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GS Chandrashekar
AICRP on Palms Arsikere, University of Horticultural Sciences, Bagalkot, Karnataka, India

HP Maheshwarappa
ICAR Central Plantation Crops Research Institute Kasaragod, Kerala, India

VS Jilu
ICAR Central Plantation Crops Research Institute Kasaragod, Kerala, India

AC Jnanesh
Central Institue of Medicinal and Aromatic Plants, Hyderabad, Telangana, India

Correspondence
VS Jilu
ICAR Central Plantation Crops Research Institute Kasaragod, Kerala, India

Evaluation of *Goniozus nephantidis* (Muesebeck) a larval parasitoid in the field against coconut black headed caterpillar (*Opisina arenosella* Walker) in Karnataka

GS Chandrashekar, HP Maheshwarappa, VS Jilu and AC Jnanesh

Abstract
A field trail was carried out on coconut black headed caterpillar in a farmer field at Kaidalu, Tiptur Tq. Tumkur Dist. Karnataka during 2014-16 following Central Plantation Crop Research Institute guidelines. Larval parasitoid *Goniozus nephantidis* was mass multiplied in the laboratory for conducting the experiments. The parasitoids were pre-conditioned to the odour of larval frass for about 48 to 72 hours in the laboratory prior to release in the field. Before releasing the parasitoids, a pre-treatment count on the number of *Opisina* larva/ leaflet was recorded. Parasitoids were released @ 20 per palm. Four releases were made at 10 days interval during the experimental period. Each treatment was replicated on 10 palms. An untreated control (check) was also simultaneously maintained. The three years pooled data indicated that there was a higher initial larval population ranging from 21.46 to 22.19 numbers per ten leaflets in October month without parasitization which gradually decreased to 1.87 numbers/ten leaflets in treatment T_1 (Conditioned) with 67.95 per cent parasitization and 4.50 numbers/ten leaflets in treatment T_2 (Unconditioned) with 58.45 per cent parasitization. In untreated control, larval population of 17.64 numbers/ ten leaflets with 3.61per cent parasitisation was recorded and it showed an increase in larval population. The conditioned parasitoids were more efficient in reducing black headed caterpillar population with higher per cent parasitization compared to un-conditioned parasitoid.

Keywords: Coconut, *Goniozus nephantidis*, black headed caterpillar, Parasitoids

1. Introduction
The coconut palm, *Cocos nucifera* L. belongs to family Arecaceae is known as "Tree of Life" or "*Kalpa vriksha*" which provides livelihood to billions of people across the world. *Opisina arenosella* Walker is one among the major pests infesting coconut, which causes severe damage to the foliage, deprive the palm of its photosynthetic area and thus, directly affects the yield [1, 2]. The black headed caterpillar is one of the serious and endemic pests of coconut in India [3, 4]. Caterpillars of this pest remain in a gallery of frassy material and they feed on leaf chlorophyll [5]. Severe infestation by this pest makes burnt appearance of the whole plantation. They cause drying of leaves/leaflets leaving only the upper epidermis intact or in case of older infestation, only midrib of the leaflet remains. When palms are severely damaged, the attacked leaves droop, bunches buckle and the immature nuts shed heavily [6]. The details of behaviour and life history of the pest was published by Remadevi *et al.* [7]. Intensive and successive foliar applications of broad spectrum chemical insecticides for controlling larval stages leads to environmental pollution and disturbance in the natural balance in addition to insecticide resistance development [8].
The black headed caterpillar is attacked by many entomophagous insects during its various developmental stages. The recorded list of natural enemies against this pest comprise of about 40 parasitoids and 20 predators [4]. Among the parasitoids, the larval parasitoid *Goniozus nephantidis* (Musebeck) (Hymenoptera: Bethylidae) is a gregarious ectoparasitoid which is extensively used for the reduction of pest population under field conditions [4]. Venkatesan *et al.* [9] reported effective suppression of the pest population with four releases of *G. nephantidis* at the rate of 10 parasitoids per palm at fortnightly interval during the larval and pupal stage. At present *G. nephantidis* is mass multiplied on *Corcyra cephalonica* [10] under laboratory condition and these parasitoids were then released in the field against *O. arenosella* larvae with which they had no previous experience [11].

