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Parasitic Potential of some Braconid Parasitoids against Okra Fruit Borers

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In surveys conducted in Coimbatore district during 2009-10, Okra fruit borers, *Earias vittella* Fabricius, *Earias insulana* Boisdual and *Helicoverpa armigera* (Hübner) were the serious pests causing 50 per cent loss. During the survey, three hymenopteran parasitiods *viz., Bassus* spp.*, Brachymeria lasus* Walker, *Goryphus* spp., of the families Braconidae, Chalcididae and Ichneumonidae against *Earias* spp. and the dipteran parasitoid, *Carcelia illota* (Tachinidae) against *H. armigera* were recorded with 0.00 to 10.00 per cent parasitization. All the parasitoids recorded were not amenable for mass culturing, and hence, other braconid parasitoids *viz*., *Bracon brevicornis* Wesmael*, Bracon hebetor* Say and *Chelonus blackburni* Cameron were studied for their parasitic potential against fruit borer complex. Cent per cent parasitization was observed with *B. brevicornis* against all instars of *E. vittella* and *H. armigera*, higher parasitizaion of 100 and 97.50 per cent was observed by *B. hebetor* at a parasitoid-host ratio of 5:10 on second instar larvae of *H. armigera* and fourth instar larvae of *E. vittella* respectively. The egg - larval parasitoid, *C. blackburni* recorded the highest parasitization of 70.54 per cent and 64.58 per cent against *E. vittella* and *H. armigera* at a parasitoid host ratio of 5:100. For *B. brevicornis* and *B. hebetor*, highest cocoon formation and parasitoid emergence was recorded at 4:10 ratio against third and fourth instars. In *C. blackburni*, the parasitoid host ratio of 3:100 yielded the highest number of adult parasitoids. *B. brevicornis* was found to be more effective against fruit borers.

Key words: Okra fruit borers, parasitic potential, *Bracon brevicornis*, *Bracon hebetor*, *Chelonus blackburni*

The successful cultivation of okra is threatened by a number of pests and diseases. Fruit borers *viz., Earias vittella* Fabricius and *Earias insulana* Boisdual cause extensive damage resulting in 69 per cent yield loss Prabhakara Rao *et al*., (2001). Mani *et al.* (2005) reported that both *E. vittella* and *Helicoverpa armigera* (Hübner) cause up to 50 per cent loss in okra. A wide range of recommended insecticides are used by the farmers for controlling the pests (Priya and Misra, 2007). However, to overcome the adverse consequences of insecticides, a biocontrol strategy involving potential natural enemies, can be successfully incorporated into a sound Integrated Pest Management (IPM) programme. Jagmohan (2001) recorded parasitoids such as *Brachymeria lasus* Walker*, Chelonus rufus* Lyle, *Goryphus nursei* Cameron, *Agathis fabiae* Nixon, *Tetrastichus acheae, T. brasiliensis, Campoletis chlorideae* (Uchida), *Aleiodes aligharensis* (Qyadri), *Aleiodes testaceus* (Spinola)*, Bracon greeni* Ashmead, *Bracon hebetor* Say, *Bracon brevicornis* Wesmael, *Bracon lefroyi* (Dudgeon and Gough), *Eriborus argenteopilosus* (Cam.), *Carcelia illota* (Curran) on *E. vittella* and *E. insulana* from Punjab. Mani *et al.* (2005) reported the natural incidence of *A. aligharensis*, *A. testaceus*, *B. hebetor*, *B. greeni* , *A. fabiae* and *Trichogramma* spp., on *Earias* spp. in okra fields. Braconids are well known parasitoids for the management of lepidopteran larvae, including okra fruit borer complex. Present investigations were made to inventory the braconid parasitoids of okra fruit borers and to evaluate their parasitic potential under laboratory condition.

Materials and Methods

Field survey for natural enemies of okra fruit borer complex

An extensive survey was made in from June 2009 to September 2010 in okra growing blocks of Coimbatore district *viz.*, Annur, Karamadai, Kinathukkadavu, Madhukkkarai, Madathukulam, Periyanayakkanpalayam, Pollachi North, Pollachi South, Sarkarsamakulam, Thondamuthur and TNAU- Orchard on the extent of damage by fruit borers and the natural incidence of its parasitoids.

