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The Parasitic Potential of *Bracon brevicornis* Wesmael and *Chelonus blackburni* (Cameron) (Hymenoptera: Braconidae) on the Age of *Earias vittella* (Fabricius) (Lepidoptera: Nolidae) and *Helicoverpa armigera* (Hübner) (Lepidoptera: Noctuidae) in Laboratory Conditions

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Aims: The current study was carried out to investigate the parasitic potential of density of two important parasitoids against the age of two important bhendi fruit borer pests.
Study Design: Completely Random Design (CRD).

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Place and Duration of Study: The study was conducted during 2019-20 and 2020-21 at bio control laboratory of National Bureau of Agricultural Insect Resources (ICAR) Hebbal, Bengaluru (Latitude: 13.097221 Longitude: 77.568291) by adopting standard methodology and materials.

Methodology: An experiment was designed to examine the effects of parasitoid densities of *Bracon brevicornis* and *Chelonus blackburni* on the host age (different instars) larvae of fruit borers two important fruit borers by checking the the percent parasitization. The second, third, and fourth instar larvae of *E. vittella* were introduced separately at different ratios of *Bracon brevicornis* parasitoids and host *viz.*, *1:10, 2:10, 3:10, 4:10*, and *5:10*. Mated female parasitoids were utilised in all cases, and the experiment was carried out in a glass jar of 18 x 12 cm, using the sandwich approach. [1] with four replications. After 24 h, the larvae were observedand the percent parasitization was calculated. The same parasitoids were used for thesecond, third, fourth, and fifth instars larvae of *H. armigera.*

To examine the parasitic potential of *C. blackburni*, another experiment was conducted with various ratios of its adults and eggs of *E. vittella* and *H. armigera* by adopting the procedure of Swamiappan and Balasubramanian [2]. 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. The observation of percent parasitization was recorded after the egg incubation period.

Results: The parasitic potential studies showed that the parasitoid host ratio of 5:10 (100%) was the best for *E. vittella* (II, III and IV instar larvae) with the highest parasitization followed by 4:10 (96.83 %), 3:10 (85.08 %), 2:10 (61.71 %) and least parasitization was observed in 1:10 parasitoid host ratio (52.71 %). Similarly, for *H. armigera* (II, III, IV and V instar larvae) parasitoid host ratio of 5:10 was recorded the highest parasitization (96.75 %), followed by 4:10 (93.69 %), 3:10 (84.11 %), 2:10 (64.75 %) and least parasitization was observed in 1:10 parasitoid host ratio (45.07 %)

The parasitic potential of *C. blackburni* revealed that the 5:100 parasitoid host ratio resulted in the maximum parasitization of 64.75% against *E. vittella,* followed by 4:100 (60.50%), 3:100 (52.55%), 2:100 (38.27%), and 1:100 (25.60%). Similarly, for *H. armigera*, parasitization was highest at a parasitoid host ratio of 5:100, followed by 4:100 (64.50%), 3:100 (58.25%), 2:100 (43.45%), and 1:100 (28.50%).

Conclusion: The parasitoids: host ratio of 5:10 for B. brevicornis and 5:100 for C. blackburni is optimal for managing the bhendi fruit borer complex at the IV instar level.

Keywords: Bhendi; fruit borer; bio control; natural enemies; parasitic potential.

1. INTRODUCTION

"Okra(*Abelmoschus esculentus* (L.) Moench) is the most common vegetable grown and consumed in India. Okra locally known as 'Bhindi' and 'Lady's Finger' is a popular and most common annual vegetable crop in both tropical and subtropical parts of the world" [3]. "It is highly nutritious, 100 g of edible fruit contains 2 g of protein, 0.19 g fat, 7.45 g carbohydrate, 1.48 g of sugars, 0.7 g, 3.2 g fiber, minerals like K (299 mg), Ca (82 mg), Mg (57 mg), Fe (0.62 mg), Zn (0.58 mg) and Vitamins like A, B1, B2, C, E and K" [4]. Okra mucilage is aslo suitable for medicinal and industrial application. Nowadays okra production is in great loss due to attack of various pests, diseases and lack of knowledge about its cultural practices. "Okra is susceptible to the attack by many insect pests from vegetative to reproductive stages that cause considerable damage and reduce the productivity and an increase in farm cost" [5]. Among the pests, Okra shoot and fruit borer (OSFB) *Earias vittella* and the okra fruit borer *Helicoverpa armigera* are said to be the crop's most serious insect pests, which interferes with its economic production in almost all okra growing countries. Srinivasan and Gowder [6] reported that "these pests may cause 40-50% damage of fruit in some areas of south-east Asian countries". Krishnaiah [7] noticed that "the insects attack fruits and cause 35% damage in harvestable fruit in India". To suppress insect pest attacks on vegetable crops, chemical pesticides are routinely utilised [8]. According to one study, "chemical insecticides are employed at least 180 times each year to protect vegetable crops from insect pests. Many problems such as insect resistance and resurgence, environmental pollution, consumer health hazards, and increased production costs have been caused by such irrational applications of chemical insecticides" [9-11]. Alternative approaches are paramount to avoid dependence on chemical insecticides. Biological control is an alternative promising approaches that only target the insect pests and establish food and healthy environments. Among the various groups of biocontrol agents, braconids are well-known parasitoids for the management of different lepidopteran pests, including the okra fruit borer complex.