Earlier studies conducted under laboratory and field conditions revealed that olfactory condition of *G. nephantidis* parasitoids *i.e*., exposure to odour of larval frass and damaged leaves enhances the parasitisation potencial of the parasitoids [11]. The per cent parasitism by *G. nephantidis* on *O. arenosella* varies from place to place. It has been reported as 3.7 to 47.6 per cent in Kerala [12] and 48.0 per cent in Karnataka [13]. It is essential to study the natural occurrence of larval parasitoids of black headed caterpillar and the intensity of parasitism under coconut growing areas of Karnataka to understand the changing scenario of black headed caterpillar and its natural enemies. The present study was carried out to evaluate the parasitisation potential of conditioned and unconditioned parasitoids, under field conditions in the dry zone of Karnataka state.

2. Materials and Methods

The field trail was conducted in coconut black headed caterpillar out break garden in a farmer's field of Kaidalu village, Tiptur Tq., Tumkur Dist., Karnataka during 2014, 2015 and 2016. Initial population of *O. arenosella* was recorded in the treatment and control palms by taking samples of 10 leaflets per palm from 10 palms each and expressed as average population per leaflet. Similarly, post-release observations on parasitized and unparasitised pest population per leaflet and per cent parasitisation were recorded at monthly intervals up to three months after release of parasitoids in treatment and control palms. An untreated control was also maintained for comparison. Observations were taken once in a month. For olfactory conditioning, the parasitoids were exposed to the odour of larval frass and damaged leaves in a 15 cm long and 3 cm diameter test tube for about 72 hours as suggested by Subaharan *et al*. [11]. The dose for the release of conditioned and unconditioned parasitoids were fixed at 20 parasitoids per palm. Four releases were made at 10 days interval during the experimental period. Each treatment was replicated on 10 palms. Three replications were maintained and an untreated control check was also simultaneously maintained. The method and time of the release of parasitoid was as per the technique suggested by Venkatesan *et al*. [9].

3. Results and Discussion

There was a high initial larval population ranging from 21.65 to 22.40 numbers per ten leaflets in October 2014 and it gradually decreased to 16.25, 5.12 and 1.86 numbers per ten leaflets in treatment T_1 (Conditioned) and 18.22,8.66 and 4.53 numbers per ten leaflets in treatment T_2 (Unconditioned). In untreated control larval population of 21.97 numbers per ten leaflets was recorded initially which increased to 23.45 and 25.22 numbers per ten leaflets in first and second months and later decreased to 16.44 in the third month (Table 1).

Table 1: Evaluation of pre-conditioned parasitoid *G. nephantidis* against *O. arenosella* in Karnataka (2014-15)

Treatment	(Pre-release count) October 2014	(*O. arenosella* larval population/ ten leaflets) (Post-release count)			Avg. No. of larvae/ ten leaflets (Pre-release count) October 2014	(% Parasitization of *O. arenosella* larval population) (Post- release count)		
		After one Month (November- 2014)	After two months (December- 2014)	After three months (January- 2015)		After one Month (November- 2014)	After two months (December- 2014)	After three months (January- 2015)
T_1 (Conditioned)	21.65 (4.65)	16.25 (4.03)	5.12 (2.26)	1.86 (1.36)	0.00	74.41	67.95	75.13
T_2(Unconditione)	22.4 (4.73)	18.22 (4.27)	8.66 (2.94)	4.53 (2.13)	0.00	63.40	58.45	63.56
T_3 (Control)	21.97 (4.69)	23.45 (4.84)	25.22 (5.02)	16.44 (4.05)	0.00	2.32	3.61	2.14
SEM±	NS	0.15	0.9	1.2		-	-	-
CD (P=0.05)	NS	0.45	2.66	2.8		-	-	-

Figures in parenthesis are square root transformed values; Values are average of ten palms

In the year 2015 also there was a high initial larval population ranging from 20.52 to 21.05 numbers per ten leaflets in October 2015 which gradually decreased to 15.11, 5.04 and 1.24 numbers per ten leaflets in treatment T_1 (Conditioned) and 17.64, 7.97 and 4.85 numbers per ten leaflets in treatment T_2 (Unconditioned). In untreated control, larval population of 21.97 numbers per ten leaflets was recorded which increased to 22.47 and 24.84 numbers per ten leaflets in first and second months and later decreased to 18.24 in third month (Table 2).