In survey areas, borer infested okra fruits collected randomly from ten plants from different field locations, were brought to the laboratory and maintained in separate cages for further study. The extent of parasitization and kind of parasitoids were observed in each block. The collected parasitoid

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specimens were preserved in 70 per cent alcohol and identified based on literature /by experts.

Laboratory rearing of host insects and parasitoids

Culturing of okra fruit borers

The larvae used in studies were collected from a stable and healthy culture maintained in the Biocontrol Laboratory, Department of Agricultural Entomology, TNAU, Coimbatore. The method standardized by Shorey and Hale (1965) was adopted with modifications which included the addition of carbendazim for mould control (Jeyarani *et al*., 2008) for culturing *H. armigera* and for *Earias* spp., the method standardized by Ambegaonkar and Bilapate (1984) was followed.

Culturing of Corcyra cephalonica Stainton, a laboratory host of braconids

Larvae of *C. cephalonica,* an important alternate host for the braconid parasitoids were cultured following the procedure of Singh and Jalali (1994).

Culturing of parasitoids Bracon brevicornis Wesmael, Bracon hebetor Say (Sandwich method) and Chelonus blackburni Cameron

The larval parasitoids *B. brevicornis* and *B. hebetor* were cultured on the larvae of rice moth, *C. cephalonica* by sandwich method. The nucleus culture of the parasitoid was obtained from the Central Plantation Crops Research Institute (CPCRI), Kayankulam, Kerala. Both parasitoids were cultured following the procedure developed by Jhansi (1984).

C. blackburni, an egg larval parasitoid was cultured on the eggs of rice moth, *C. cephalonica* following the procedure of Swamiappan and Balasubramanian (1979). The nucleus culture was obtained from the National Bureau for Agriculturally Important Insects (NBAII), Bangalore.

Studies on the parasitic potential of braconids

Influence of parasitoid density and host age on parasitic potential of B. brevicornis and B. hebetor

The experiment was designed to examine the effects of increased parasitoid host densities within a confined space and also, to determine the most suitable age of the host larvae for maximum parasitization. The second, third, fourth, fifth and sixth instar larvae of *H. armigera* were offered separately at 1:10, 2:10, 3:10, 4:10 and 5:10 (parasitoid: host) and were confined in a plastic jar (18x10 cm) covered by muslin cloth with four replications. In all the cases, mated females were used and the experiment was carried out in a plastic jar of 18x12 cm size, by sandwich method. Since, *H. armigera* larvae were cannibalistic, the fourth, fifth and sixth instars were compartmentalized individually by small pieces of card boards and were exposed for parasitization by sandwich method. Data on the number of cocoons formed and adult emerged were recorded.

Similar study was also carried out for the second, third and fourth instars larvae of *E. vittella*. Since, *E. vittella* larvae were feeding on the okra fruits internally; the parasitic potential of *B. brevicornis* was also studied after introducing the larvae in the fruits with seven replications. The optimum parasitoid-host ratio identified from the previous experiment was utilized for this study.

Parasitic potential of C. blackburni against E. vittella and H. armigera

This experiment was carried out with different ratios of *C*. *blackburni* adults and eggs of *E. vittella and H. armigera.* The parasitoid and host eggs were maintained at a ratio of 1:100, 2:100, 3:100 4:100 and 5:100 with four replications. Twenty four hours after exposure, the egg cards were transferred to a plastic tray (30x15x5 cm). The hatching larvae were provided with cut pieces of okra fruit as feed. The larvae reaching second instar were transferred to multi cavity tray with cut pieces of okra. Observations on the number of cocoons formed, adult emerged and per cent parasitization were recorded.

