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Comparison of the Life Cycle Related Parameters of *Bracon hebetor* say on *Helicoverpa armigera Hubner* Reared on different Hosts

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ABSTRACT: *Helicoverpa armigera* is a prolific, widespread, troublesome and difficult to control insect due to its high mobility, high fecundity and ability to develop resistance against chemical insecticides. In recent years, efforts are being focused on the development of eco-friendly and non-chemical strategies for insect pest management, among which the use of natural enemies *ie*. parasitoids and predatorsis gaining popularity and spreading its wings across the world including India. *Bracon hebetor* is one of the important and effective larval ectoparasitoids, that attacks a variety of lepidopteran pests of field crops including the notorious *H. armigera*. Since diet plays an important role in the growth and life cycle related parameters of any insect, particularly for polyphagous pests, which further acts as a decisive factor for the parasitoids, choosing their host for attack. Hence, it is imperative to know the best suitable diet, therefore, the present study on the comparison of life cycle of *Bracon hebetor* Say on larvae of *H. armigera* reared on nine different hosts *viz.* chickpea, pigeonpea, marigold, tomato, cabbage, maize, soybean, artificial diet, and *Corcyra cephalonica* (as Standard check) was taken up under laboratory conditions at IGKVV, Raipur, Chhattisgarh. The statistical analysis of the data generated revealed that the host fed on different diets had a great impact on the biological parameters of the parasitoid developing on it. The duration of development of the parasitoid was significantly shortened in case of the parasitoid reared on *C. Cephalonica* and 4th instar larvae of *H. armigera* fed on chickpea and marigold (11.49, 12.75, and 13.08 days) followed by the larvae reared on tomato, soybean, maize, artificial diet, pigeon pea and cabbage (13.67, 14.67,15.23, 15.34, 15.72, 15.94 days) respectively.

Keywords: *Bracon hebetor*, life stages, *H. armigera*, parasitoid, fecundity, developmental time.

INTRODUCTION

The chickpea pod borer, *Helicoverpa armigera* Hubner (Lepidoptera: Noctuidae) is one of the most destructive insect pests, causing high economic losses in a diverse array of agricultural host plant species (Kouhi *et al*., 2014). It feeds on over 300 species belonging to 68 plant families around the world, including major crops such as cotton, soybean, maize, pigeonpea, chickpea, marigold, and a wide range of horticultural crops (Pearce *et al.,* 2017). Young larvae of *H. armigera* feed exclusively on foliage, flower buds, and flowers while the later instars bore into the fruits and pods and render them unmarketable. The host plants of phytophagous insect pests is an important parameter that plays a significant role in its growth and development. This factor is more decisive in case of polyphagous pests feeding on a wide range of crops. The most suitable and preferred host acts as the key factor for attaining optimal growth at the shortest duration of time. Further, the choice of the parasitoids attacking the host larvae fed on different diets is another crucial factor that needs to be explored. Considering the damage caused by the pests and the methods used to control them, mainly involves massive spraying of synthetic chemical insecticides, which has led to several environmental hazards and reasons for resurgence and resistance developing issues. Hence, it is important to search for new tools that can be used to manage this pest in an eco-friendly and sustainable way. In this aspect, the adoption of natural parasitoids represents an important avenue of investigation. Since *H. armigera* feeds on different host plants, it can be easily utilised for the mass rearing of the parasitoids that favours not only the control of the pest but also for the mass multiplication of the *Bracon hebetor* Say (Braconidae: Hymenoptera) under laboratory conditions. These parasitoids are highly polyphagous, cosmopolitan, idiobiont, and gregarious in nature that paralyzes the hosts by stinging and injecting them with venom, after which the female lays eggs on the surface of the paralyzed host. These natural enemies can reproduce continuously as long as the hosts or alternative hosts are available (Uneo and Uneo, 2007). Therefore, the present studies were designed to evaluate some biological aspects of *B. hebetor* Say on *H. armigera* larvae reared on nine different hosts.

MATERIALS AND METHODS

Studies on the biology of *B. hebetor* were carried out on *H. armigera* reared on nine different hosts *viz.*

chickpea, pigeonpea, marigold, tomato, cabbage, maize, soybean, artificial diet, and *Corcyra cephalonica* (as Standard check) at the Biological Control Laboratory, Department of Entomology, College of Agriculture, Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.) during the year 2019-2020. During the study period the average temperature and relative humidity were maintained at 28 ± 0.5°C, 65 ± 5% RH, 16:8 h L:D photoperiod. The culture of *H. armigera* was initiated in the laboratory by using pupae procured from the NBAIR, Bengaluru and subsequent generations were established for further studies. Initially, *B. hebetor* was collected from the field using an aspirator and was released on the *C. cephalonica* for its multiplication. The second generation of the parasitoids was used for the study of their biology on *H. armigera* reared on different host plants.

