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Efficacy of percentage preference of *Bracon hebetor* Say on (Hymenoptera: Braconidae) on the *Helicoverpa armigera* & *Maruca vitrata* in pigeonpea under laboratory conditions

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Abstract
Bracon hebetor is a common parasitic wasp of Lepidopteran larvae and can attack coleopteran larvae. It is an ecto larval parasitoid belongs to the family Braconidae of order Hymenoptera. The wasp has wide host range and successful biocontrol agent recommended for the control of lepidopteran larvae in many crops and stored grains. The study revealed that when all the hosts were offered to *Bracon hebetor* it is parasitizing in the order of *C. cephalonica* followed by *H. armigera*, and then *Maruca vitrata* and testing for preference of *Bracon hebetor* among the larvae of spotted pod borer (*M. vitrata*) and pod borer (*H. armigera*) of pigeonpea it was found that *B. hebetor* highly preferred larvae of *H. armigera* as compared to *M. vitrata* and it was observed that mature larvae was highly preferred as host by *B. hebetor* as compared to immature larvae.

Keywords: Correlation, direct and indirect effect

Introduction

Bracon hebetor is most widely used gregarious polyphagous ecto parasitoid which parasitizes many lepidopteran larvae. *B. hebetor* females first paralyze the last-stage larvae of their host in a "wandering" phase by injecting paralytic venom and ovipositing variable numbers of eggs on or near the surface of paralyzed host (Mukti and Thomas, 2010) [7]. It attacks many important lepidopterous pests of stored products as well as field crops (Landge *et al*., 2009 and Dabhi *et al*., 2011) [5, 1]. The rice moth *Corcyra cephalonica* Stainton is an important insect-pest of different stored products in tropics (Jyoti *et al*., 2017) [4]. In India, this pest is being utilized in bio-control research developmental units for mass production of number of natural enemies which includes both parasitoids and predators (Jalali and Singh, 1992, Jyoti *et al*., 2017) [3, 4]. *Helicoverpa armigera* is a major pest of many economically important crops including cotton, pigeon pea, chickpea, sunflower, tomato, sorghum, millet, okra, and corn in India, (Manjunath *et al*., 1989) [6]. The spotted pod borer, *Maruca vitrata* (Geyer) derives its pre-eminent importance as a pest of tropical grain legumes from its extremely wide geographical distribution, extensive host range. Its ability to feeding on reproductive parts, the young growing plant tips, stems, flower buds, flowers, pods and seeds. During recent years due to introduction of short duration pigeonpea cultivars, the incidence of *M. Vitrata* has been aggravated as flowering of these varieties occur during periods of high humidity and moderate temperature which is congenial for the development of pest (Sharma *et al*., 1999) [9].

The pod borer complex, which also comprises *H. armigera*, *E. atoma*, and *M. obtusa*, has been confirmed to be a target this seed, by attacking the reproductive parts of the plant, the complex results in large reductions in the yield of grains ranging from 30 to 100 per cent. Up to 50 % of the pigeonpea crop loss is attributable to *H. armigera* alone. (Thakare, 2001 and Dodia *et al*., 2009) [12, 2].

Biological control is emphasized as an important remediation strategy to combat pest outbreaks by many workers (Shanower *et al*., 1998; Singh *et al*., 1994; Singh *et al*., 1991) [8, 10, 11].

It is the need of the hour towards an eco-friendly management of insect pests to sustain a healthy and pollution free environment and to save the non target species.

Materials and Methods

Parasitoid: For culture of *Bracon hebetor*, bracocards containing pupa of *B. hebetor* in varying number was used. After the emergence of adults, male and female were left for mating and for this experiment only female were used.

Host: Larvae of *H. armigera* and *Maruca vitrata* was reared in small pieces of pods of pigeonpea.

Methodology - 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. Different instar larvae such as 2nd, 3rd, 4th and 5th of *H. armigera* and *Maruca vitrata* were introduced separately.

