

## Impact of Innundative Releases of Bio Agents in the Management of Coconut Black Headed Caterpillar *Opisina arenosella* in Andhra Pradesh under Out Break Conditions

N. B. V. Chalapathirao\*, A. Snehalatha Rani, N. Emmanuel,  
G. Ramanandam and H. P. Maheswarappa<sup>1</sup>

AICRP on Palms, Horticultural Research Station, Ambajipeta 533 214  
Dr YSR Horticultural University, Andhra Pradesh

<sup>1</sup>Project Coordinator, AICRP on Palms, CPCRI, Kasargod, Kerala 671 124

\*Corresponding Author E-mail: [chalapathirao73@gmail.com](mailto:chalapathirao73@gmail.com)

Received: 28.11.2017 | Revised: 31.12.2017 | Accepted: 4.01.2018

### ABSTRACT

The coconut black headed caterpillar *Opisina arenosella* Walker is a major pest of the coconut and its regular incidence without break under favourable conditions was recorded in coastal Andhra Pradesh from decades and one of the earliest organized attempts for biological control was against this pest in India. Among the important bio agents the most promising bio agents against *O. arenosella* are larval parasitoids *Bracon hebetor*, *Goniozus nephantidis*, pupal parasitoid *Brachymeria nosatoi* and anthocorid predator *Cardiastethus exiguus*. Large scale field demonstration of biological control of coconut black headed caterpillar *O. arenosella* was taken up in the black headed caterpillar affected gardens in eight villages in East Godavari district of Andhra Pradesh during the severe incidence of this pest from October 2011 – June 2013. A total of 22.60 lakh bio agents were mass multiplied in laboratory and systematically supplied to farmers for stage specific release in the infested gardens. The pre release larval population ranging from 71.9 to 168.9 per 10 leaflets in the affected villages completely decreased after innundative bio agents release in three to six months after release.

**Key words:** Coconut black headed caterpillar, *Opisina arenosella*, Bio agents, innundative releases, Andhra Pradesh

### INTRODUCTION

The coconut black headed caterpillar *Opisina arenosella* Walker, the leaf eating caterpillar is a major pest of the coconut palm<sup>3, 14</sup>. Outbreak of this pest assumes severe proportions on the coastal and backwater tracts. This pest has been observed regularly and is persistent in

Godavari districts of Andhra Pradesh<sup>6</sup> since 1947. Infestation by this pest in severe cases makes the whole plantation present a burnt appearance due to the drying of leaves/leaflets with only the upper epidermis intact or in cases of old infestation leaves remain with midrib of the leaflet only.

**Cite this article:** Chalapathirao, N.B.V., Rani, A.S., Emmanuel, N., Ramanandam, G. and Maheswarappa, H.P., Impact of Innundative Releases of Bio Agents in the Management of Coconut Black Headed Caterpillar *Opisina arenosella* in Andhra Pradesh under Out Break Conditions, *Int. J. Pure App. Biosci.* 6(2): 427-433 (2018). doi: <http://dx.doi.org/10.18782/2320-7051.6041>

When palms are severely damaged, the attacked leaves droop, bunches buckle and the immature nuts shed heavily<sup>10</sup>. Among the important bio agents the most promising bio agents against *O. arenosella* are larval parasitoids *Bracon hebetor*, *Goniozus nephantidis*, pupal parasitoid *Brachymeria nosatoi* and anthocorid predator *Cardiastethus exiguus*.

