The Pharma Innovation Journal 2022; 11(12): 6395-6397

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; 11(12): 6395-6397

www.thepharmajournal.com
Received: 16-10-2022
Accepted: 18-11-2022

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Biology of larval parasitoid, *Goniozus nephantidis* (Muesebeck) on rice moth, *Corcyra cephalonica* (Stainton)

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Abstract
The laboratory experiment was conducted on "Biology of larval parasitoid, *Goniozus nephantidis* (Muesebeck) (Bethylidae: Hymenoptera)" under South Telangana conditions. Study on the biology of *G. nephantidis*, revealed that the maximum number of eggs were laid on the on dorso-lateral side on 5th to 6th abdominal segments of *Corcyra cephalonica*. The incubation period was 2.80±0.50 days. The average egg hatching of *G. nephantidis* on *C. cephalonica* was 80.25±7.20 percent. The larval period of *G. nephantidis* was 3.25±0.68 days. The average precocoon period was 1.55±0.40 days. The cocoon period was 4.90±0.65 days. The average pre-oviposition period, oviposition period and post oviposition period of *G. nephantidis* were 4.85±0.60, 16.35±2.17 and 2.90±0.56 days, respectively. The average sex ratio (male: female) of *G. nephantidis* was 1:5.15. The adult emergence of *G. nephantidis* was 78.85±4.20 percent. The average male and female longevity of *G. nephantidis* on *C. cephalonica* was 12.15±0.9 and 23.10±1.25 days, respectively. The average fecundity of *G. nephantidis* was 47.15±6.45 eggs per female. The total life cycle of male and female was 24.65±4.30 and 35.60±6.50 days, respectively.

Keywords: Biology, larval parasitoid, *Goniozus nephantidis*, *Corcyra cephalonica* and longevity

Introduction
The coconut palm is infested by a number of insect pests. Among them, Coconut black headed caterpillar, *Opisina arenosella* Walker causes the severe damages to the foliage, depriving the palm of its photosynthetic area and thus, directly affecting the yield (Sujatha and Chalam, 2009) [6]. The black headed caterpillar, *O. arenosella* is one of the serious and endemic pest of coconut in India (Gurav *et al*., 2014) [2]. The caterpillar is gregarious in habit and is voracious feeders. This pest living in galleries constructed with silk and frass on the under surface of the leaves, they feed by scraping out the green parenchyma of the leaflet and leaving a thin parchment like upper epidermis. Earlier attempt pertaining to control of this pest were mostly mechanical, cultural and chemical. Indiscriminate use of pesticides leads to destruction of ecological cycle. Biological control is living weapon and excellent strategy over chemical control, which is modern and prestigious adoption at global level. The black headed caterpillar is attacked by many entomophagous insects during its developmental stages. Among them, *Goniozus nephantidis* is a gregarious larval parasitoid and responsible for the reduction in the population pest under field condition (Rao *et al.*, 2013) [5]. *G. nephantidis* is an important larval ectoparasitoid of *O. arenosella* which can be easily mass produced in bio control laboratories either on *Corcyra cephalonica* as factitious hosts and *O. arenosella* as natural host. A considerable work on the biology of *Goniozus* respect to this parasitoid is yet scanty. In this view, it was felt necessary to conduct a research aspect on the biology of *G. nephantidis*.

Materials and Methods
The experiment was conducted at Entomology Laboratory, Department of Entomology, College of Horticulture, Mojerla, Wanaparthy, Telanagana, Sri Konda Laxman Telangana State Horticultural University during the year 2021-22. The materials and methods used for investigation on various aspects of *Goniozus nephantidis* (Muesebeck) on factitious host, *Corcyra cephalonica* (Stainton) are presented hereunder.

