank during the formation of pre-pupa and the fully-grown larvae were started producing silken threads that were used for cocoon making. The cocoon of *G. nephantidis* was made loosely woven by silken threads and white in colour with oblong in shape and become tough attached with substrate. There was no significant difference observed in cocoons reared on both the hosts. The average length and breadth of *G. nephantidis* cocoon were 4.37 ± 0.58 and 2.03 ± 0.41mm on *G. mellonella* however, it was 4.15 ± 0.57 and 1.87 ± 0.55mm on *C. cephalonica*, respectively (Table 1). The present findings on the morphological description of cocoon are in accordance with the findings of Gordh (1976) who noted that the pre-pupa of *G. gallicola* superficially resembled the feeding larva except the cuticle was opaque and urete cells were distinctly white. Moreover, Gurav et al. (2018) found that the average length and breadth of *G. nephantidis* cocoon were 4.07 ± 0.67 and 1.89 ± 0.56mm, respectively on *C. cephalonica* while, it was 4.03 ± 0.68 and 1.90 ± 0.55mm, respectively on *O. arenosella*.

The duration of pre-cocoon was 1.50 ± 0.51 days when reared on *G. mellonella* the similar results were observed (1.70 ± 0.47 days) on *C. cephalonica* (Table 2). The similar observations were also made by Naganna and Shinde (2017) who recorded that the duration of pre-cocoon period of *G. nephantidis* was 1.53 ± 0.51 days on C. cephalonica. There was no significant difference observed in cocoon period, it was 4.95 ± 1.05 and 5.20 ± 0.62 days on *G. mellonella* and *C. cephalonica*, respectively (Table 2). The present findings are in conformity with the reports of Naganna and Shinde (2017) who studied that the cocoon period of *G. nephantidis* varied from 4.0 to 7.0 days with an average of 5.53 ± 1.00 days on *C. cephalonica*.

The newly emerged adults were black in colour with transparent membranous wings, head of the adults was also black in colour and blunted triangular with sharp dark brown colour mandibles. The filiform 13 segmented antennae; yellowish-brown in colour and attached to head by scape. The thorax was black in colour with 3 segmented and bears two pairs of membranous wings on 2nd and 3rd segments, three pairs of yellowish-brown legs present in all thoracic segments. The abdomen of females was bulged at anterior portion and sharp at posterior end with a pointed ovipositor. The male abdomen had short blunted posterior tip and differs from females. The length of the male was shorter as compared to females.

There was no significant difference observed in morphometrics of adults of *G. nephantidis* reared on two hosts. The body

length and breadth of male were 1.27 ± 0.17 and 0.46 ± 0.12mm, respectively while, the body length and breadth of female were 1.85 ± 0.44 and 0.82 ± 0.24mm, respectively when *G. nephantidis* reared on *G. mellonella*. Moreover, on *C. cephalonica* the body length and breadth of male were 1.27 ± 0.17 and 0.49 ± 0.14mm, respectively while, the body length and breadth of female were 1.84 ± 0.43 and 0.77 ± 0.26mm, respectively (Table 1). A more or less similar description on measurements of *G. nephantidis* had narrated by Naganna and Shinde (2017) who reported that the body average length and breadth of *G. nephantidis* male were 1.25 ± 0.13 and 0.51 ± 0.13mm, respectively. While that of female were 1.83 ± 0.42 and 0.94 ± 0.30mm, respectively when reared on *C. cephalonica*.

The pre-oviposition period of *G. nephantidis* was 5.10 ± 0.91 and 4.85 ± 0.75 days on *G. mellonella* and *C. cephalonica*, respectively. The oviposition period was 14.95 ± 2.31 and 16.65 ± 3.08 days when *G. nephantidis* reared on *G. mellonella* and *C. cephalonica*, respectively. Moreover, the post-oviposition period of *G. nephantidis* was 3.20 ± 1.24 and 3.60 ± 1.14 days on *G. mellonella* and *C. cephalonica*, respectively. (Table 2). There were no significant variations observed in pre-oviposition, oviposition and post-oviposition period of *G. nephantidis* reared on two hosts. The present results are more or less concur with Gurav *et al*. (2018) who noted the pre-oviposition, oviposition and post-oviposition period of *G. nephantidis* was 4.95 ± 0.83 and 4.65 ± 0.75, 17.75 ± 3.35 and 11.95 ± 2.78, 3.00 ± 0.79 and 2.55 ± 1.19 days when reared on *C. cephalonica* and *O. arenosella*, respectively.