Results and Discussion

Survey revealed borer damage on shoots and fruits upto 63 and 64 per cent respectively. Level of parasitism of okra borer complex under field conditions ranged from 0.00 to 10.00 per cent. Highest parasitization of 10 per cent was noticed in Narasipuram village of Thondamuthur block. Masinayakanpathy of Madhukkarai block recorded second highest parasitization of 8.75 per cent (Table 1). The low level of parasitization may be due to continuous application of synthetic pesticides. The activity of natural enemies was often hampered by the indiscriminate use of pesticides (Armstrong and Jones, 1996). Mani *et al*. (2005) also reported that the application of conventional/broad spectrum insecticides interfered with the activity of naturally occurring biocontrol agents in horticultural ecosystem, which could be overcome by the use of non conventional chemicals, botanicals and biopesticides. During the survey, three hymenopteran parasitiods *viz., Bassus* spp*., Brachymeria lasus* Walker, *Goryphus* spp., of the families Braconidae, Chalcididae and Ichneumonidae were recorded on *Earias* spp. Natural occurrences of *Bassus* spp*., B. brevicornis, B. greeni, B. lefroyi, Chelonus* spp*., Chelonus rufus, Brachymeria* spp*., B. lasus* were documented by several workers (Jagmohan, 2001; Mani *et al.,* 2005).

Occurrence of a dipteran parasitoid, *Carcelia illota* Curran (Family) Tachnidae was also recorded on *H. armigera* in okra ecosystem. Parasitization of *H. armigera* by *Carcelia* spp., *Carcelia kockiana* Tns, *Carcelia raoi* Mensil, *Carcelia illota* Curran on okra, tomato, field bean and other vegetable crops was earlier reported by Mani *et al.,* (2005).

Table 1. Survey on parasitoids of okra fruit borers in Coimbatore district

Block	Village	Borer damage (%) Shoot	Borer damage (%) Fruit	Parasitization (%)
Annur	Allapalayam	-	25	0.00
	Kithciliampalayam	2	15	0.00
Karamadai	Tholampalayam	-	40	0.00
	Velliangadu	-	20	0.00
Kinathukadavu	Mullupadi	3	25	0.00
	Nallatypalayam	-	20	0.00
	Pattanam	-	11	2.50
Madathukulam	Kaniyur	-	26	1.50
	Vedapatti	-	30	0.00
Madhukkarai	Arisipalayam	15	22	0.00
	Masinayakanpathy	63	12	8.75
Peiryanayakkanpalayam	Naikenpalayam	-	20	0.00
	Nanjundapuram	-	40	0.00
	Pannimadai	-	30	2.20
Pollachi North	Okkilipalayam	-	10	0.00
	Vellapalayam	-	18	0.00
	Aathimayanur	-	24	0.00
Pollachi South	Dhalavaipalayam	2	18	0.00
	Nattukal palayam	-	14	0.00
	Solayampalayam	-	40	0.00
Sarkarsamakulam	A.S. Kulam	2	41	0.00
	Athipalayam	-	64	0.00
	Kallipalayam	2	43	1.20
Thondamuthur	Alandurai	-	12	2.50
	Narasipuram	-	26	10.00
	Perumalkovil pathy	-	13	0.00
	Pullakoundanpudhur	-	14	0.00
	Puthur	2	32	4.00
	Semmadu	-	40	0.00
	Thevarayapuram	-	14	5.00
TNAU-Orchard	Vegetable garden	3	24	7.00

Studies on parasitic potential of braconids

The braconid parasitoids recorded during the survey were limited in numbers and were not amenable for mass culturing. Hence investigations were carried out using available braconid parasitoids *viz., B. brevicornis, B.hebetor and C. blackburni.* Studies showed that all the braconid parasitoids tested were effective against *E. vittella* and *H. armigera* in the order of efficacy *viz., B. brevicornis* > *B. hebetor* > *C. blackburni.*

Influence of parasitoid density and host age on the parasitic potential of braconid parasitoids against E. vittella

The parasitic potential studies showed that *B. brevicornis* was highly effective with cent per cent parasitization against all the instars studied at 5:10 parasitoid: host ratio. *Bracon hebetor* was next in the order of efficacy with a maximum of 97.5 per cent parasitization against fourth instar. No cocoon formation and adult emergence were observed for both *B. brevicornis* and *B. hebetor* against second instar larvae of *E. vittella*, whereas highest cocoon formation and parasitoid emergence was observed for 4:10 ratio in third and fourth instar for both the parasitoids (Table 2). As the parasitoid host ratio increased, the population of males also increased for both the parasitoids. Suppression of parasitoid development might be due to insufficient nutrition in the early instars. These findings were in confirmation with earlier results reported by Li *et al*., (2006) for *Microplitis mediator* (Haliday) against *Mythimna separata.* In the present study, the highest adult emergence was observed in fourth instar indicating the preference of parasitoid for late instars. schopf (1991) also reported the preference of braconid parasitoid, *Glyptapantebs liparidis* for the late instar larvae of *Lymantria dispar*. According to him nutritional status of the host might influence the parasitoid development.