Two potential parasitoids *viz. Bracon brevicornis* is an ectoparasitoid of diverse range of larval-stage of lepidopteran pests and *Chelonus blackburni* which is a uniparental solitary egglarval parasitoid of lepidopteran pests [12,13].

In okra, however, information on the parasitic potential of natural enemies' densities on okra pests especially on their different host age is very scarce. Keeping these in view, the current study was carried out to investigate the parasitic potential of parasitoids against two important bhendi fruit borer pests host density.

2. MATERIALS AND METHODS

The methodology and materials used in this investigation were developed at the National Bureau of Agricultural Insect Resources (ICAR NBAIR) Hebbal, Bengaluru (Latitude: 13.097221 Longitude: 77.568291), during 2019-20 and 2020-21 (Plate.1).

2.1 Culture of Parasitoids

The larval parasitoid, *Bracon brevicornis* Wesmael (Braconidae: Hymenoptera) was cultured by sandwich method [1]. The culture was kept alive in a plastic container of 18 × 12 × 12 cm size. Fully grown rice moth *Corcyra cephalonica* larvae as laboratory host and they were placed on muslin cloth and subjected to parasitization by mated females of *B. brevicornis* at the (parasitoid: host ratio) 1: 20. The muslin cloth containing the *C. cephalonica* larvae was immediately closed with another khada cloth and fastened with rubber bands to arrest the movement of larvae and facilitate easy parasitization by *B. brevicornis.* The larvae were replaced once in 24 hours until the death of the parasitoid. Each day, the parasitized *C. cephalonica* larvae were removed and placed on filter papers until pupation of *B. brevicornis*. These filter papers containing pupae of *B. brevicornis* were transferred to plastic containers to aid the emergence of the adults of *B. brevicornis* for continuing the parasitoid culture. The emerging adults were given a sugar: honey solution (1: 1) dipped in cotton swab and stuck within the plastic containers for the nourishment of adult parasitoids (Plate 2)

The egg larval parasitoid *Chelonus blackburni* (Braconidae: Hymenoptera) was cultured by sprinkling of *Corcyra cephalonica* eggs on white card with gum and allowing the parasitoids @ 1:100 (parasitoids : eggs) in a plastic container to expose for 24 hours, The cards were transferred to another plastic container with 250g of broken bajra grains. The Parasitoids was seen developed inside the larvae and they spin their white cocoon,in the larvae. The adult parasitoids emerged in 15-20 days (Plate 2).

2.2 The Parasitic Potential of *Bracon brevicornis* and *Chilonus blackburni* against Fruit Borers

"An experiment was designed to examine the effects of different parasitoid densities on host age of two important fruit borers of okra. The second, third, and fourth instar larvae of *E. vittella* were introduced separately at different ratios of *Bracon brevicornis* parasitoids and host *viz.,* 1:10, 2:10, 3:10, 4:10, and 5:10. Mated female parasitoids were utilised in all cases, and the experiment was carried out in a glass jar of 18 x 12 cm, using the sandwich approach [1] with four replications". After 24 h, the larvae were observed and the percent parasitization was calculated. A similar study was carried out for the second, third, fourth, and fifth instars larvae of *H. armigera*.

To examine the parasitic potential of *C*. *blackburni*, another experiment was conducted with various ratios of its adults and eggs of *E. vittella* and *H. armigera* by adopting the procedure of Swamiappan and Balasubramanian [2]. 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. The observation of percent parasitization was recorded after the egg incubation period.

2.3 Statistical Analysis

The data was statistically evaluated for completely random design (CRD), Duncan's multiple range test (DMRT), and one factor ANOVA, and the results were interpreted.