Laboratory culture of *C. cephalonica*

The factitious host rice moth, *C. cephalonica* eggs were procured from National Institute of Plant Health Management (NIPHM) Hyderabad, Telangana. The culture was maintained and mass produced at Entomology Laboratory, Department of Entomology, College of Horticulture, Mojerla, Wanaparthy, Telangana. The bold grains of sorghum were milled in a domestic milling machine by making two to three pieces of each grain and heat sterilized in hot air oven at 100^0C for 30 minutes to make free from any secondary infestation. Material was also been treated with streptomycin sulphate of 0.2 g per kg, to prevent the bacterial infection. Crushed, raw groundnut of 250 g was added to one kilogram of sorghum and kept in pre sterilized circular plastic trays (35 x 12 cm). Trays were arranged in a metal shelf. Ant well was also placed to avoid crawling of ants. Each tray was inoculated with 10000 eggs of *Corcyra* (2-3 days olds) 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 either larvae. The trays were kept undisturbed for 15 days. After 15 days, the mature larvae were collected daily with manual collection in the morning hours in a small Petri dish from each tray. The collection of larvae was continued up to the formation of pupae. The laboratory culture of larvae was maintained for undertaking the further research aspects.

Rearing technique of parasitoid, *Goniozus nephatidis*

The standard rearing method of *G. nephantidis* suggested by Venkatesan *et al*. (2008) [7] was adopted during the present investigation. The nucleus culture of *G. nephantidis* was procured from National Institute of Plant Health Management (NIPHM) Hyderabad, Telangana. The parasitoid adults were obtained from the laboratory rearing stock culture and maintained on the mature and healthy larvae of *Corcyra cephalonica* under laboratory condition. Male and female of *G. nephantidis* were released in to small plastic vials (7x2.5 cm) for mating under diffused light. Males and females were differentiated as female were larger in size with prominent ovipositor and males were smaller with blunted abdominal tip. The droplets of honey solution (20% diluted) on a wax coated paper stripes and water were provided as an adult food. After pre-oviposition period, the females were separated and kept in glass test tubes (13.5x1.5 cm) containing fresh full-grown larva for egg deposition and covered with cotton plug to avoid escape of the adults. The female was transferred every at 24 hours to a similar glass test tubes. The larva parasitized and containing eggs of *G. nephantidis* were removed regularly from the vials till the death of the female. Such larvae were kept in accordion type paper strips in plastic boxes for the successful completion of life cycle. The developed cocoons were utilized to further investigation.

Results and Discussion

The results obtained during the present studies are presented and discussed hereunder.

Egg

The maximum number eggs of *G. nephantidis* were laid on the on dorso-lateral side of 5^{th} to 6^{th} abdominal segments of *C. cephalonica* larvae and there were not any egg on the thorax and the last segment of abdomen. The egg was loosely attached to the host's integument and deposited parallel to the longitudinal axis of the body. The most of eggs were placed on dorso-lateral side of the host larvae. The present findings are agreed with Naganna and Shinde (2017) [4], who reported *G. nephantidis* were laid on the on dorso-lateral side of 5^{th} to 6^{th} abdominal segments of *C. cephalonica* larvae. Freshly laid eggs were creamy white in colour and become translucent later. The deposited eggs were spindle shaped slightly curved, hyaline colourless and loosely attached to the surface of the host body.

Table 1: Biology of predatory reduviid bug, *R. marginatus* reared on rice moth, *C. cephalonica*

Parameters	Days (Mean duration±SD)
Incubation period (Days)	2.80±0.50
Larval Period	3.25±0.68
Pre Cocoon	1.55±0.40
Pupal Period	4.90±0.65
Adult longevity	
Male (Days)	12.15±0.9
Female (Days)	23.10±1.25
Total life cycle	
Male (Days)	24.65±4.30
Female (Days)	35.60±6.50
Adult emergence	78.85±4.20
Sex ratio (Male: Female)	1:5.15
Pre-oviposition period (Days)	4.85±0.60
Oviposition period (Days)	16.35±2.17
Post-oviposition period (Days)	2.90±0.56
Fecundity - Total no. of eggs/female	47.15±6.45
Egg Hatchability (%)	80.25±7.20

*n=30

The incubation period of *G. nephantidis* was 2.80±0.50 days (Table-1). The egg hatching of *G. nephantidis* on *C. cephalonica* was 80.25±7.20 percent. Once the egg hatches, the position of the larva remains fixed. The findings are in accordance with the investigations of Naganna and Shinde (2017) [4], who reported that the incubation period of *G. nephantidis* was ranged from 1.0 to 3.0 days with an average of 2.10±0.71 days and egg hatching of 87.03±5.86 percent.