Table 2. Parasitic potential of *B. brevicornis* and *B. hebetor* against larvae of *E. vittella*

Parasitoid: Host ratio	*B. brevicornis*						*B. hebetor*					
	II instar		III instar		IV instar		II instar		III instar		IV instar	
	Parasitization (%)*	P.E (nos. / larva)**	Parasitization (%)*	P.E (nos. / larva)**	Parasitization (%)*	P.E (nos. / larva)**	Parasitization (%)*	P.E (nos. / larva)**	Parasitization (%)*	P.E (nos. / larva)**	Parasitization (%)*	P.E (nos. / larva)**
1:10	45.00 (42.13)$_{e}$	0.00 (0.71)$_{a}$	55.00 (48.16)$_{d}$	2.25 (1.50)$_{e}$	57.50 (49.31)$_{d}$	2.25 (1.66)$_{e}$	21.50 (27.62)$_{e}$	0.00 (0.71)$_{a}$	25.00 (30.00)$_{e}$	2.50 (1.73)$_{e}$	35.00 (36.30)$_{e}$	2.50 (1.73)$_{e}$
2:10	55.00 (47.87)$_{d}$	0.00 (0.71)$_{a}$	67.50 (55.24)$_{c}$	4.22 (2.05)$_{d}$	62.00 (51.94)$_{c}$	4.18 (2.16)$_{d}$	30.00 (33.2)$_{d}$	0.00 (0.71)$_{a}$	45.00 (42.13)$_{d}$	2.25 (1.66)$_{d}$	47.50 (43.57)$_{d}$	3.80 (2.07)$_{d}$
3:10	75.00 (60.00)$_{c}$	0.00 (0.71)$_{a}$	85.00 (67.21)$_{b}$	5.70 (2.39)$_{c}$	95.50 (77.75)$_{b}$	7.15 (2.77)$_{c}$	35.00 (36.27)$_{c}$	0.00 (0.71)$_{a}$	70.50 (57.10)$_{c}$	4.15 (2.16)$_{c}$	72.00 (58.10)$_{c}$	6.00 (2.55)$_{c}$
4:10	90.00 (71.56)$_{b}$	0.00 (0.71)$_{a}$	100.00 (90.00)$_{a}$	9.85 (3.14)$_{a}$	100.00 (90.00)$_{a}$	10.95 (3.38)$_{a}$	57.00 (43.28)$_{b}$	0.00 (0.71)$_{a}$	90.00 (71.56)$_{b}$	6.25 (2.60)$_{a}$	90.50 (72.05)$_{b}$	8.50 (3.00)$_{a}$
5:10	100.00 (90.00)$_{a}$	0.00 (0.71)$_{a}$	100.00 (90.00)$_{a}$	7.75 (2.78)$_{b}$	100.00 (90.00)$_{a}$	9.00 (3.08)$_{b}$	65.00 (55.73)$_{a}$	0.00 (0.71)$_{a}$	95.00 (77.08)$_{a}$	5.55 (2.46)$_{b}$	97.50 (80.90)$_{a}$	7.50 (2.83)$_{b}$

P.E- Parasitoid Emergence ; Mean of four replications in each treatment ; *Figures in parentheses are arc sine values

**Figures in parentheses are $\sqrt{x+0.5}$ transformed values; In a column, means followed by same letter(s) are not significantly different by DMRT (P= 0.05)

Preferences of the parasitoid may vary with host insects (CPCRI- annual report, 2006; Sheeba and Narendran, 2007). According to them *B. brevicornis* was more effective than *B. hebetor* against *O. arenosella* with 90 and 55 per cent parasitization, respectively. This is in concurrence with the present finding that *B. brevi*cornis was more effective against *E. vittella* than *B. hebetor* showing higher per cent parasitization and progeny production.

