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Comparative biology of *Bracon hebetor* say on *Corcyra cephalonica* stainton, *Helicoverpa armigera* (hub.) and *Spodoptera litura* fabricius under no choice and dual choice conditions

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Abstract
Bracon hebetor is one of the most common polyphagous larval ecto parasitoid in the Indian sub-continent. It has wide host range and successful bio control agent recommended for control of lepidopteran larvae in many crops and stored grains. Laboratory studies were conducted to know the prasitization of *B. hebetor* on three hosts, *Corcyra cephalonica, Helicoverpa armigera* and *Spodoptera litura.* In no choice and dual choice condition it was found that *B. hebetor* parasitized *C. cephalonica* and *H. armigera* larvae and not parasitized *S. litura* larvae. Fecundity was found to be zero on *S. litura* under dual choice condition with *C. cephalonica* or *H. armigera*. *C. cephalonica* and *H. armigera* are found to be preferred hosts for *B, hebetor*.

Keywords: *Bracon hebetor, Corcyra cephalonica, Helicoverpa armigera, Spodoptera litura,* Biological control

Introduction
Bracon hebetor Say 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) [11]. It attacks many important lepidopterous pests of both stored product as well as pests of field crops (Dabhi *et al.*, 2011, Landge *et al.,* 2009) [3, 8].
The rice moth *Corcyra cephalonica* Stainton is an important insect-pest of different stored products in tropics (Jyothi *et al.*, 2017). 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, Jyothi *et al.*, 2017) [5]. *S. litura* is a serious pest of various economically important crops such as cotton, tomato, grondnut, chilli, tobacco, castor, okra and pulses in India, China and Japan (Promod *et al.*, 2015) [14]. *H. armigera* is a major pest of many economically important crops in India, including cotton, pigeonpea, chickpea, sunflower, tomato, sorghum, millet, okra, and corn (Manjunath *et al.* 1989, Sharma 2001) [9, 16]. *H. armigera* is a polyphagous insect pest in the Indian cropping system and completes approximately 10 generations per year among the crops it attacks (Ravi *et al*. 20015) [15]. Laboratory studies were conducted on these three insects as host for *B hebetor* rearing.

Materials and Methods
The laboratory studies were carried out in Bio control laboratory at National Institute of Plant Health Management during the year 2018.
Bracon hebetor Culture: A clean dry tub was taken and a cotton swab dipped in honey was placed on one side of tub. Then 50 g of broken sorghum grain was taken in the tub and 400 *Corcyra* larvae were placed and 50 *B. hebetor* adults were released. Tub was covered with muslin cloth and kept it for 30-40 days. Honey cotton was changed once in two days and sorghum grain was turned once in a week. The adults coming after 30-40 days were collected and used to conduct experiment (NIPHM). *H, armigera* culture: Larvae of *H. armiger* were obtained from a laboratory culture maintained at NIPHM. Supplemented with field-collected larvae. Larvae were reared on a chickpea based diet (Armes *et al*., 1993) at 27˚C.

S. litura culture: Larvae of *S. litura* were reared on castor leaves at NIPHM and used for experiment.

For no choice tests, equal size and equal weight 0.0544 g/ larvae were taken for the studies. The method followed was Sandwich method (NIPHM). In this method, 20 *B. hebetor* adults were released in the jar and cotton dipped in 10% honey solution was placed to one side of the jar which provides nutrition for the adult *B. hebetor*. The jar was covered on the top with a muslin cloth. Ten *C. cephalonica* larvae were placed on the cloth and again it was covered with a muslin cloth on the top. The adults which were present in the jar were fed on the honey solution and parasitized the larva by inserting ovipositor through muslin cloth. In the second jar 20 adults of *B. hebetor* were released and 10 *S. litura* larvae were taken for parasitization (Table 1)

For Dual choice tests in the third jar, a combination of *C, cephalonica* 10 larvae and *S. litura* 10 larvae were taken. The experiment was initiated on 16th January 2018; the parasitized larvae were shifted to petri plates on 18th January 2018 and the adults were counted for 3 days after first emergence.

The experiment was repeated on 23rd January 2018 including *H. armigera* as the third host. In jar 1 *C. cephalonica*, in jar 2 *S. litura* and in jar 3 *H. armigera* were provided under no choice conditions. In jar 4 *H. armigera and C cephalonica* and in jar 5 *H. armigera and S. litura* were provided under dual choice conditions. In all the experiments 5 larvae were taken with total weight of 0.2722 g. Parasitized larvae were shifted to Petri plates on 2nd day, number of pupae were recorded on 4th day and number of *B. hebetor* adults emerged were counted for 3 days from the date of first adult emergence.

Results

The experiment was initiated on 16th Jan 2018 and on 18th January it was found that the larvae of *C. cephalonica* in two jars were parasitized, whereas none of the *S. litura* from either no choice experiment or from the dual choice experiment was parasitized. In the first jar 80 pupae were formed on *C. cephalonica*. Fourteen days after parasitization 38 adults were emerged from jar 1 on 30th January 2018; later 20 adults emerged on 31st January 2018 followed by 21 adults on 1st February 2018. In the second jar, none of the *S. litura* larvae were parasitized. Hence, pupae were not formed. In the third Jar, 41 pupae were formed on *C. cephalonica*. The adult emergence started in the same day as seen in the first jar i.e., 30th January 2018. On the first day 18 adults emerged, followed by 10 adults on 31st January and 13 adults on first January 2018 (Table 1).