A bio-intensive pest management strategy has been developed for the management of this pest when it is in an epidemic form<sup>11,19</sup>. Pest incidence can be checked by the bio control methods utilizing indigenous parasitoids. Among the parasitoids recorded from India<sup>15</sup>, the larval parasitoid *G. nephantidis* Mues. (Bethyridae), the pre-pupal parasitoid *Elasmus nephantidis* Rohw. (Elasmidae) and the pupal parasitoid *B.nosatoi* Habu. (Chalcididae) are the most promising ones. *B. brevicornis* Wesmael (Braconidae) also parasitizes the late larval stage of the pest. Abdurahiman *et al.*<sup>1</sup> in their studies on the biology of *Cardiastethus* sp. reported that both the nymphs and adults fed on egg and early stage larvae of *O.arenosella*. The intrinsic behaviour and life cycle of the anthocorid bug *C. exiguus* on *O. arenosella*<sup>12</sup> and limited scale field efficacy of this predator on coconut leaf eating black headed caterpillar *O. arenosella* has been taken up at Kerala<sup>13</sup>. Kapadia<sup>7</sup> described the biology of *Cardiastethus* sp.nr. *nazareus* Reuter, preying on the coconut caterpillar in Gujarat.

Though advocated bio control has not made clear inroads as a technology in the farmers fields especially in plantation crops under out break conditions with prime obstacles being large scale, timely availability of the bio agents synchronising with pest cycle. Therefore, to stress on the timely release and importance of biological control in coconut pest management, during black headed caterpillar out break, mass multiplication of major parasitoids, predators was carried out and large scale field demonstration programmes were taken up in the affected gardens of various villages in East Godavari district of Andhra Pradesh

during the out break of this pest from October 2011 to June 2013.

## MATERIAL AND METHODS

Large-scale field validation programme on bio intensive IPM for the management of coconut black headed caterpillar was implemented under the Coconut development board, Kochi, Kerala funded TMOC (Technology mission on coconut) project by HRS., Ambajipeta in a total area of nearly 600 acres in eight villages from October 2011 to December 2012. The incidence was recorded in both fish pond and sole coconut gardens (Table 1). The total operational area of approximately 50 acres in each village was divided into 5 clusters of 10 acres each for assessing incidence of the target pest and inundative bio agents release was made accordingly in the clusters at fortnightly intervals. Egg predator *C. exiguus*, larval parasitoids (*G. nephantidis* and *B. hebetor*) and Pupal parasitoid (*B. nosatoi*) were multiplied in the Entomology laboratory of Horticultural research station Ambajipeta as per the standard multiplication techniques and the details of bio agents released in each village were mentioned in Table 2. Mass culturing procedures of *C. exiguus*<sup>2</sup>, *G. nephantidis*<sup>18</sup> and *B. nosatoi*<sup>16</sup> were utilised for multiplication of these bio agents in lab.

The data on pre and post release population of coconut black headed caterpillar *O. arenosella* was arrived by collecting 10 sample leaflets from lower / middle whorl of leaves through destructive sampling (41-60% leaflets of 20% leaves from the lower or middle whorl) from 40 fixed sample palms from each of the cluster (10 acres each) at monthly interval (totalling to 200 palms for 5 clusters together in the each experimental village) and expressed as average pest population per 10 leaflets and the data obtained was subjected to paired t test. In S. Yanam, Matlapalem, N. Raguvulapeta and Undrajavaram villages the inundative releases were done for three months and data on pest population was recorded at monthly

intervals while in Gogannamatam, Mutyalapalem, Gachhakayala pora and Dwarapudi villages where incidence was observed from December 2012 post Neelam Cyclone occurrence the releases were continued up to six months and the data on pest population was recorded in these villages in one, three and six months after release. The parasitoids were released in the field after assessing the population of the target stage of the pest at fortnightly intervals inundatively as there was a high incidence (all the lower whorls of leaves or entire crown damaged) of the pest. As unconditioned bio agents had only low response to *O. arenosella* as compared to those conditioned to odour of *O. arenosella*<sup>4,21</sup> therefore, before releasing the parasitoids in field they are fed with honey and are exposed to the host odours for 72 hours for olfactory conditioning (smell of the volatiles of the injured *O. arenosella* larvae and gallery volatiles). The releases in the affected villages were made in accordance to the pest population in the affected gardens and farmer's participation and involvement were ensured during the release programme. The release of parasitoids was continued until a decline in the pest population was observed.