The parasitic potential of the most effective parasitoid, *B. brevicornis* was also evaluated for their efficacy in parasitizing the host larvae when it is in the okra fruits. The results revealed cent per cent parasitization against second instar and this could be due to the superficial feeding of the larvae on the fruits. After reaching third instar, the larvae bored into the fruits and hence the parasitization was very much less (24.29%). At fourth instar, the larva came out of the fruit for pupation and was parasitized; recording 35.57 per cent which was higher than the third instar. The present findings are in agreement with the results reported by Temerak and Dabellen (1982) for *B. brevicornis* against

Table 3. Parasitic potential of *B. brevicornis* and *B. hebetor* against larvae of *H. armigera*

Parasitoid: Host ratio	II instar		III instar		IV instar		V instar		VI instar	
	Parasitization (%)*	Parasitoid emergence (nos./ larva)**	Parasitization (%)*	Parasitoid emergence (nos./ larva)**	Parasitization (%)*	Parasitoid emergence (nos./ larva)**	Parasitization (%)*	Parasitoid emergence (nos./ larva)**	Parasitization (%)*	Parasitoid emergence (nos./ larva)**
i. B. brevicornis										
1:10	40.50	0.00	50.00	2.15	52.00	2.15	37.11	3.00	15.00	2.00
	(39.52)d	(0.71)a	(45.00)d	(1.63)e	(46.15)c	(1.63)e	(30.52)e	(1.87)d	(22.79)e	(1.58)c
2:10	70.00	0.00	68.73	6.2	75.00	6.50	45.11	4.75	25.10	2.15
	(56.78)c	(0.71)a	(55.98)c	(2.59)c	(60.00)b	(2.65)d	(42.19)d	(2.91)c	(30.07)d	(1.63)c
3:10	83.15	0.00	90.00	5.54	100.00	7.40	63.00	7.10	33.00	4.75
	(65.76)b	(0.71)a	(71.56)b	(2.46)d	(90.00)a	(2.81)c	(52.53)c	(2.76)a	(35.06)c	(2.29)b
4:10	100.00	0.00	100.00	9.60	100.00	10.63	74.00	6.50	47.00	5.99a
	(90.00)a	(0.71)a	(90.00)a	(3.18)a	(90.00)a	(3.34)a	(59.67)b	(2.65)ab	(43.28)b	(2.55)
5:10	100.00	0.00	100.00	7.50	100.00	8.50	87.00	5.75	55.00	4.60
	(90.00)a	(0.71)a	(90.00)a	(2.83)b	(90.00)a	(3.00)b	(68.86)a	(2.50)bc	(47.87)a	(2.26)b
ii. B. hebetor										
1:10	40.00	0.00	37.11	2.25	47.50	3.00	25.00	2.00	10.00	1.00
	(39.23)e	(0.71)a	(37.53)e	(1.66)c	(43.6)e	(1.87)d	(30.00)e	(1.58)d	(18.44)e	(1.22)d
2:10	62.50	0.00	65.00	5.50	67.00	6.10	40.00	5.10	18.50	1.00
	(52.24)d	(0.71)a	(53.73)d	(2.45)b	(54.93)d	(2.57)c	(39.23)d	(2.37)c	(25.48)d	(1.22)d
3:10	77.50	0.00	77.50	7.15	80.50	8.25	56.50	6.78	27.50	3.05
	(61.68)c	(0.71)a	(61.68)c	(2.77)a	(63.79)c	(2.96)a	(48.73)c	(2.70)b	(31.63)c	(1.88)c
4:10	87.50	0.00	88.00	7.35	90.00	7.65	70.51	7.25	37.11	4.90
	(69.30)b	(0.71)a	(71.56)b	(2.80)a	(71.56)b	(2.85)b	(57.10)b	(2.78)a	(30.52)b	(2.32)a
5:10	100.00	0.00	94.00	7.25	97.00	7.41	80.90	6.35	42.00	3.50
	(90.00)a	(0.71)a	(75.82)a	(2.78)a	(80.02)a	(2.81)b	(64.08)a	(2.62)b	(44.00)a	(2.00)b