Experiment was done by using sandwich method. Female parasitoids were introduced into a plastic jar (18x12 cm) with the help of aspirator and covered with muslin cloth. Then fresh and healthy larvae were kept for parasitization on the muslin cloth and covered with another muslin cloth using rubber band to restrict the larval movement (as per sandwich technology). After 24 hrs of exposure, the parasitized host larvae were transferred to petri plates individually and observations were taken on number of parasitized larvae and thereby for calculating per cent parasitization from each petri plate. From each host larva the number of *B. hebetor* eggs and larvae emerging were observed and recorded under digital stereo trinocular microscope.

Using the below formula, % parasitization was calculated;

$$\% \text{ Parasitization} = \frac{\text{Number of host larvae parasitized (containing eggs,grubs of } B.hebetor)}{\text{Number of host larvae exposed for parasitization}} X\, 100$$

Statistical analysis: Each experiment was repeated 5 times for a particular instar. The data obtained from the laboratory studies were subjected to analysis of variance (ANOVA) by Completely Randomized Design (CRD). Per cent parasitization was subjected to arcsine transformation.

Results and Discussion

Preference of *Bracon hebetor* towards different larval instars of *Helicoverpa armigera* in pigeonpea under laboratory conditions.

The studies on larval parasitization by *Bracon hebetor* conducted under laboratory conditions showed that, there were significant differences in parasitization of different larvae of *H. armigera* as depicted in (Table 1).

During 2021-22, among the six different larval instars of *H. armigera* tested, the most preferred larval stage for parasitization by *B. hebetor* was sixth instar with (88.00 %) followed by fifth instar (84.00%), fourth instar (72.00%), third instar (60.00%) and least preferred stage was second instar (10.00 %).

Similarly, during 2022-23, among the six different larval instars of *H. armigera* tested, the most preferred larval stage for parasitization by *B. hebetor* was again observed in the sixth instar larval stage with 94.00 % followed by fifth instar (88.00%), fourth instar (68.00%), third instar (66.00%) and least preferred stage was second instar with 14.02 %.

The pooled mean on larval parasitization by *Bracon hebetor* were found to be maximum on sixth instar larval stage with 91.00 % followed by fifth instar (86.00%), fourth instar (70.00%), third instar (63.00%) and least preferred stage was second instar (12.01 %).

Similar findings were reported by Gupta (2018) [14] who also mentioned that significantly higher parasitization of 33.40 per cent was observed by *B. hebetor* on the sixth instar of *H. armigera*. The present findings are also supported by Saxena (2012) [15] stating that fourth and fifth instar larvae were most suitable, representing 100% parasitism and parasitoid development and sixth instar larvae were the next most suitable for parasitism (96.7%) by *B. hebetor* of *H.armigera*.

In the table 1, clearly depicts during 2021-2022 that significantly highest per cent of adult emergence of *B. hebetor* was observed from sixth instar larval stage with (61.80 %) which was found to be superior over rest of the larval stages followed by fifth instar (52.00%), fourth instar (58.40%), third instar (24.00%) and least adult emergence was recorded from second instar (3.00 %).

Similar results were observed during 2022-23 also and significantly highest percent of adult emergence of *B. hebetor* was observed from the sixth instar larval stage with (70.20 %) which was found to be superior among all the larval stages followed by fifth instar larval stage 64.60 %, fourth instar (46.60 %), third instar (40.00%) and least adult emergence was recorded from second instar larvae with (9.60 %).

Data on pooled mean on adult emergence of *Bracon hebetor* were found to be maximum on sixth instar larval stage (66.00 %) followed by fifth instar (58.30%), fourth instar (52.50%), third instar (32.00%) and least preferred stage was second instar larvae with (6.30 %.).

The present findings are also in agreement with Gupta (2018) [14] who reported that significantly higher emergence of adults of 29.40 per cent was observed in *B. hebetor* on sixth instar of *H. armigera.*

Similar finding was also reported by Thanavendan and Jeyarani (2012) [16] who mentioned in their research that the *braconid viz*., *B. hebetor* and *B. brevicornis* against *H. armigera* revealed that there was significant difference between different parasitoid host ratios. Significantly the highest parasitization of 97.50 per cent was recorded in the same ratio (5:10 ratio) against second to sixth instar larvae of *H. armigera*.