Host plants were raised in small pots throughout the period of study to maintain the availability of different diets for *H. armigera*. The experiment was maintained with eight host plants along with one standard check *i e. C. cephalonica.* Five replicates were used for each host species. The males and females *B. hebetor* were identified based on their size and ovipositor. The females were bigger, with a prominent ovipositor, while the males are slender and smaller in size. A pair of newly emerged *B. hebetor* was introduced in a small plastic container (100 ml) and covered with a piece of white muslin cloth over which one 4th instar larva reared on the respective host were placed. After placing the larva, it was covered with another piece of white muslin cloth of the same size and secured tightly with a rubber band (Sandwich method). After one day (24 hrs.) of parasitization, the larva was removed and placed in small Petri dishes of 5 cm dia. with the help of a fine camel brush without causing damage to the parasitized larvae. Observations were recorded on various biological parameters *viz.* number of eggs laid, incubation period, duration of survival from egg to adult, and total period of the life cycle of *B. hebetor* on *H. armigera* reared on different hosts respectively.

A. Statistical Analysis

The biology of the parasitoid, *B. hebetor* on the 4th instar larvae of *H. armigera* reared on different hostswere studied by using mean and standard deviation by applying Completely Randomised Design.

RESULTS AND DISCUSSIONS

Female *B. hebetor* laid eggs in groups of 2 to 4. Data presented in table 1 indicated that a significantly maximum egg period was registered in *C. cephalonica* (11.2 days) with the maximum number of eggs and post ovipositional days (96 eggs and 4.8 days) followed by *H. armigera* larvae reared on chickpea host (8.8 days and 75.2 eggs) respectively whereas lowest number of eggs (46.4) and post ovipositional period of 1.8 days were recorded on larvae reared on cabbage. The preference and variation in the oviposition might be attributed to the presence of nutrient content of the host.

Table 1: Effect on different ovipositional parameters of *Bracon hebetor* reared on 4th instar larva of *Helicoverpa armigera* fed on different host plants.

***H. armigera* rearedon different hosts**	**Pre-oviposition (days)***	**Oviposition (days)**	**Number of eggs observed/ ovipositional period**		**Post-oviposition (days)**
			Total	**Mean**	
Chickpea	0.6 (1.02)	8.8 (2.94)	376	75.2 (8.63)	3.8 (1.92)
Pigeon pea	1.0 (1.22)	6.4 (2.52)	323	64.6 (7.93)	2.2 (1.46)
Marigold	0.6 (1.02)	9.2 (3.02)	403	80.6 (8.88)	3.8 (1.92)
Tomato	0.6 (1.02)	7.2 (2.67)	359	71.8 (8.45)	3.4 (1.82)
Cabbage	0.8 (1.12)	5.6 (2.36)	232	46.4 (6.72)	1.8 (1.33)
Maize	0.6 (1.02)	6.4 (2.51)	324	64.8 (7.97)	3.0 (1.71)
Soybean	0.8 (1.12)	6.6 (2.56)	309	61.8 (7.73)	3.8 (1.92)
Artificial diet	0.8 (1.12)	5.8 (2.40)	268	53.6 (7.20)	2.8 (1.66)
C. cephalonica	0.4 (0.91)	11.2 (3.34)	480	96.0 (9.74)	4.8 (2.17)
Mean ± SD	1.06 ± 0.091	2.70 ± 0.33	341.5 ± 69.56	8.14 ± 0.26	1.77 ± 0.91
SEm ±	0.11	0.127	-	0.581	0.137
CD at 5%	NS	0.366	-	1.673	0.395

*Figures in parentheses are (x+0.5) square root transformed values
Figures in parentheses are square root transformed values

Data presented in Table 2, clearly reveals that the mean incubation period of *B. Hebetor* on the nine different hosts varied significantly with each other and was lowest on *C. cephalonica* (1.05 days). The result are in line with (Farag *et al*., 2015) who reported the lowest incubation period of 1.3 days on *C. cephalonica*, followed by chickpea and marigold (1.25 and 1.27 days) while it was highest on the larvae reared on tomato, soybean, maize, artificial diet, pigeon pea and cabbage (1.36, 1.44, 1.45, 1.46, 1.47 and 1.53) respectively. Similar findings were reported by (Kaur *et al*. 2009) who also observed an incubation period of 1.33 days when *B. hebetor* was reared on larvae of *Spodoptera litura* (F.). The pupal phase was the longest among all developmental stages, lasting about a week. This finding supported the report of (Ghimire *et al*., 2008 and Latha *et al*., 2019). Pupation took place in a silken cocoon near the vicinity of the host that matches with the findings of (Ladge *et al.,* 2009 and Quicke (2015) mentioning the same habit of *B. hebetor* for pupation. This might be due to the potential risk of