## RESULTS AND DISCUSSIONS

The incidence of coconut black headed caterpillar was initially observed on the fish pond bund coconut trees in the Matlapalem village, East Godavari district in December 2011 and an average pre treatment population of 156.9 larvae /10 leaf lets was recorded and a total of 55,000 *B. hebetor*, 8000 numbers *G.nephantidis* and 1600 numbers of *B. nosatoi* parasitoids were released in various months in this village. The release of the parasitoids had resulted in decrease of average larval population to 19.3, 6.8 and nil for 10 leaflets respectively after one, two and three months after release. The incidence of this caterpillar was observed on the fish pond bund coconut trees in the N. Ragavulapeta Village, S. Yanam villages in East Godavari and in Undrajvaram village in West Godavari in first,

second and third quarters of 2012. The average pre treatment larval population observed was found to be high at N. Ragavulapeta Village with 168.9 larvae /10 leaf lets and the inundative release of bio agents has resulted in decrease of average larval population to 47.4 ,23.2 and 5.0 per 10 leaflets respectively after one ,two and three months after parasitoid release. In S.Yanam and in Undrajvaram villages the pre release larval population was found to be 76.8 larvae and 71.90 larvae /10 leaf lets. A total of 1.0 lakhs ,0.63 lakhs of *B. hebetor* parasitoids 0.15 ,0.06 lakhs of *G. nephantidis* parasitoids 800, 600 numbers of *B. nosatoi* parasitoids and 0.75,1.0 lakhs of predator *C. exiguus* respectively were released in the demonstration experimental gardens and a decrease of larval population to 30.5 and 19.3 per 10 leaflets , respectively after one month 7.7 and 9.7 per 10 leaflets respectively, after two months and to 19.3 and nil population respectively, after three months after release of parasitoids was recorded. After three months of release about 97 percent at S. Yanam and N. Ragavulapeta , hundred percent at Undrajvaram village was recorded .Sujatha and Chalam <sup>22</sup> also recorded a decrease in black headed caterpillar population from 16.73 to 8.73 /palm with 30 % parasitisation that release of larval parasitoid *B. hebetor* , *G. nephantidis* and pupal parasitoid *B. nosatoi* along with *C.exiguus* release which also reduced the pest population from 102.3 to 5.4 /palm. Similar results in the demonstration villages was achieved in present study through inundative releases. However, release of hymenopterous parasitoids viz., *B. hebetor*, *B. brevicornis* and *G. nephantidis* at fortnightly intervals at 15, 20 and 25% of the pest population in four villages in Puri district of Orissa during 1996 and 1997 revealed that effective control was achieved when the parasitoids were released at 20% of the pest population<sup>9</sup>. The efficacy of *C. exiguus* as an efficient egg larval predator of *O. arenosella* was reported by Rajamanickam *et al.*<sup>17</sup> and in present study as stage specific parasitoids were released which were have a

oviposition preferences for the larvae the efficacy of *C. exiguus* was not affected as it mainly feeds on eggs. After the receipt of high rainfall due to Neelam cyclone in November 2012 in coastal Andhra Pradesh a high incidence of black headed caterpillar was observed in new villages viz., Gogannamatham, Mutyalapalem, Gachakayalapora and Dwarapudi where again inundative releases were taken up for a period of six months. The pre release larval population in these villages was found to be ranging from 84.1 to 124.1 larvae /10 leaflets and after inundative release a decrease in larval population ranging from 33.84 to 53.15 per cent (ranging from 39.4 to 82.10 larvae per 10 leaflets) after one month and over 75 per cent in three months (ranging from 21.0 to 32.40 larvae per 10 leaflets) was observed. The pest population had decreased to nil in all the villages after six months (June 2013). A significant decrease in larval population was observed between the months in all the villages during the entire study period. Similar results of success of biological control in coconut was earlier reported by Sathiamma *et al.*<sup>20</sup> who had observed 94 % reduction in pest population in a heavily infested coconut garden of 2.8 ha (Thodiyoor, Kerala) for a period of four years. Chandrika Mohan and Nair<sup>5</sup> reported 52.6 and 94.7% reduction in black headed caterpillar pest population after