To study the preference of *Bracon hebetor* towards different larval instars of *Maruca vitrata* under laboratory conditions

The studies on larval parasitization by *B. hebetor* showed that, there were significant differences in parasitization between different larval instars of *M. vitrata* by *B. hebetor* as depicted in (Table 1).

During 2021-22, among the five different larval instars of *M. vitrata* tested, the most preferred larval stage for parasitization by *B. hebetor* was the fifth instar larval stage with 82.00 % followed by fourth instar (76.00%), third instar (56.00%) and least preferred stage was the second instar only 08.00 % parasitization.

Similarly, during the next year (2022-23), among the five different larval instars of *M. vitrata* tested, the most preferred larval stage for parasitization by *B. hebetor* was fifth instar larval stage with 76.00 % followed by fourth instar (64.00%), third instar 48.00% and least preferred stage was second instar with (12.00 %).

The pooled mean data of two years on larval parasitization by *B. hebetor* revealed, maximum per cent parasitization on fifth instar larval stage with 91.00 % followed by fourth instar (79.00%), third instar (70.00%), second instar (52.00%) and least preferred stage was instar (10.00 %).

Similar finding was reported by Gupta (2018) [14] who also mentioned that significantly higher parasitization of 24.40 per cent was observed in *B. hebetor* on 5th instar larvae of *M. vitrata* which was significantly higher than other instars.

In the table 1 clearly depicts during 2021-22, significantly highest percent of adult emergence of *B. hebetor* from the fifth instar larval stage with (59.40 %) which was significantly superior than rest of the larval instars, followed by fourth instar 53.00 %, third instar 34.40% and least adult emergence was recorded from second instar larvae with 3.60 %.

Similarly, during 2022-23 significantly highest per cent of adult emergence of *B. hebetor* was observed from the fifth instar larval stage with (47.20 %) which was significantly superior over rest of the larval stages, followed by fourth instar 40.80 %, third instar 27.80% and least adult emergence was recorded from second instar larvae with 7.40 %.

The pooled mean on adult emergence of *B. hebetor* were found to be maximum on fifth instar larval stage with 53.30 % followed by fourth instar (46.90 %), third instar (31.10 %) and least preferred stage was second instar (5.50 %).

The present findings are in match with Gupta (2018) [14] who also mentioned that significantly higher emergence of adults of 20.80 percent was observed in *B. hebetor* on 5th instar of *M. vitrata.*

Table 1: Percentage preference (%) of *Bracon hebetor* towards different larval instars of *Helicoverpa armigera* and *Maruca vitrata* in pigeonpea

	%Parasitization						%Adult emergence					
Treatments	***Helicoverpa armigera***			***Maruca vitrata***			***Helicoverpa armigera***			***Maruca vitrata***		
	2021	**2022**	**Pooled mean**	**2021**	**2022**	**Pooled mean**	**2021**	**2022**	**Pooled mean**	**2021**	**2022**	**Pooled mean**
II Instar	10.00	14.02	12.01	08.00	12.00	10.00	3.00	9.60	6.30	3.60	7.40	5.50
	(11.95)	(17.62)	(15.89)	(10.62)	(15.93)	(14.30)	(4.55)	(17.45)	13.45	(5.01)	(12.30)	(10.25)
III Instar	60.00	66.00	63.00	56.00	48.00	52.00	24.00	40.00	32.00	34.40	27.80	31.10
	(50.974)	(54.95)	(52.89)	(48.44)	(43.82)	(46.12)	(29.25)	(39.16)	34.39	(35.85)	(31.39)	(33.75)
IV Instar	72.00	68.00	70.00	76.00	64.00	70.00	58.40	46.60	52.50	53.00	40.80	46.90
	(58.22)	(55.81)	(56.99)	(61.17)	(53.20)	(56.98)	(49.96)	(43.03)	46.44	(46.70)	(39.67)	(43.20)
V Instar	84.00	88.00	86.00	82.00	76.00	79.00	52.00	64.60	58.3	59.40	47.20	53.30
	(66.66)	(69.91)	(68.17)	(65.62)	(60.75)	(63.01)	(46.14)	(53.61)	49.77	(50.41)	(43.37)	(46.87)
VI Instar	88.00	94.00	91.00	-	-	-	61.80	70.2	66.00	-	-	-
	(71.978)	(78.92)	(74.35)	-	-	-	(51.87)	(57.12)	54.36	-	-	
C.D. at 5%	13.23	13.38	12.22	12.61	10.88	10.88	8.84	7.44	6.34	8.11	9.32	7.67
SEm ±	4.45	4.50	4.11	4.17	3.60	3.59	2.97	2.50	2.13	2.68	3.08	2.53