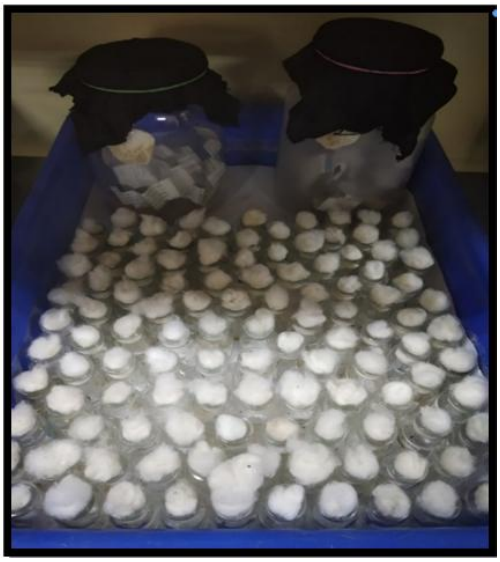
3. RESULTS AND DISCUSSION

3.1 The Parasitic Potential of *B. brevicornis* against Fruit Borers, *E. vittella* and *H. armigera*

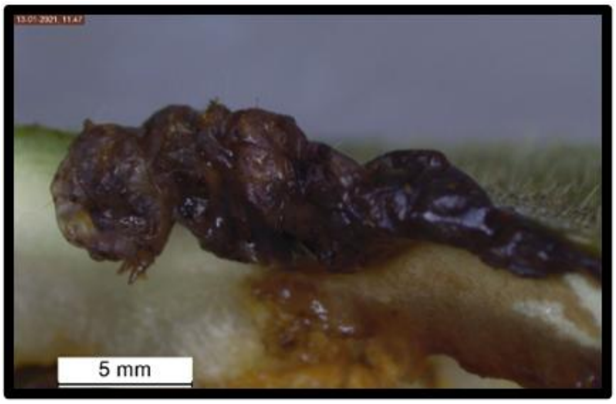
The parasitic potential studies showed that the parasitoid host ratio of 5:10 (100%) was the best for *E. vittella* (II, III and IV instar larvae) with the highest parasitization followed by 4:10 (96.83 %), 3:10 (85.08 %), 2:10 (61.71 %) and least parasitization was observed in 1:10 parasitoid host ratio (52.71 %). Similarly, for *H. armigera* (II, III, IV and V instar larvae) parasitoid host ratio of 5:10 was recorded the highest parasitization (96.75 %), followed by 4:10 (93.69 %), 3:10 (84.11 %), 2:10 (64.75 %) and least parasitization was observed in 1:10 parasitoid host ratio (45.07 %) (Table 1).

Sheeba and Narendran (2007) reported that "preferences of the parasitoid vary with host insects and *B. brevi*cornis was more effective against *E. vittella* followed by *H. armigera*. According to them, *B. brevicornis* was more effective against *Opisina arenosella* with 90% parasitization". The current study also discovered the fourth instar larvae were preferred by the parasitoids than the early instars larvae. The host acceptance and parasitization percentage may differ depending on the host's age. Hopper [14] reported that "*Microplitis croceipes* preferred the third and fourth instar larvae of *Heliothis virescens* (F.)". However, early instars were also parasitized. It is in confirmation by earlier findings of Reichmuth et al. [15]. According to them, very young and small lepidopteran hosts can also be killed when stung by the parasitoids.

Chelonus blackburni



Bracon brevicornis



***Bracon brevicornis* parasitised *Earias vittella* larvae**

Plate 1. Rearing methods followed for rearing of natural enemies

3.2 The parasitic potential of *C. blackburni* against fruit borers *E. vittella* and *H. armigera*

The parasitic potential of *C. blackburni* showed that the highest parasitization of 64.75 % was recorded against *E. vittella* in 5:100 parasitoid host ratio followed by 4:100 (60.50 %), 3:100 (52.55%), 2:100 (38.27%) and least parasitization was observed in 1:100 (25.60 %). Similarly, for *H. armigera*, at a parasitoid host ratio of 5:100 was recorded highest parasitization (70.50%), followed by 4:100 (64.50 %), 3:100 (58.25 %), 2:100 (43.45 %) and1:100 (28.50 %) (Table.2). The current findings agreed with Swamiappan and Balasubramanian [2], who found 59.60% parasitization against *E. vittella*, and Jeyarani et al. [16], who reported 87.11% parasitization of *H. armigera* by *C. blackburni* [17,18].