putrification of the non consumed host tissue. Maximum pupation period was registered on the larvae reared on cabbage (6.57 days) and minimum on *C. cephalonica* (5.19 days). *B. hebetor* completed its developmental stages significantly faster on *C. cephalonica* with a minimum duration of (11.49 days)which is in agreement with the findings of (Dabhi *et al.,* 2013 and Saad at *et al*., 2014) who also reported that *C. cephalonica* was the most suitable host for the development of *B. hebetor*, followed by the larvae reared on chickpea, marigold, tomato, soybean, maize, artificial diet and pigeon pea (12.75, 13.08, 13.67, 14.67, 15.23, 15.34, 15.72 days) respectively and lowest on cabbage (15.94 days). The present findings are in line with (Forouzan *et al*., 2003, Ghimire *et al*., 2014 and Pezzini *et al.,* 2017)who also reported that the parasitoid completes its development in 12.09 days when reared on larvae of *Galleria mellonella* and *Ephestia kuehniella.*

Table 2: Effect on the developmental period of *Bracon hebetor* reared on different instars of *Helicoverpa armigera* larvae fed on different host plants.

***H. armigera* reared on different hosts**	**Mean incubation period (days)**	**Mean developmental period of different stages (days)**						**Total period (egg to adult) (days)**
		(1st instar)	**(2nd instar)**	**(3rd instar)**	**(4th instar)**	**Pre-pupa**	**Pupa**	
Chickpea	1.25 (1.12)	1.13 (1.06)	1.15 (1.07)	1.12 (1.06)	1.18 (1.09)	1.22 (1.10)	5.70 (2.39)	12.75
Pigeon pea	1.47 (1.21)	1.58 (1.26)	1.55 (1.24)	1.52 (1.23)	1.57 (1.25)	1.51 (1.23)	6.50 (2.55)	15.72
Marigold	1.27 (1.13)	1.23 (1.11)	1.23 (1.11)	1.19 (1.09)	1.20 (1.10)	1.22 (1.10)	5.74 (2.40)	13.08
Tomato	1.36 (1.17)	1.34 (1.16)	1.26 (1.12)	1.36 (1.17)	1.30 (1.14)	1.33 (1.15)	5.72 (2.39)	13.67
Cabbage	1.53 (1.24)	1.57 (1.25)	1.57 (1.25)	1.54 (1.24)	1.61 (1.27)	1.55 (1.25)	6.57 (2.56)	15.94
Maize	1.45 (1.20)	1.47 (1.21)	1.63 (1.27)	1.44 (1.20)	1.54 (1.24)	1.58 (1.26)	6.12 (2.47)	15.23
Soybean	1.44 (1.20)	1.40 (1.18)	1.56 (1.25)	1.49 (1.22)	1.53 (1.24)	1.53 (1.23)	5.73 (2.39)	14.67
Artificial diet	1.46 (1.21)	1.49 (1.22)	1.51 (1.23)	1.54 (1.24)	1.46 (1.21)	1.50 (1.22)	6.38 (2.53)	15.34
C. cephalonica	1.05 (1.03)	1.07 (1.03)	1.06 (1.03)	1.02 (1.01)	1.05 (1.03)	1.05 (1.03)	5.19 (2.28)	11.49
Mean ± SD	1.17 ± 0.06	1.17 ± 0.08	1.17 ± 0.09	1.16 ± 0.08	1.17 ± 0.08	1.18 ± 0.08	2.44 ± 0.09	
SEm ±	0.025	0.022	0.021	0.019	0.017	0.019	0.008	-
CD at 5%	0.071	0.063	0.059	0.055	0.05	0.054	0.023	-

Figures in parentheses are square root transformed values

Data presented in Table 3 depicts that significantly maximum number of eggs of *B. hebetor* were observed on the standard check *i.e C. cephalonica* (18.6 eggs) and minimum was on the larvae reared on cabbage (8.4 eggs). The total number of adults emerged also showed the same trend with maximum emergence of (18.0) in *C. cephalonica* followed by larvae reared on chickpea (14.8) whereas the minimum number of adults emergence was seen on the larvae reared on cabbage (5.4). The female and male ratio also varied among the nine hosts.

B. Eggs.

A. *Bracon hebetor* female parasitizing larvae of *H. armigera.*

C. Parasitoid pupae.

Fig.1.

Table 3: Effect on number of immatures and adults emergence of *Bracon hebetor* reared on larvae of *Helicoverpa armigera* fed on different host plants.