Similarly, in the year 2016 there was a high initial larval population ranging from 22.21 to 23.12 numbers per ten leaflets in October 2016 which gradually decreased to 17.25, 7.21 and 2.51 numbers per ten leaflets in treatment T_1 (Conditioned) and 19.20, 10.23 and 4.12 numbers per ten leaflets in treatment T_2 (Unconditioned). In untreated control the larval population of 24.41 numbers per ten leaflets was recorded initially which increased to 24.12 and 25.98 numbers per ten leaflets in first and second months and later decreased to 18.24 in third month (Table 3).

Table 2: Evaluation of pre-conditioned parasitoid *G. nephantidis* against *O. arenosella* in Karnataka (2015-16)

Treatment	Avg. No. of larvae/ ten leaflets (Pre-release count) October 2015	(*O. arenosella* larval population/ ten leaflets) (Post-release count)			Avg. No. of larvae/ ten leaflets (Pre-release count) October 2015	(% Parasitization of *O. arenosella* larval population) (Post- release count)		
		After one month (November-2015)	After two months (December- 2015)	After three months (January- 2016)		After one month (November- 2015)	After two months (December- 2015)	After three months (January- 2016)
T_1 (Conditioned)	20.52 (4.53)	15.11 (3.88)	5.04 (2.24)	1.24 (1.11)	0.00	69.40	75.13	77.88
T_2 (Unconditioned)	21.05 (4.58)	17.64 (4.22)	7.97 (2.82)	4.85 (2.20)	0.00	58.18	63.56	67.12
T_3 (Control)	20.84 (4.56)	22.47 (4.74)	24.84 (4.98)	18.24 (4.27)	0.00	1.08	2.14	3.51
SEM±	NS	1.70	5.20	5.40	-	-	-	-
CD (P=0.05)	NS	4.20	13.10	13.50	-	-	-	-
CV	5.80	7.80	8.20	7.50	-	-	-	-

Figures in parenthesis are square root transformed values; Values are average of ten palms.

Table 3: Evaluation of pre-conditioned parasitoid *G. nephantidis* against *O. arenosella* in Karnataka (2016-17) (Average of ten palms)

Treatment	Avg. No. of larvae/ ten leaflets (Pre-release count) October 2016	(*O. arenosella* larval population/ ten leaflets) (Post-release count)			Avg. No. of larvae/ ten leaflets (Pre-release count) October 2016	(% Parasitization of *O. arenosella* larval population) (Post- release count)		
		After one month (November-2016)	After two months (December-2016)	After three months (January-2017)		After one month (November-2016)	After two months (December-2016)	After three months (January- 2017)
T_1 (Conditioned)	22.21 (28.11)	17.25 (4.15)	7.21 (2.69)	2.51 (1.58)	0.00	69.41	74.07	78.72
T_2 (Unconditioned)	23.12 (28.73)	19.20 (4.38)	10.23 (3.20)	4.12 (2.03)	0.00	57.41	63.67	70.11
T_3 (Control)	22.41 (28.25)	24.12 (4.91)	25.98 (5.10)	18.24 (4.27)	0.00	1.03	2.63	3.18
SEM	NS	1.4	4.2	5.1	-	-	-	-
CD(P=0.05)	NS	3.5	10.5	12.75	-	-	-	-
CV	6.21	7.2	11.2	10.8	-	-	-	-

Figures in parenthesis are square root transformed values; Values are average of ten palms.

The three years pooled data indicated that, there was a high initial larval population ranging from 21.46 to 22.19 numbers per ten leaflets and gradually decreased to 16.20, 5.79 and 1.87 numbers/ten leaflets in treatment T_1(Conditioned) and 18.35, 8.95 and 4. 50 numbers/ten leaflets in treatment T_2 (Unconditioned). In untreated control the larval population of 21.74 numbers /ten leaflets was recorded and showed an increase to 23.34 and 25.34 numbers/ten leaflets in first and second months and later decreased to 17.64 in third month (Table 4).