one and two years, respectively of parasitoid release in heavily infested homestead coconut gardens in an area of 3 ha in Neendakara (Kerala). Further, the survival of *G. nephantidis* and *B. brevicornis* from eggs to adult eclosion was 89.6 and 81.8%, respectively, when larvae of *O. arenosella* were exposed to these parasitoids individually and both these parasitoids tend not to oviposit on parasitised hosts bearing larvae of either parasitoid, and the parasitoids did not kill the larvae of the other species<sup>23</sup>. The effectiveness of *C. exiguus* as a predator of *O. arenosella* under field conditions was reported by Kumar *et al.*<sup>8</sup>.

Therefore, systematic, inundative and timely release of stage specific bio agents even under outbreak conditions will successfully manage coconut black headed caterpillar in larger areas and the self perpetuating parasitoids prevents the spread of the outbreak to other mandals. The farmers can be educated from resorting to the use of hazardous insecticides monocrotophos and dichlorovos in the coconut ecosystem if a successful bio control programme is in operation. In the days where hazardous pesticides usage is becoming a matter of concern, this success of biological control as an alternate system of pest control, gives impetus to sustainable agriculture and can strengthen the concept of pesticide free produce in this important plantation crop.

**Table 1: Details of experimental villages affected by coconut black headed caterpillar and dates of initiation of bio agents release**

S. No	Name of the village	Mandal and district	Date of initiation of bio agents release	Area in acres in each village selected	Coconut cropping system
1	S Yanam	Uppalaguptham, East Godavari	15.10.11	50	Fish pond bund trees
2	Matlapalem	Tallarevu, East Godavari	13.12.11		Fish pond bund trees
3	N.Raguvulapeta	Uppalaguptham, East Godavari	22.01.12		Fish pond bund trees
4	Undrajavaram	Undrajavaram, West Godavari	13.04.12		Sole gardens
5	Gogannamatam	Razole, East Godavari	20.12.12		Sole gardens
6	Mutyalapalem	Razole, East Godavari	21.12.12		Sole garden
7	Gachhakayala pora	Uppalaguptham, East Godavari	22.12.12		Fish pond bund trees
8	Dwarapudi	Mandapeta, East Godavari	31.12.12		Sole garden

**Table 2: Total number of different bio agents supplied to the farmers for release in coconut black headed caterpillar affected villages (In thousands)**