H. armigera reared on different hosts	Mean number of eggs observed	Mean number of immature stages of *B. hebetor* observed						Mean number of adults observed	Mean number of Male observed	Mean number of Female observed	Female: Male
		(1st instar)	(2nd instar)	(3rd instar)	(4th instar)	Prepupa	Pupa				
Chickpea	16.2 (4.01)	15.6 (3.93)	15.4 (3.91)	15.4 (3.91)	15.2 (3.89)	15.2 (3.89)	15.0 (3.86)	14.8 (3.83)	6.4 (2.52)	8.4 (2.88)	1:0.76
Pigeon pea	10.6 (3.20)	10.0 (3.10)	9.6 (3.05)	9.4 (3.02)	9.4 (3.02)	8.8 (2.93)	8.8 (2.93)	8.0 (2.78)	3.4 (1.81)	4.6 (2.10)	1:0.74
Marigold	15.2 (3.87)	14.8 (3.82)	14.6 (3.79)	14.0 (3.70)	14.0 (3.70)	13.8 (3.68)	13.8 (3.68)	13.6 (3.66)	5.4 (2.29)	8.2 (2.84)	1:0.65
Tomato	14.4 (3.73)	13.8 (3.66)	13.4 (3.61)	13.4 (3.61)	13.2 (3.58)	13.0 (3.56)	13.0 (3.56)	12.8 (3.54)	6.8 (2.52)	6.0 (2.42)	1:1.13
Cabbage	8.4 (2.87)	7.2 (2.66)	7.2 (2.66)	7.2 (2.66)	6.8 (2.58)	6.8 (2.58)	6.2 (2.47)	5.4 (2.29)	2.2 (1.48)	3.2 (1.74)	1:0.68
Maize	12.8 (3.56)	12.4 (3.50)	12.0 (3.45)	11.8 (3.42)	11.8 (3.42)	11.6 (3.39)	11.6 (3.39)	10.8 (3.27)	4.8 (2.14)	6.0 (2.45)	1:0.8
Soybean	13.2 (3.62)	12.4 (3.50)	12.2 (3.48)	12.0 (3.45)	12.0 (3.45)	12.0 (3.45)	12.0 (3.45)	11.4 (3.36)	5.8 (2.36)	5.6 (2.33)	1:1.04
Artificial diet	12.0 (3.41)	11.4 (3.33)	11.0 (3.28)	10.4 (3.19)	10.4 (3.19)	10.4 (3.19)	10.2 (3.16)	9.6 (3.07)	4.2 (1.99)	5.4 (2.31)	1:0.77
C. cephalonica	18.6 (4.31)	18.4 (4.29)	18.2 (4.27)	18.2 (4.27)	18.2 (4.27)	18.2 (4.27)	18.2 (4.27)	18.0 (4.24)	9.4 (3.05)	8.6 (2.92)	1:1.09
Mean ± SD	3.62 ± 0.41	3.53 ± 0.45	3.50 ± 0.45	3.47 ± 0.45	3.46 ± 0.46	3.44 ± 0.47	3.42 ± 0.50	3.34 ± 0.55	2.24 ± 0.43	2.44 ± 0.37	-
SEm ±	0.234	0.227	0.213	0.213	0.210	0.200	0.199	0.202	0.209	0.171	-
CD at 5%	0.673	0.652	0.613	0.613	0.606	0.575	0.574	0.583	0.600	0.490	-

Figures in parentheses are square root transformed values

The ratio of females was more on the larvae reared on maize, artificial diet, chickpea, pigeon pea, cabbage, and marigold (1:0.80, 1:0.77, 1:0.76, 1:0.74, 1:0.68, 1:0.65) respectively, whereas tomato, *C. cephalonica* and soybean (1:1.13, 1:1.09, 1:1.04) registered more number of males than females. This discrepancy might be due to the variation in the nutrient content of the host and the conditions under which the study had been conducted. The present findings are in accordance with Ahmed (2012), Khalil *et al*., 2016 and Saxena and Duraimurgan, 2009 who also reported that the sex ratio in *B. hebetor* was biased towards females.

CONCLUSION

Thus, among the nine hosts tested, *C. cephalonica* was found to be highly suitable for the rearing of *B. hebetor* which is evident by maximum oviposition and emergence of adults with a shortest developmental period of various immature stages. However, *H. armigera* larvae reared on chickpea and marigold were also found suitable for the rearing of *B. hebetor* in case the factitious host, *C. cephalonica* was not available, followed by the larvae reared on tomato, soybean, maize, and artificial diet, whereas pigeon pea and cabbage were found to be least effective for the rearing of the ectoparasitoid, *B. hebetor*. Since, *H. armigera* is causing high economic losses to farmers, the utilization of *B. hebetor* parasitoids might be helpful to facilitate farmers in the control of economically important crop pests of Lepidoptera order. Hence, proper timing of release synchronizing with the availability of hosts would ensure successful control of *H. armigera.*

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