The three years pooled data on per cent parasitization indicated that, there was very low i.e., zero per cent parasitization which gradually increased to 68.96, 74.04 and 78.72 per cent in treatment T_1 and 57.84, 63.40 and 68.45 per cent parasitization in treatment T_2. In untreated control there was zero per cent parasitization initially and it increased to 1.03 and 2.32 numbers per ten leaflets in first and second months and 3.61 in third month. Hence, the parasitization level indicated that the conditioning of parasitoid is more efficient in reducing black headed caterpillar population compared to un-conditioned parasitoid. This result is in line with the findings of Chalapathi Rao *et al*. [14]. During the years 2011 and 2012, they observed an increase in pest population in untreated control even though initial natural parasitisation on a lower scale was recorded. After 3rd month of release of conditioned parasitoid, cent per cent parasitisation was achieved in both 2011 and 2012 whereas, in the unconditioned parasitoid treatment parasitization to a level of 83.8 and 83.5 per cent respectively was observed. In a similar research, Subaharan *et al*. [11] observed that the three days laboratory conditioned parasitoids when offered a choice for parasitism preferred *O. arenosella* (64%) against its surrogate host *C. cephalonica* (36%) on which they were reared. The present study inferred that conditioning of parasitoids to the frass of its natural host, *O. arenosella*, increased the host searching and parasitisation efficiency in the field even though they were continuously reared on laboratory host. *C. cephalonica*.

Table 4: Three years pooled data on evaluation of pre-conditioned parasitoid *G. nephantidis* against *O. arenosella* in Karnataka

Treatment	Avg. No. of larvae/ ten leaflets (Pre-release count)	(*O. arenosella* larval population/ ten leaflets) (Post- release count)			Avg. No. of larvae/ten leaflets (Pre-release count)	(% Parasitization of *O. arenosella* larval population) (Post- release count)		
		After one Month	After two months	After three months		After one month	After two months	After three months
T_1(Conditioned)	21.46 (4.63)	16.20 (4.02)	5.79 (2.41)	1.87 (1.36)	0.00	68.96	74.04	78.68
T_2 (Unconditioned)	22.19 (4.71)	18.35 (4.28)	8.95 (2.99)	4.50 (2.12)	0.00	57.92	62.97	68.45
T_3 (Control)	21.74 (4.66)	23.34 (4.83)	25.34 (5.03)	17.64 (4.20)	0.00	0.98	2.18	3.61
SEM	NS	0.05	0.18	0.9	-	-	-	-
CD(P=0.05)	NS	0.15	0.54	2.7	-	-	-	-
CV	6.17	8.2	10.3	7.6	-	-	-	-

Figures in parenthesis are square root transformed values; Values are average of ten palms.

Subaharan[15] reported that the larval population of *O. arenosella* decreased to 59 per cent in palms on which the conditioned parasitoids were released, while the reduction was to a tune of 26 per cent in the palms where the unconditioned parasitoids were released. The control plot recorded the highest larval population (5 per leaflet). Observations revealed that there was a significant difference in the larval population in the palms where the conditioned and unconditioned parasitoids were released. Control palms recorded the highest pest incidence of 4.8 larvae per leaflet. The olfactory conditioning of *G. nephantidis* reared on *C. cephalonica* with the odor of *O. arenosella* frass increased its parasitisation efficiency. The volatiles emitted from *O. arenosella* damaged coconut leaf and its frass showed antennal Electro Antenna Gram (EAG) response of female G. *nephantidis.* Conditioning of *G. nephantidis* with odors of *O. arenosella* can be easily followed in mass multiplication units so as to enhance the host searching ability of the parasitoids which were reared on *C. cephaionica.*

4. Conclusion

The larval parasitoid *G. nephantidis* is an efficient parasitoid which helps in suppression of *O. arenosella* in field. The parasitoids were reared on *C. cephalonica* under laboratory condition. In the current experiment, the parasitoids were exposed to odour of larval frass in the laboratory to pre-condition prior to release in the field. The results of the study proved that pre-conditioned parasitoids were more efficient in reducing black headed caterpillar population with higher per cent parasitization compared to un-conditioned parasitoids. Therefore pre-conditioning of the parasitoid may be taken up before inundative release of parasitoid to increase host searching ability and field efficacy of the parasitoid.

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