S. No	Name of the villages	Duration of release	<i>C.exiguus</i>	<i>B. hebetor</i>	<i>G. nephandidis</i>	<i>B.nosatoi</i>
1	S. Yanam	1 <sup>st</sup> month	5000	20000	3000	100
		2 <sup>nd</sup> month	10000	25000	5000	140
		3 <sup>rd</sup> month	3000	15000	1800	0
		<b>Total</b>	<b>18000</b>	<b>60000</b>	<b>9800</b>	<b>240</b>
2	Matlapalem	1 <sup>st</sup> month	0	20000	2000	500
		2 <sup>nd</sup> month	0	25000	5000	800
		3 <sup>rd</sup> month	0	10000	1000	200
		<b>Total</b>	<b>0</b>	<b>55000</b>	<b>8000</b>	<b>1600</b>
3	N.Raguvulapeta	1 <sup>st</sup> month	15000	20000	1500	200
		2 <sup>nd</sup> month	25000	35000	2000	300
		3 <sup>rd</sup> month	10000	10000	1000	100
		<b>Total</b>	<b>50000</b>	<b>65000</b>	<b>4500</b>	<b>600</b>
4	Undrajavaram	1 <sup>st</sup> month	0	20000	2000	200
		2 <sup>nd</sup> month	10000	25000	3000	300
		3 <sup>rd</sup> month	0	18000	1000	100
		<b>Total</b>	<b>10000</b>	<b>63000</b>	<b>6000</b>	<b>600</b>
5	Gogannamatam	1 <sup>st</sup> month	15000	20000	300	0
		2 <sup>nd</sup> month	15000	30000	1500	800
		3 <sup>rd</sup> month	18000	50000	2500	1200
		4 <sup>th</sup> month	10000	50000	1500	0
		5 <sup>th</sup> month	5000	50000	500	0
		6 <sup>th</sup> month	5000	4500	200	0
		<b>Total</b>	<b>68000</b>	<b>204500</b>	<b>6500</b>	<b>2000</b>
6	Mutyalapalem	1 <sup>st</sup> month	12000	30000	200	0
		2 <sup>nd</sup> month	15000	75000	2000	100
		3 <sup>rd</sup> month	15000	70000	2000	800
		4 <sup>th</sup> month	15000	50000	3000	500
		5 <sup>th</sup> month	15000	30000	500	0
		6 <sup>th</sup> month	5000	3250	200	0
		<b>Total</b>	<b>77000</b>	<b>258250</b>	<b>7900</b>	<b>1400</b>
7	Gachhakayala pora	1 <sup>st</sup> month	10000	20000	0	100
		2 <sup>nd</sup> month	10000	30000	1000	100
		3 <sup>rd</sup> month	22000	70000	1500	300
		4 <sup>th</sup> month	15000	80000	500	600
		5 <sup>th</sup> month	10000	20000	300	200
		6 <sup>th</sup> month	8000	3380	0	0
		<b>Total</b>	<b>75000</b>	<b>223380</b>	<b>3300</b>	<b>1300</b>
8	Dwarapudi	1 <sup>st</sup> month	10000	20000	500	200
		2 <sup>nd</sup> month	20000	50000	1000	200
		3 <sup>rd</sup> month	30000	60000	1500	400
		4 <sup>th</sup> month	50000	60000	2000	400
		5 <sup>th</sup> month	50000	60000	1000	300
		6 <sup>th</sup> month	23000	38000	500	100
		<b>Total</b>	<b>183000</b>	<b>288000</b>	<b>6500</b>	<b>1600</b>

**Table 3: Impact of inundative release of bio agents in suppression of coconut black headed caterpillar *O.arenosella* in the affected villages**

S. No	Village and date of initiation of bio agents release	Total number of bio agents released (in thousands)	Mean $\pm$ SE (per 10 leaflets)				T value		
			Pre release	Post release			Pre-1month	Pre-2 months	Pre-3months
				After 1 month	After 2 months	After 3months			
1	S Yanam 15.10.11	88040	76.80 $\pm$ 6.28	30.50 $\pm$ 1.25	7.70 $\pm$ 1.02	2.00 $\pm$ 0.42	7.18**	10.41**	12.16**
2	Matlapalem 13.12.11	64600	156.90 $\pm$ 9.87	19.30 $\pm$ 1.87	6.80 $\pm$ 1.64	0.0 $\pm$ 0.0	12.32**	14.92**	15.88**
3	N.Raguvulapeta 22-01-12	120100	168.9 $\pm$ 12.13	47.40 $\pm$ 5.77	23.20 $\pm$ 2.57	5.00 $\pm$ 0.788	11.39**	12.99**	13.47**
4	Undrajavaram 13-04-12	79600	71.90 $\pm$ 3.55	19.30 $\pm$ 1.32	9.70 $\pm$ 1.52	0.0 $\pm$ 0.0	14.43**	15.55**	20.23**
			Pre release	After 1 month	After 3 months	After 6months	Pre-1month	Pre-3 months	Pre-6 months
5	Gogannamatam 20.12.12	281000	119.20 $\pm$ 5.29	65.20 $\pm$ 3.22	32.40 $\pm$ 2.46	0.0 $\pm$ 0.0	11.06**	16.51**	22.51**
6	Mutyalapalem 21.12.12	344550	124.10 $\pm$ 5.57	82.10 $\pm$ 2.63	25.00 $\pm$ 1.70	0.0 $\pm$ 0.0	6.84**	19.62**	22.27**
7	Gachhakayala pora 22.12.12	302980	123.80 $\pm$ 4.00	76.30 $\pm$ 3.34	26.00 $\pm$ 1.57	0.0 $\pm$ 0.0	13.83**	23.65**	30.87**
8	Dwarapudi 31.12.12	479100	84.10 $\pm$ 2.36	39.40 $\pm$ 1.89	21.00 $\pm$ 1.20	0.0 $\pm$ 0.0	18.23**	22.83**	35.48**
	Total	2259970							