Table 1. Parasitic potential of *B. brevicornis* against the larvae of *E. vittella* and *H. armigera*

Sl. No.	Treatment (parasitoid: Host) ratio	% Parasitization (%)*								
		***Earias vittella* larvae**				***Helicoverpa armigera* larvae**				
		II instar	**III instar**	**IV instar**	**Mean**	**II instar**	**III instar**	**IV instar**	**V instar**	**Mean**
1	1:10	45.50 (42.40)^{e}	55.25 (47.99)^{d}	57.38 (49.22)d	52.71 (46.53)	40.63 (39.58)^{d}	50.00 (44.98)^{d}	52.38 (46.34)^{c}	37.25 (37.60)	45.07 (42.13)
2	2:10	55.25 (47.99)^{d}	67.25 (55.07)^{c}	62.63 (52.29)^{c}	61.71 (51.78)	70.00 (56.77)^{c}	68.50 (55.84)^{c}	75.00 (59.98)^{b}	45.50 (42.40)	64.75 (53.74)
3	3:10	75.25 (60.14)^{c}	85.25 (67.39)^{b}	94.75 (76.73)^{b}	85.08 (68.08)	83.45 (65.97)^{b}	90.00 (71.54)^{b}	100.00 (90.00)^{a}	63.00 (52.51)	84.11 (70.01)
4	4:10	90.50 (72.03)^{b}	100 (90.00)^{a}	100.00 (90.00)^{a}	96.83 (84.01)	100.00 (90.00)^{a}	100.00 (90.00)a	100.00 (90.00)^{a}	74.75 (59.81)	93.69 (82.45)
5	5:10	100.00 (90.00)^{a}	100 (90.00)^{a}	100.00 (90.00)^{a}	100 (90)	100.00 (90.00)^{a}	100.00 (90.00)^{a}	100.00 (90.00)^{a}	87.00 (68.84)	96.75 (84.71)
C.D @ 0.05 %		0.95	0.652	0.62	-	0.19	0.28	0.33	0.64	-
SE(m) ±		0.31	0.209	0.20	-	0.06	0.09	0.11	0.20	-
C.V.		0.84	0.513	0.48	-	0.15	0.22	0.25	0.66	-

** Mean of four replications in each treatment ** Figures in parentheses are arc sin values*
In a column, means followed by same letter(s) are not significantly different by DMRT (P<0.05)

***Bracon brevicornis* (Wesmael)**

***Chelonus blackburni* (Cameron)**

Plate 2. Parasitoids of bhendi fruit borer a. *Bracon brevicornis* b. *Chelonus blackburni*

Table 2. Parasitic potential of *C. blackburni* against *E. vittella* and *H. armigera* eggs

Sl. No.	Treatment (parasitoid: Host) ratio	Parasitization (%)**	
		E. vittella	***H. armigera***
1	1:100	25.60 (30.38)[e]	28.50 (32.25)[e]
2	2:100	38.27 (38.20)[d]	43.45 (41.22)[d]
3	3:100	52.55 (46.44)[c]	58.25 (49.73)[c]
4	4:100	60.50 (51.04)[b]	64.50 (53.41)[b]
5	5:100	64.75 (53.56)[a]	70.50 (57.08)[a]
C.D @ 0.05 %		0.82	0.17
SE(m) ±		0.26	0.05
C.V.		1.09	0.20

** Mean of four replications in each treatment ** Figures in parentheses are arc sin values*
In a column, means followed by same letter(s) are not significantly different by DMRT (P<0.05)

4. CONCLUSION

The parasitic potential of *B. brevicornis* against fruit borers, *E. vittella* and *H. armigera* was checked by maintaining different parasitoid host ratio. The result revealed that the parasitoid host ratio of 5:10 showed the highest parasitization for *E. vittella* (II, III and IV instar larvae) followed by 4:10, 3:10, 2:10 and least parasitization was observed in 1:10 parasitoid host ratio. Similarly, in *H. armigera* (II, III, IV and V instar larvae) parasitoid host ratio of 5:10 was recorded the highest parasitization, followed by 4:10, 3:10, 2:10 and least parasitization was observed in 1:10 parasitoid host ratio.

The parasitic potential of *C. blackburni* against fruit borers *E. vittella* and *H. armigera* was checked and the result showed that the highest parasitization was recorded against *E. vittella* in 5:100 parasitoid host ratio followed by 4:100, 3:100, 2:100 and least parasitization was observed in 1:100. Similarly, for *H*. *armigera*, at a parasitoid host ratio of 5:100 was recorded highest parasitization, followed by 4:100, 3:100, 2:100 and 1:100.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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