Larva

The colour, shape and size of larva of *G. nephantidis* revealed that the first instar was apodous, white, devoid of any sign of external segmentation and distinguished from the egg only by waves of internal content of gut contraction and the movement of haemolymph within the parasite'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 larval period of *G. nephantidis* on *C. cephalonica* was recorded with an average of 3.25±0.68 days. Present studies on larval period are in accordance with Desai *et al*, 2020 [1], who found that the larval period of *G. nephantidis* was shortest (3.05±0.76 days) on *C. cephalonica*.

Cocoon

The data presented pertaining to biological attributes of cocoon of *G. nephantidis* revealed that the final instar larva ceased feeding and then search suitable place, where it remained stationary. This formed the beginning of cocoon formation stage. The caudal region was firmly attached to the substrate; the body was shrunken during the formation of pre-

pupa and the fully-grown larvae were started producing silken threads that were used for making of cocoon. 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. The duration of pre-cocoon was 1.55±0.40 days. The cocoon period was recorded with an average of 4.90±0.65 days. The present finding is in conformity with the reports of Desai *et al*, 2020 [1], who found that the pupal period of *G. nephantidis* was 5.20±0.62 days on *C. cephalonica*.

Adult

The newly emerged adults were black in colour with transparent membranous wings, head of the adults were also black in colour and blunted triangular in shape with sharp brown to black colour mandibles. The antennae were filliform, yellowish-brown in colour. The thorax was black in colour with two pairs of membraneous wings and three pairs of yellowish brown legs. The abdomen of females was bulged at anterior portion and sharp at posterior end with pointed ovipositor. The male abdomen differs from females due to short blunted posterior tip. The length of the male was shorter as compared to females. The pre-oviposition period was 4.85±0.60 days. The oviposition period of *G. nephantidis* was 16.35±2.17 days. The post oviposition period was 2.90±0.56 days (Table- 1). The present results are more or less concur with Gurav *et al*. (2018) [3] who noted the pre-oviposition, oviposition and post-oviposition period of *G. nephantidis* was 4.95±0.83, 17.75±3.35 and 3.00±0.79 days when reared on *C. cephalonica*.

Based on the morphological characters, the adults were differentiated into their sexes. Adults emerged from laboratory mass culture during period of investigation, 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 1:5.15 when reared on *C. cephalonica*. The present results are in accordance with Naganna and Shinde (2017) [4] who reported sex ratio (M:F) as 1:4.45. The percent of adult emergence of *G. nephantidis* on *C. cephalonica* varied was 78.85±4.20. The male longevity of (12.15±0.9 days) was observed on *C. cephalonica*. However, highest female longevity (23.10±1.25days) observed on *C. cephalonica*. Gurav *et al*. (2018) [3] reported that the adult emergence of *G. nephantidis* was 80.44, the male and female longevity were 12.90±2.55 and 25.70±3.16 days, respectively when *G. nephantidis* reared on *C. cephalonica*

Fecundity

The fecundity varies with an average of 47.15±6.45 eggs per female (Table-1). The present findings are corroborated with reports of Gurav *et al*. (2018) [3] who reported the average fecundity of *G. nephantidis* was 54.80±9.98 on *C. cephalonica.*

Total life cycle

The duration of total life cycle varied with an average of 24.65±4.30 days for males and with an average of 35.60±6.50 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 present studies on total life cycle of *G. nephantidis* are more or less in accordance with reports of Naganna and Shinde (2017) [4] 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.*

Conclusion

The results also focused that the parasitoid, *G. nephantidis* had few good attributes like high fecundity, maximum eggs hatchability, preponderance of females and longer female longevity which would be helpful in the management of *O. arenosella* through inundative release under field conditions.

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