Biological suppression of coconut black headed caterpillar *Opisina arenosella* outbreak in East Godavari district of Andhra Pradesh – eco friendly technology

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The leaf eating black headed caterpillar *Opisina arenosella* is a serious pest of coconut palm causing significant yield loss in all the coconut growing tracts of India. During 2015–16, a high infestation of black headed caterpillar was observed in all the coastal districts of Andhra Pradesh, and an incidence ranging from 42.82% to 62.86% was recorded. From October 2015 to April 2016 inundative releases of about 3,788,000 larval parasitoids *Bracon hebetor* and *Goniozus nephantidis* were carried out in pest affected gardens in Allavaram and Uppalaguptam mandals of East Godavari. To study the impact of the parasitoid releases, 10 leaflets/palm were randomly collected from 10 sample gardens in seven villages of these mandals and the pest population recorded. After three months of parasitoid release, the larval population of *O. arenosella* decreased by 34.08–75.88%, pupal population by 33.33–94.52%, and the paralysed larval population recovered was 8.30–26.92%. After six months, the larval population decreased by 59.65–100%, the pupal population up to 92.77–100% and the paralysed larval population recovery was also high, ranging from 18.68% to 34.61%. The impact of inundative release of bio agents for suppression of leaf eating caterpillar 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.

Keywords: Biological control, coconut, *Opisina arenosella*, outbreak, parasitoids.

THE four southern states of India, viz. Tamil Nadu, Kerala, Karnataka and Andhra Pradesh (AP) account for 90% of the coconut growing area. Among them, AP shares about 104,000 ha area. The districts East Godavari (50,789 ha), West Godavari (20,437 ha), Srikakulam (14,619 ha) and Visakhapatnam (7763 ha) are important coconut growing coastal districts in the state[1].

One of the major factors that contributes to the loss in coconut production and productivity is damage due to insect pests, especially the leaf eating caterpillar or the black headed caterpillar *Opisina arenosella* Walker[2,3]. The other hosts for this pest are palmyrah (*Borassus flabellifer*), talipot (*Corypha umbraculifera*) and wild date (*Phaoenix sylvestris*). Low feeding damage by this pest on oil palm (*Elaeis guineensis*) was also recorded. It is an outbreak pest and in severe cases the whole affected plantation presents a burnt up appearance due to drying of leaves. The attacked leaves droop, the bunches buckle and the immature nuts shed heavily[4]. During 2000, about 1.6 million coconut palms were affected with black headed caterpillar in Karnataka[5]. In 2013, nearly 200 ha of coconut plantations in Anakapalle, Elamanchali and Munagapaka mandals of the Visakhapatnam district in AP were affected with the same pest[6]. Roving surveys conducted in coastal districts of AP from July 2015 to May 2016 reported a high infestation of black headed caterpillar in all the surveyed districts of the state, with incidence ranging from 42.82% to 62.86%, and an outbreak was recorded in Allavaram and Uppalaguptam mandals of East Godavari district[7].

The caterpillar lives on the lower surface of leaflets in galleries made of excreta and silken web and feeds on parenchymatous tissues. Continuous feeding removes superficial tissues of the abaxial (lower) leaf surface leaving only the top layer and the leaf lamina which appears white[8]. 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. During severe outbreaks, it feeds even on green surfaces of petioles, spathes and nuts. The cropping system for coconut trees on fish pond bunds prevalent in the coastal ecosystem of AP, provides highly favourable climatic conditions for multiplication of black-headed caterpillar and subsequent outbreaks (Figures 1–3).

These outbreaks could be successfully managed by adopting an integrated pest management (IPM) strategy with emphasis on biological control. Field evaluation of various parasitoids against black-headed caterpillar showed a significant reduction of the pest population in the field[9]. Two larval parasitoid wasps, *Goniozus nephantidis* (Muesebeck) (Bethylidae) and *Bracon brevicornis* Wesmael (Braconidae), which parasitize third to seventh instar larvae of *O. arenosella* are widely employed, either singly or in combination, for the biological control of this pest in India[10–14].