Mean of four replications in each treatment; * Figures in parentheses are arc sine values
** Figures in parentheses are $\sqrt{x+0.5}$ transformed values; In a column, means followed by same letter(s) are not significantly different by DMRT (P= 0.05)

Sesamia cretica Led. They also reported that the parasitoids were strongly attracted by the odour stimuli from the food plant of the host and the host larvae and hence they were able to parasitize the larvae even when it was inside the fruit.

Influence of parasitoid density and host age on the parasitic potential of braconid parasitoids against H. armigera

Parasitization increased with increase in the parasitoid density from 1:10 to 5:10 against second to fourth instars Table 3. Cent per cent parasitization was observed with *B. brevicornis* in first to third instars and second alone in *B. hebetor* at 5:10 ratio. Highest cocoon formation and parasitoid emergence was observed for 4:10 ratio against third and fourth instars for both parasitoids.

The host acceptance and per cent parasitization may vary according to the age of the host. The progeny production of the parasitoid was found to be high in third and fourth instars. These results were in confirmation with the findings of Hopper (1986). who reported that *M. croceipes* preferred third and fourth instar larvae of *Heliothis virescens* (F.). Late instars were less preferred which was evident from the number of cocoons formed and adults emerged which might be due to high level of immunity in these instars. This is in agreement with the findings of Hopper (1986) for *M. croceipes* against *H. virescens*. In the present study, fourth instar larvae were more preferred than early instars. However, early instars were also parasitized to some extent. It is in confirmation with earlier findings of Reichmuth *et al*., (1997). According to them, very young and small lepidopteran hosts can also be killed when stung by the parasitoids. No cocoon formation in second instar could be due to mortality of the host larvae prior to pupation by the parasitoids.

Parasitic potential of C. blackburni against E. vittella and H. armigera

The highest parasitization of 70.54 per cent and 64.58 per cent against *E. vittella* and *H. armigera* at a parasitoid host ratio of 5:100 (Table 4). However,

Table 4. Parasitic potential of *C. blackburni* against *E. vittella* and *H. armigera*

Parasitoid: Host ratio	Parasitization* (%)		Parasitoid emergence**(nos.)	
	E. vittella	*H. armigera*	*E. vittella*	*H. armigera*
1:100	28.40	25.60	21.12	19.54
	(32.20)e	(30.39)e	(4.65)d	(4.48)e
2:100	43.48	38.31	35.49	31.25
	(41.24)d	(38.22)d	(5.99)a	(5.63)b
3:100	58.07	52.81	36.81	35.64
	(49.65)c	(46.61)c	(6.10)a	(6.01)a
4:100	64.85	60.00	31.68	25.48
	(53.65)b	(50.76)b	(5.67)b	(5.09)c
5:100	70.54	64.58	26.59	24.59
	(57.13)a	(53.49)a	(5.20)c	(5.00)d

Mean of four replications in each treatment ; *Figures in parentheses are arc sine values **Figures in parentheses are $\sqrt{x+0.5}$ transformed values
In a column, means followed by same letter(s) are not significantly different by DMRT (P= 0.05)

Swamiappan and Balasubramanian (1979) reported 59.60 per cent parasitization against *E. vittella* and Jeyarani *et al* . (2008) reported 87.11 per cent parasitization on *H. armigera*. Efficacy of *C.*

blackburni against cotton bollworms *viz*., *E. vittella, E. insulana* and *H. armigera* was also reported by Pawar and Prasad (1985). In the present study, the parasitoid host ratio of 3:100 yielded the highest number of adult parasitoids. This is in accordance with the results of Seeras and Bilapate (1987) on *C. cephalonica.*

Normally under field conditions, a combination of two or three parasitoids targeting different stages of the pest will be more viable. Present investigations could pave way for the biosuppression of okra fruit borer complex by targeting different pest stages with the egg larval parasitoid, *C. blackburni* and the larval parasitoid, *B. brevicornis.*

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