The values with \*\* are significantly differ with each other at 1% LOS

### Acknowledgements

The investigators sincerely thank the Chairman and The Director, Coconut Development Board, Kochi for sponsoring the TMOG (Technology mission on coconut) project on Mass multiplication of parasitoids, predators, bio agents and large scale demonstration of biological control of major insect pests and diseases of coconut in Andhra Pradesh and The Director NBAIR, Bengaluru for providing and augmenting the culture of *G. nephantidis*. The authors thank the farmers in mass demonstration villages East Godavari district of Andhra Pradesh for their full cooperation in the execution of the demonstrations, assistance in data collection and for active involvement in the project.

### REFERENCES

1. Abdurahiman, U. C., Mohammed, U. V. K. and Remadevi, O. K., Studies on the biology of a predator *Cardiastethus* sp. (Hemiptera: Anthocoridae) found in the galleries of *Nephantis serinopa* Meyrick (Lepidoptera: Xylorictidae). *Cur. Sci*, **51(11)**: 574 (1982).
2. Ballal, C.R., Singh, S.P., Poorani, J. and Gupta, T., Feasibility of mass multiplication and utilization of *Cardiastethus exiguus* Poppius, a potential anthocorid predator of *Opisina arenosella* Walker (Lepidoptera: Oecophoridae), In: *Proceedings Biological control of*
3. *Lepidopteran Pests* (Eds.) Tandon, P.L., Ballal, C. R., Jalali, S. K. and Rabindra, R.J., Society for Biocontrol Advancement, PDBC, Bangalore. pp. 29-35 (2002).
4. Becker, V. O., Identities and provenance of the gelechiid moths originally described by Francis Walker from Unknown countries. *Syst. Ent*, **6(2)**: 137-141 (1981).
5. Chalapathi Rao, N. B. V., Emmanuel, N. and Subaharan, K., Impact of olfactory conditioned parasitoid *Goniozus nephantidis* (Muesebeck) in suppression of *Opisina arenosella* Walker under field conditions in east coast of Andhra Pradesh. *J. Plant. Crops*, **41**: 460-462 (2013).
6. Chandrika, M. and Nair, C. P. R., A case study on demonstration of Bio-intensive IPM for the control of coconut leaf eating caterpillar, *Opisina arenosella* Walk. Paper presented in "Symposium on biological control of lepidopteran pests, Bangalore, India, during July 17-16, P. 64 (2002).
7. Dharmaraju, E., The biological control of the black headed caterpillar of coconut (*Nephantis serinopa* M.) in the East Godavari district of Madras State. *Indian Coconut. J*, **5 (4)**: 171 -176 (1952).
8. Kapadia, M. N., Biology of *Cardiastethus* sp. *nazareus* Reuter (Hemiptera: Anthocoridae) a predator of *Opisina*