An outbreak of black-headed caterpillar was observed in Allavaram and Uppalaguptam mandals in East Godavari district of AP in approximately 675 ha with high intensity (all the lower whorls of leaves or entire crown damaged) whereas the other coconut growing mandals, viz. Katrenikona and Razole mandals (approximately 300 ha) in the Konaseema region of the East Godavari district of AP recorded a medium intensity damage (2–3 damaged fronds with clear drying). Both fish pond bund

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coconut trees and sole coconut garden were affected by the pest. To study the impact of biological control in reducing pest population in the outbreak affected villages and contain the spread of pest to neighbouring coconut growing mandals, H.R.S., Ambajipeta (under AICRP on Palms), Dr Y.S.R. Horticultural University in association with the Department of Horticulture, Government of Andhra Pradesh, Coconut Development Board state centre (Hyderabad) and M/s Noveeal Coconut Producer Company (Amalapuram) conducted an experiment through large scale inundative releases of the bio agents *G. nephantidis* and *B. hebetor* (Figures 4 and 5). The field release programmes in the affected mandals were carried out through coconut producer societies formed in villages and operating under M/s Noveeal Company. The Samanthakurru, Mogallamuru, Thrupulanka, Godilanka and Bendamurlanka villages in Allavaram mandal and N. Kothapalli and Challapalli in Uppalaguptam mandal were selected to study the impact of this biological control programme (Table 1).

In the selected villages, the operational area was divided into clusters of 5 ha for assessing the incidence of target pest. In each 5 ha cluster, a central area of 2 ha was selected for sampling palms and release of parasitoids. To record the pest and parasitoid populations, 10 leaflets/palm were randomly collected from 10 palms located in the central 2 ha area in each village at three-month intervals. The larval population was expressed as mean larval population per 10 leaflets. Sample leaflets were collected from lower or middle whorl of the crown

Figure 1. Coconut black headed caterpillar infestation on coconut bunches.

Figure 2. Black headed caterpillar infested coconut garden.

Figure 3. Coconut palms on fish pond bunds infested with black headed caterpillar.

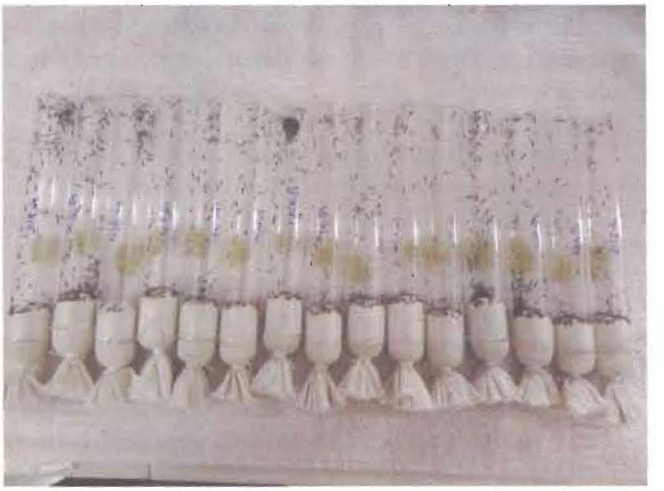

Figure 4. *Goniozus nephantidis* parasitoid multiplied in the laboratory.

Figure 5. Bio Control Laboratory HRS, Ambajipeta.

Table 1. Details of initiation and number of parasitoids released in the selected villages

Village	Cropping system	Date of initiation of parasitoids releases	Parasitoid and numbers released	
			Bracon hebetor	*Goniozus nephantidis*
Samanthakurru	Fish pond bunds	30 July 2015	392,000	200,800
Thurpulanka	Fish pond bunds and sole gardens	10 October 2015	62,580	25,000
Mogallamuru	Fish pond bunds	13 November 2015	115,250	26,500
Godilanka	Fish pond bunds	22 November 2015	50,000	10,000
Bendamurlanka	Fish pond bunds	16 December 2015	70,000	17,000
N. Kothapalli	Fish pond bunds and sole gardens	15 December 2015	25,000	5,000
Challapalli	Fish pond bunds and paddy field bunds	28 December 2015	40,000	8,000

through destructive sampling[15] (41–60% leaflets of 20% leaves from the lower or middle whorl). In each selected palm, the number of larvae, parasitized larvae, and pupae was recorded and the data obtained was subjected to statistical analysis (paired *T* test). As there was high intensity of black-headed caterpillar (all the lower whorls of leaves or entire crown damaged), inundative releases of parasitoids at fortnightly intervals were taken up based on the stage of the pest in affected gardens. The farmers of the coconut producer societies in the affected villages were educated about identification of the stage of the pest and timely release of parasitoids through the extension personnel of Department of Horticulture. Supply was made according to indents received by societies from time to time.