Table 1: *Bracon hebetor* Say development on Corcyra cephalonica Stainton and Spodoptera litura Fabricius in no choice and dual choice experiments, NIPHM, Rajendranagar

Exp. on 16-01-2018	Larvae/Adults released	No. of l/A	Total Wt. g/larvae used	No. of Pupae on 20-01-2018	No of adults on 30-01-2018	No of adults on 31-01-2018	No of adults on 01-02-2018
Jar 1	C. cephalonica larvae	10	0.5444	80	38	20	21
	B. hebetor adults	20					
Jar 2	S. litura larvae	10	0.5444	0	0	0	0
	B. hebetor adults	20					
Jar 3	S. litura larvae	5	0.2722	0	0	0	0
	C. cephalonica larvae	5	0.2722	41	18	10	13
	B. hebetor larvae	20					

On 23rd January 2018 experiment was initiated and it was found that the larva of *C. cephalonica* and *H. armigera* in two jars under no choice and dual choice were parasitized whereas none of the *S. litura* from either no choice experiment or from the dual choice experiment were parasitized. In the first jar 40 pupae were formed on *C. cephalonica*. It was observed that 25 adults emerged from jar 1 on 6th Feb 2018 i.e., 14 days after parasitization, later 10 adults emerged on 7th February 2018 followed by 03 adults on 8th February 2018. In the second jar, none of the *S. litura* larvae were parasitized. Hence, pupae were not formed. In the third Jar, 36 pupae were formed on *H. armigera*. The adult emergence started in the same day as seen in the first jar i.e., 6th Feb 2018. On the first day, 18 adults emerged, followed by 15 and 2 adults. Under dual choice condition, in jar 4 both *H. armigera* and *C, cephalonica* were parasitized, pupated and adults were emerged. On *H, armigera* 35 pupae were formed and 32 pupae on *C. cephalonica*. Adult emergence was normal on both the hosts. When dual choice conditions were provided with *H. armigera* and *S. litura* larvae, it preferred only *H. armigera* and formed 30 pupae out of which 29 adults were emerged but no pupae were formed on *S. litura* (Table 2).

Table 2: *Bracon hebetor* Say on Corcyra cephalonica Stainton, Helicoverpa armigera (Hub.) and Spodoptera litura Fabricius in no choice and dual choice conditions

23-01-2018	Larvae	No. of larvae/ adults	Wt. g/ 5 larvae	No. of Pupae on 27-01-2018	No of adults on 06-02-2018	No of adults on 07-02-2018	No of adults on 08-02-2018
jar 1	*C cephalonica* larvae	5	0.2722	40	25	10	3
	B hebetor adults	10					
jar 2	*S litura* larvae	5	0.2722	0	0	0	0
	B hebetor adults	10					
Jar 3	*H. armigera* larvae	5	0.2722	36	18	15	2
	B hebetor adults	10					
jar 4	*H. armigera* larvae	5	0.2722	35	20	13	2
	C cephalonica larvae	5	0.2722	32	18	12	2
	B hebetor adults	10					
jar 5	*H. armigera* larvae	5	0.2722	30	16	12	1
	S litura larvae	5	0.2722	0	0	0	0
	B hebetor adults	10					

Discussion

B. hebetor prefers both *C, cephalonica* and *H. armigera* for its multiplication. *B. hebetor* reared in laboratory can be released in field to control *H. armigera.* Nikam and Pawar 1993 [12] reported that *Bracon hebetor* Say (Hym. Braconidae) population can be increased naturally on *Corcyra cephalonica* Staint. (Lep., Pyralidae) and *B. hebetor* acts as key parasitoid of *Helicoverpa armigera* Hbn. The results are in line with Dabhi *et al.*, 2011 [3] who stated that *C. cephalonica* was the best host for mass rearing of *B. hebetor*.

S. litura is neither preferred host for rearing or to control it using *B. hebetor*. Dabhi *et al.*, 2013 [3] stated that longest egg period was recorded in *S. litura* and lowest period for one life-cycle of *B. hebetor* female was found in *S. litura.* Khalil *et al.*, 2016 stated that intermediate biological activities were found on *H. armigera, and S. litura* compared to *Galleria mellonella*. Mukti and Thomas (2010) [11] who found out that *Spodoptera exigua* produced the greatest number of parasitoid progeny among the noctuid hosts tested in his experiment. The results are in line with Alam, *et al.*, 2016. [1] Who stated that lowest parasitism was recorded on Yard long bean pod borer followed by *S. litura*. Mohammad *et al.*, 2017 [10] stated that the paralysis and parasitisation potential of *B. hebetor* were found higher on *C. cephalonica* while it was shortest on *S. litura*. Srinivasan and Mohan (2017) [17] stated that *C. cephalonica* possess the requisite nutritional quality for the growth and development of the larval parasitoid, *B. brevicornis.*

B. hebetor has ability to develop and produce significantly higher number of adult progeny from *H. armigera* compared with other noctuid host species. This variation in progeny production could be caused by venom selectivity that may require higher levels of venom to effectively paralyze the host or that may induce another physiological response, so that parasitoid larvae could successfully complete development (Alam, *et al.*, 2016) [1]. Based on the results *B. hebetor* could be recommended as effective biological control agent to control polyphagous pest *H. armigera* which in turn reduce pesticide application in many crops.

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