Figure in the parentheses are angular transformed values

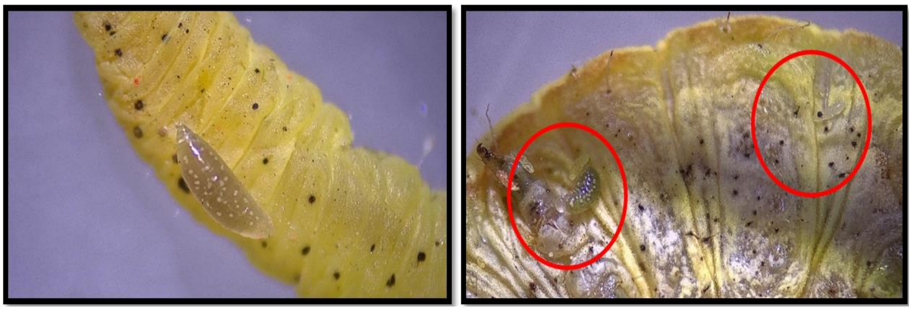

Plate 1: Eggs and grubs of *Bracon hebetor* on parasitized larvae of *Maruca vitrata*

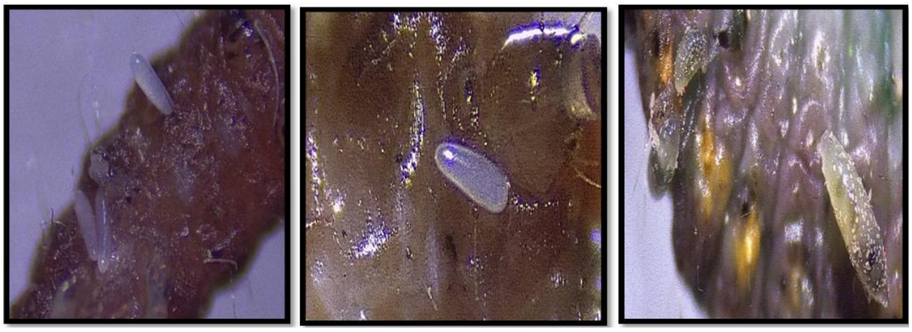

Plate 2: Eggs and grubs of Bracon hebetor on parasitized larvae of Helicoverpa armigera

Conclusion

Based on the present laboratory study results it was evident that the *B. hebetor* was an effective parasitoid of *H. armigera* and *M. vitrata* and further need to be tested for its efficacy in field conditions. If it proves as effective biological control agent of *H. armigera* and *M. vitrata* under field conditions, it will reduce the threat of damage to many crops especially pigeonpea in India. Use of biocontrol agents like parasitoids reduces the pesticide usage and environmental pollution.

Life cycle of *B. hebetor* has 4 stages and completes in 20 days during warm weather and extends to 60-70 days during winter. Egg period is 1-2 days, larval period 2-4 days and pupal period 3-7 days. Larval stage is parasitic and rearing in laboratory is easy using *C. cephalonica* as host. Adult is free living with average pre oviposition period of 3 (2-5) days, oviposition period 37.7 (22-55) days and post oviposition period 4.4 (1-8) days, the fecund female live for 45 (20-63) days. Pupal cards or adults @ 5000 adults/hectare or 4000- 5000 pupae/hectare need be released in the field. Adult takes shelter on flowering plants and consumes nectar of small flowers. So along with parasitoids flowering plants are also to be recommended for their shelter and food. NIPHM maintains biological control laboratory with various parasitoids and predators for the purpose of training of on farm production of biocontrol agents and maintains ecological engineering organic polyculture field for the demonstration of these biocontrol agents role in pest management. This is a great combination for bio intensive pest management through combination of release and conservation of parasitoids for sustainable agriculture.

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