For mass production of parasitoids, eggs of *Corcya cephalonica* were provided by HRS (Ambajipeta), Bio control lab, RARS (Anakapalle), Acharya N.G. Ranga Agricultural University and NBAIR (Bengaluru, ICAR). A total of 850 cc were utilized from July 2015 to April 2016 for production of *B. hebetor* and *G. nephantidis*. The newly emerged parasitoids were exposed in the laboratory to the host odours for 72 h (smell of the volatiles of the frass from galleries obtained from infested leaflets), and then released in the field after feeding them with honey[16]. Though *Corcyra cephalonica* is an ideal host for mass multiplication of the parasitoid in the laboratory, continuous laboratory rearing of *G. nephantidis* causes inherited response to host from which it had emerged but their preference can be altered by mere exposure to the odour cues of *O. arenosella* without any physical contact. This would help the parasitoids to search for the host and parasitize it in the field with ease. To suppress the incidence of black-headed caterpillar in the affected villages, a total of 755,000 *B. hebetor* parasitoids and 292,000 *G. nephantidis* parasitoids were released at regular intervals. The detailed month-wise release of parasitoids in selected villages is presented in Table 2.

The incidence of coconut black-headed caterpillar was recorded in July 2015 in the fish pond bund coconut trees in Samanthakurru village. In Mogallamuru, Thurpulanka and Godilanka villages of the same mandal the incidence was recorded in October 2015, and in Bendamurlanka village of Allavaram mandal, and N. Kothapalli and Challapalli villages of Uppalaguptam mandal of the East Godavari district in December 2015.

The mean initial larval population observed in the villages ranged from 87.1 larvae/10 leaflets at Samanthakuru village to 40.9 larvae/10 leaflets in Thurpulanka village. The inundative release of parasitoids resulted in a decrease of pest population in all the villages three and six months after the release. In Samanthakurru village, the larval population decreased to 21 larvae/10 leaflets after three months and to 3.40 larvae/10 leaflets after six months. Maximum reduction was recorded in Bendamurulanka village where the initial population of 58.6 larvae/10 leaflets was reduced to 20.9 larvae/10 leaflets after three months, and to 0 larvae/10 leaflets after six months (Table 3). The release studies clearly show that higher the number of parasitoids released, smaller the final larval population, as previously reported by George *et al.*[17].

A management strategy targeting a particular developmental stage, if accurately timed, may be more effective against populations with discrete generation cycles. There is a definite time lag in the appearance of different developmental stages, and timing of inundative releases of larval and pupal parasitoids is essential for a more effective management of the pest[18]. A poorly synchronized release of parasitoids could explain the results obtained in Thurpulanka and N. Kothapalli villages, where the initial larval population of 49 and 40.9 larvae/10 leaflets was reduced only to 32.3 and 33.1 larvae/10 leaflets after three months, and to 16.1 and 16.5 larvae/10 leaflets after six months respectively.

The total number of unemerged pupae and paralysed larvae in the collected samples was also recorded. The number of pupae of *O. arenosella* present before the release of parasitoids was high in all the villages and ranged from 6.60 to 12.60/10 leaflets. A gradual decrease was observed at three and six months after the inundative release of parasitoids (except in Bendamurulanka village). The decrease in the number of pupa represents a reduction in pest population in the gardens where the parasitoids were released. It was evident that parasitoids

Table 2. Monthly release of parasitoids in coconut black-headed caterpillar *O. arenosella* affected villages

	August 2015		September 2015		October 2015		November 2015		December 2015		January 2016		February 2016		March 2016	
Village	*B. h.**	*G. n**.	*B. h.*	*G. n.*	*B. h.*	*G. n.*	*B. h.*	*G. n.*	*B. h.*	*G. n.*	*B. h.*	*G. n.*	*B.h.*	*G. n.*	*B. h.*	*G. n.*
Samanthakurru	50,000	10,000	13,000	6,000	10,000	7,800	0	0	25,000	30,000	39,000	82,000	49,000	35,000	206,000	30,000
Thurpulanka	0	0	0	0	0	0	10,500	6,000	16,500	10,000	10,580	5,000	15,000	0	10,000	4,000
Mogallamuru	0	0	0	0	5,000	0	15,250	7,500	20,000	10,000	0	0	50,000	9,000	25,000	0
Godilanka	0	0	0	0	0	0	20,000	5,000	0	0	15,000	3,000	15,000	2,000	0	0
Bendamurlanka	0	0	0	0	0	0	0	0	0	0	20,000	12,000	0	0	50,000	5,000
N. Kothapalli	0	0	0	0	0	0	0	0	4,000	1,000	3,000	2,000	8,000	1,000	10,000	1,000
Challapalli	0	0	0	0	0	0	0	0	8,000	2,000	9,000	2,500	10,000	2,500	13,000	1,000