Based on the morphological characters, the adults were differentiated into their sexes. Adults emerged from laboratory mass culture during period of study, indicated that the preponderance of female. There was no significant difference among two hosts observed in the sex ratio of *G. nephantidis*. The sex ratio (M:F) of *G. nephantidis* was 1:5.23 and 1:5.69 when reared on *G. mellonella* and *C. cephalonica*, respectively (Table 2). The present results are in accordance with Naganna and Shinde (2017) who reported sex ratio (M:F) as 1:4.45. There was a highly significant difference (t = 3.30**) recorded in adult emergence of *G. nephantidis* reared on two hosts. Adult emergence observed highest (61.24 ± 5.59%) on C. cephalonica as compared to *G. mellonella* (52.42 ± 10.5%). The adult emergence of *G. nephantidis* was 80.44 and 77.38 per cent when reared on *C. cephalonica* and *O. arenosella* larvae, respectively (Gurav *et al*., 2018). The fluctuation in adult emergence might be due to larva reared on different host insect.

The significant difference recorded in male and female adult longevity (t = 2.12* and 2.13*, respectively) of *G. nephantidis* reared on two hosts.

The highest male longevity (13.00 ± 2.47 days) observed on *G. mellonella* as against *C. cephalonica* (11.60 ± 1.60 days). However, highest female longevity (25.10 ± 3.23 days) observed on *C. cephalonica* as against *G. mellonella* (23.25 ± 2.17 days). Gurav *et al*. (2018) reported that the male and female longevity were 12.90 ± 2.55 and 25.70 ± 3.16 days, respectively when *G. nephantidis* reared on *C. cephalonica* however, it was 11.45 ± 1.76 and 19.15 ± 4.72 days, respectively on *O. arenosella*. The discrepancy in adult longevity of *G. nephantidis* perhaps this might be due to different host insects used for rearing, diet for adults and oviposition period of adult female.

The fecundity showed significant difference (t = 2.10*) among both the hosts, higher fecundity (56.80 ± 14.49 eggs/female) observed in *G. mellonella* while it was lowest (49.05 ± 7.84 eggs/female) in *C. cephalonica* (Table 2). The daily fecundity revealed that the highest fecundity observed on the second day of oviposition and the fecundity gradually decreased with days (Fig. 1). The results pertaining to the fecundity of *G. nephantidis* are more or less similar to Gurav *et al*. (2018) who reported the average fecundity of *G. nephantidis* was 54.80 ± 9.98 and 53.10 ± 8.54 on *C. cephalonica* and *O. arenosella*, respectively. The divergence in fecundity of *G. nephantidis* might be due to size of host larva used for rearing and food of the adult parasitoid.

The duration of total life cycle varied from 21.00 to 29.00 days with an average of 24.90 ± 2.27 days for males and 31.00 to 40.00 days with an average of 35.15 ± 2.35 days for females when *G. nephantidis* reared on *G. mellonella*. However, it varied from 22.00 to 27.00 days with an average of 24.15 ± 1.76 days for males and 30.00 to 42.00 days with an average of 37.65 ± 3.23 days as in case of female on *C. cephalonica*. There was no significant difference observed in total life cycle of male however, in case of female highly significant difference observed. The significantly (2.78*) longer life cycle of female (37.65 ± 3.23 days) on *C. cephalonica* than *G. mellonella* (Table 2). The present studies on total life cycle of *G. nephantidis* are more or less in accordance with reports of Naganna and Shinde (2017) who reported that the total life cycle of male and female of *G. nephantidis* was 26.97 ± 3.45 and 39.33 ± 3.24 days, respectively on *C. cephalonica*. The difference in total life cycle might be due to change in test insect, host insect used, prevailing rearing conditions existing in a particular locality and methodology adopted for their investigation.

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