- arenosella* Walker. *Guj. Agri. Univ. Res. J*, **12(2)**: 55-56 (1987).
8. Kumar., Suneel., Singh, S. V., Arvind, K. and Khan, M. A., Predatory potential of *Canthecona furcellata* on defoliating stages of *Clostera fulgurita*. *Ann. Pl. Protec. Sci*, **16**: 485- 486 (2008).
  9. Mohanty, J. N., Prakash, A., Rao, J., Pawar, A. D., Patnaik, N. C. and Gupta, S. P., Parasitization of the coconut black-headed caterpillar, *Opisina arenosella* Walk. in Puri district of Orissa by field release of hymenopterous parasitoids. *J. App. Z. Res*, **11(1)**: 17-19 (2000).
  10. Muthiah, C., Estimation of yield loss caused by eriophyid mite on coconut. *Ann. Pl. Protec. Sci*, **15**: 484-486 (2007).
  11. Nair, C. P. R., Daniel, M. and Ponnamma, K. N., Integrated Pest management in Palms. Coconut Development Board, Cochin. pp.30 (1997).
  12. Nasser, M. and Abdurahiman, U. C., Influence of diet on the nymphal development and reproductive potential of the predatory bug, *Cardiastethus exiguus* Poppius (Hemiptera : Anthocoridae), *J. Z. Soc, Kerala*. **6&7**: 11-18 (1996).
  13. Nasser, M. and Abdurahiman, U. C., Efficacy of *Cardiastethus exiguus* Poppius (Hemiptera : Anthocoridae), as a predator of the coconut caterpillar, *Opisina arenosella* Walker (Lepidoptera: Xylorictidae). *J. Ent. Res*, **22(4)**: 361-368 (1998).
  14. Nirula, K. K., Investigations on the pests of coconut palm, Part III, *Nephantis serinopa* Meyrick. *Indian Coconut. J*, **9**: 101-131 (1956).
  15. Pillai, G. B. and Nair, K. R., A checklist of parasitoids and predators of *Opisina arenosella* Wlk. on coconut. *Ind. Coc. J*, **23(9)**: 2-9 (1993).
  16. Pillai, G. B. and Nair, R. K., A technique for laboratory multiplication of *Brachymeria nosatoi* and other species of chalcidid parasitoids of *Nephantis serinopa* Meyrick. *Entomon*, **7**: 213-211 (1982).
  17. Rajamanickam, K., Johnson, I. and Subaharan., K., Evaluation of egg larval predator anthocorid bug, *Cardiastethus exiguus* Poppius against *Opisina arenosella* in Tamil Nadu. *J. Plantn. Crops*, **41(3)**: 444-446 (2013).
  18. Remadevi, O. K., Mohamed, U.V.K and Abdurahiman, U.C., Some aspects of biology of *Parasierola nephantidis*(Hymenoptera : Bethyridae) a larval parasitoid of *Nephantis serinopa* Meyrick( Lepidoptera: Xylorictidae). *Poliske Dismo Entomologiczne* , **51**: 597-604 (1981).
  19. Sathiamma, B., *Opisina arenosella* Wlk., the leaf eating caterpillar of coconut palm. *Tech. Bull.* 10, Central Plantation Crops Research Institute, Kasaragod, pp. 12 (1993).
  20. Sathiamma, B., Sabu, A. S. and Pillai, G. B., Field evaluation of the promising species of indigenous parasitoids in the biological suppression of *Opisina arenosella* Wlk. the coconut leaf eating caterpillar. *J. Plantn. Crops*, **24**: 9-15 (1996).
  21. Subaharan,K., Ponamma, K.N.,Sujatha, A., Basheer, B.Md., and Raveendran, P., Olfactory conditioning in *Goniozus nephantidis*( Musebeck) a parasitoid of coconut black headed caterpillar , *Opisina arenosella* Walker. *Entomon*, **30(2)**: 165-170 (2005).
  22. Sujatha, A., and Chalam, M.S.V., Status of coconut black headed caterpillar *Opisina arenosella* Walker and evaluation of bio-agents .*Ann.Pl.Protec.Sci*, **17(1)**: 65-68(2009).
  23. Venkatesan, T., Sushil Kumar, J. and Kotilingam Srinivasamurthy, K., Competitive interactions between *Goniozus nephantidis* and *Bracon brevicornis*, parasitoids of the coconut pest *Opisina arenosella*. *Int. J. P. Man*, **55(3)**: 257–263 (2009).