**B.h.*, *Bracon hebetor*; **G.n.*, *Goniozus nephantidis*.

Table 3. Larval population of coconut black-headed caterpillar, *O. arenosella* in the sample gardens in selected villages before and after the release of parasitoids

	No. of larvae per 10 leaflets (mean ± SE)				
		Post-release		*T* value and (*P* value)	*T* value and (*P* value)
Village	Pre-release	After three months	After six months	Pre-release versus 3 months	Pre-release versus 6 months
N. Kothapalli	49.00 ± 2.62	32.30 ± 3.12	16.10 ± 0.94	4.73* (0.00107)	11.72* (0.00001)
Samanthakurru	87.10 ± 4.96	21.00 ± 6.04	3.40 ± 0.52	10.87* (0.00001)	17.12* (0.00001)
Mogallamuru	45.40 ± 3.83	21.70 ± 1.74	5.40 ± 0.81	5.47* (0.00039)	10.29* (0.00001)
Bendamurlanka	58.60 ± 6.47	20.90 ± 2.79	Nil	4.91* (0.00083)	9.05* (0.00001)
Thurpulanka	40.90 ± 2.68	33.10 ± 2.42	16.50 ± 2.46	2.01 (0.07532)	7.40* (0.00004)
Godilanka	48.90 ± 4.33	28.70 ± 2.76	6.70 ± 1.13	3.15* (0.01173)	9.10* (0.00001)
Challapalli	41.20 ± 3.04	12.10 ± 2.13	5.30 ± 0.26	8.98* (0.00001)	11.89 (0.00001)

The values with * are significantly different with each other at 5% LOS.

Table 4. Pupal population of *O. arenosella* in the sample gardens in selected villages before and after release of parasitoids

	No. of pupae per 10 leaflets (mean ± SE)				
		Post-release		*T* value and (*P* value)	*T* value and (*P* value)
Village	Pre-release	After three months	After six months	Pre-release versus 3 months	Pre-release versus 6 months
N. Kothapalli	8.30 ± 2.48	4.90 ± 1.37	0.60 ± 0.31	1.10 (0.29988)	2.99* (0.01520)
Samanthakurru	12.60 ± 3.08	3.70 ± 2.02	0.10 ± 0.10	2.63* (0.02735)	4.12* (0.00259)
Mogallamuru	6.60 ± 1.75	7.40 ± 2.53	0.10 ± 0.10	0.27 (0.79324)	3.83* (0.00402)
Bendamurlanka	8.90 ± 1.87	10.40 ± 0.54	Nil	0.67 (0.51967)	4.76* (0.00103)
Thurpulanka	7.70 ± 2.73	7.40 ± 2.34	1.10 ± 0.60	0.10 (0.92253)	2.52* (0.03276)
Godilanka	8.40 ± 1.85	5.60 ± 1.52	0.10 ± 0.10	1.54 (0.15794)	4.53* (0.00142)
Challapalli	7.30 ± 2.38	0.40 ± 0.22	Nil	3.00* (0.01495)	3.07* (0.01335)

The values with * are significantly different with each other at 5% LOS.

Table 5. Paralysed larval population of *O. arenosella* in sample gardens before and after release of parasitoids

	No. of paralysed larvae per 10 leaflets (mean ± SE)				
		Post-release		*T* value and (*P* value)	*T* value and (*P* value)
Village	Pre-release	After three months	After six months	Pre-release versus 3 months	Pre-release versus 6 months
N. Kothapalli	Nil	3.70 ± 2.02	3.70 ± 0.91	6.19* (0.00016)	4.08* (0.00275)
Samanthakurru	0.20 ± 0.20	3.80 ± 1.24	1.80 ± 0.49	3.25* (0.00999)	3.36* (0.00838)
Mogallamuru	Nil	4.80 ± 1.08	1.80 ± 0.53	4.43* (0.00164)	3.37* (0.00825)
Bendamurlanka	0.10 ± 0.10	7.70 ± 0.78	Nil	9.96* (0.00001)	1.00 (0.34343)
Thurpulanka	0.60 ± 0.43	1.80 ± 0.35	5.20 ± 0.98	2.45* (0.03675)	4.88* (0.00087)
Godilanka	0.90 ± 0.38	2.60 ± 0.54	2.10 ± 0.35	2.08 (0.06726)	2.45* (0.03675)
Challapalli	Nil	1.70 ± 0.63	Nil	2.68* (0.02520)	2.26 (0.05017)

The values with * are significantly differ with each other at 5% LOS.

effectively paralysed the larvae of *O. arenosella*, and did not allow the formation of pupae. The pupal count was less than 1 pupa/10 leaflets after six months in all villages except Thurpulanka (Table 4).

The natural parasitism levels of *G. nephantidis* and *B. brevicornis* on *O. arenosella* vary from 3.7% to 57.6% and 5.7% to 12.2% respectively, in India[19,20] and a 19% parasitism levels of *G. nephantidis* on *O. arenosella* was recorded in Sri Lanka[10]. However, the naturally paralysed larvae recorded in this study was low before the release of parasitoids and significantly increased after three months of releases, except in Godilanka village of the Allavaram mandal. In Bendamurlanka village a high parasitization of up to 7.7 paralysed larvae/10 leaflets was recorded three months post-release (Table 5). After six months, a comparatively higher number of paralysed larval population was recorded in Thurpulanka and N. Kothapalli villages, coinciding with higher mean larval

population of 16.50 and 16.10 larvae/10 leaflets respectively. In general, the percentage of paralysed larval population was 8.30–26.92% after three months and increased to 18.68–34.61% after six months of parasitoids releases.

Sathiamma *et al.*[9] reported the success of biological control against black-headed caterpillar with 94% reduction in pest population after the release of stage specific parasitoids at fixed norms and intervals in a heavily infested coconut garden of 2.8 ha (Thodiyoor, Kerala) for a period of four years. Mohan and Nair[21] also reported 52.6% and 94.7% reduction in pest population after one and two years respectively of parasitoid releases in heavily infested homestead coconut gardens spread over 3 ha in Neendakara (Kerala). For a large area field management of the pest in an epidemic outbreak, inundative releases of parasitoids at fortnightly intervals and further monitoring and augmentative releases during probable periods of pest build-up are required. The farmer beneficiaries in these areas need to be educated and the role of extension specialist is paramount.

As per the earlier yield loss studies conducted with regard to nut yield, a maximum crop loss of 45.4% would be recorded from infested palms in the succeeding year of severe pest incidence, and the pest-attacked palms will regain their normal yield potential by the fourth year after the heavy pest infestation[22]. Based on this assumption, an amount of Rs 188.3 millions was saved in terms of prevention in coconut yield loss in the pest-affected gardens of this region. Further, the self-perpetuating parasitoids prevented the spread of outbreak to other mandals, and the joint effort of various organizations prevented the farmers from resorting to the use of hazardous insecticides such as monocrotophos and dichlorovas in the coconut ecosystem. The cost involved in bio-control was Rs 2.006 million and the assumed cost of chemical intervention if resorted was Rs 6.318 million. Thus Rs 4.312 million were saved with the compounded benefit of an undisturbed natural ecosystem with a self-regulating biological control in operation. The overall monetary loss prevented due to biological control intervention in the pest-affected areas of nearly 975 ha, when calculated at Rs 3.50 per nut, was Rs 192.6 millions.

The periodic outbreaks of coconut black-headed caterpillar in coastal coconut plantations of AP are becoming a cause of concern to plantation farmers and the management of these outbreaks with insecticides has undesirable attributes, viz. environmental pollution, residues, resistance, side-effects on non-target organisms and the natural enemies of pests. In case of severe outbreaks, the financial loss suffered by the farmer is also huge and this hampers his investment strength of providing regular farm inputs to his coconut plantations, which ultimately affects production. The large scale timely availability of bio agents will strengthen and boost the confidence of farmers on biological control methods. The large scale success of biological control as an alternative system to insecticide usage gives impetus to sustainable agriculture coupled with reducing the cultivation cost and can be a viable step for doubling the farmers' income if ably supported by governmental organizations and institutions in association with farmer societies.

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