South Asian Journal of Parasitology

5(4): 53-58, 2021; Article no.SAJP.73265

Effect of Host Size on Biological Characteristics of *Bracon hebetor* Say Parasitizing Indian Meal Moth *Plodia interpunctella* Hübner

Md. Forhad Hossain[1,2*], Md. Mahbub Hasan[2] and Raosonara Khatun[2]

[1]Institute of Food and Radiation Biology, Atomic Energy Research Establishment, Bangladesh Atomic Energy Commission, Ashulia, Savar, Dhaka-1349, Bangladesh.
[2]Department of Zoology, University of Rajshahi, Rajshahi-6205, Bangladesh.

Authors' contributions

This work was carried out in collaboration among all authors. Author MMH planned the research and designed the Methodology. Authors MFH and MRK conducted the experiments and analyzed the data and Author MFH drafted the manuscript. All authors read and approved the final manuscript.

Article Information

Editor(s):
(1) Dr. Somdet Srichairatanakool, Chiang Mai University, Thailand.
Reviewers:
(1) Harpal Singh Randhawa, India.
(2) JALAJKAKSHI.S, Bangalore City University, India.
Complete Peer review History: https://www.sdiarticle4.com/review-history/73265

Original Research Article

Received 18 June 2021
Accepted 26 August 2021
Published 02 September 2021

ABSTRACT

The parasitoid *Bracon hebetor* has been successfully used as a biological control agent against some pyralid moths. The present study was conducted to know the impact of host size on the performance of *Bracon hebetor* to elevate its mass rearing technique. In this experiment, two different sizes of the host (*Plodia interpunctella*) larvae were infested by one pair of *B. hebetor* and some biological characteristics of this parasitoid were studied. This investigation showed no significant effect on parasitism rate, pupae number, adult emergence, longevity and developmental period (larval, pupal and total developmental period) due to different host sizes. On the contrary, the sex ratio ($P<0.05$) and body size ($P<0.05$) of parasitoids varied significantly with the host size. However further investigation should be focused on the walk-in field cage trials.

Keywords: Biological control; Bracon hebetor; Plodia interpunctella; host size; mass rearing.

**Corresponding author: E-mail: mfhbgd@gmail.com;*

1. INTRODUCTION

Indian meal moth (IMM) *Plodia interpunctella* Hübner (Lepidoptera: Pyralidae) is an important insect pests of stored food products and other processed food commodities which is forthrightly responsible for direct economic and quality loss [1-3]. The conventional chemical control may cause health hazards and environmental pollution. Therefore, presently it is encouraged to apply environmental friendly biological control methods [4-5].

Bracon hebetor Say (Hymenoptera: Braconidae) is an important gregarious ectoparasitoid of stored grain insect-pests [6-8]. This parasitoid has been widely used as it can be easily reared and multiplied in the laboratory. The propagation of insect-origin biological control agents in laboratories or insectaries is very much expensive and finding out the cost-effective mass rearing technique of these natural enemies is a primary need for the application of biological control methods [9].

Usually, the parasitoid developmental period, adult emergence, adult size, longevity, reproduction and sex ratio directly associated with the host size [10-11]. Host quality has impacts on parasitoid fitness, for instance on the life span, developmental period, fecundity and parasitoid size [12-14]. The adult size is very much associated with its fitness in the case of both sexes. The mating competitiveness, fecundity, flight ability and longevity of female parasitoids depend on their body size [15]. The longevity of females having larger body size is usually higher than that of the smaller body size and having longer life the larger females can attack more hosts to oviposit in [16]. Furthermore, the larger male has more mating competitiveness than smaller [17] though not all the time [16]. There is an exigent demand to study the relationship between the parasitoid quality parameters and host quality. Various experiments regarding the impact of host size on the parasitoids size and of the clutch size on the quality parameters of different aged parasitoids have been extensively studied [17-18]. In case of gregarious parasitoid species, a close relationship is present between clutch and host size with quality parameters. The quality parameters of parasitoid depend on both host size and the number of parasitoid larvae or offspring developing in the host body [15].

The objective of the present investigation was to make an attempt to know the impact of host size on the performance of *B. hebetor* to ameliorate its mass rearing technique as it is one of the most important biological control agents.

2. MATERIALS AND METHODS

The average temperature and relative humidity of the laboratory were 25±0.65 ^{0}C and 54.37±0.80% respectively. The hosts, Indian meal moth *P. interpunctella* were obtained from Post Harvest Entomology Laboratory, Department of Zoology, University of Rajshahi [19]. Ten larvae (length 1.91± 0.02 cm and weight 0.65± 0.03 g) of *P. interpunctella* were released in a transparent container (the height and diameter of the container were 7 and 6 cm, respectively and the lid was perforated for the aeration) and 10 small larvae (length 1.38±0.01 cm and weight 0.27±0.03 g) were released in the next 3 containers. A folded paper strip was placed into each and every container, prior to host release to provide a wider surface area for the host larvae. After releasing one pair of fresh adult of *B. hebetor,* the containers were covered with black cloth to ease the infestation process. Then the containers were put into a shelf that had ant well for preventing the ants. The temperature and humidity of the laboratory were recorded twice a day regularly by using a thermo-hygrometer. After 2/3 days, the parasitized host larvae were counted as well as the number and date of pupae formation were also checked regularly. Thus, the total number of pupae was counted in each container. When adults (next generation) started to emerge, they were counted and collected by using a light source and test tube. After that, the sex ratio, developmental period and longevity (without food) were calculated. When F1 generation emerged then they were counted and the size (total length, head length, thorax length, abdominal length and wingspan in mm) of the parasitoid was measured with the help of a stereomicroscope and a 1/10 mm scale.

3. RESULTS AND DISCUSSION

3.1 Effect of Host Size on Parasitoids Parasitism Rate and Pupae Formation

The data on parasitized host larvae (%) by *B. hebetor* in large and small hosts were (100±0%) (Fig. 1A) varied non-significantly. The maximum and minimum F_1 parasitoid pupae were found in large host size (27.67±4.91) and small host size (26±3.61), respectively. There is no significant difference between the number of parasitoid pupae formed from large and small host size.

3.2 Effect of Host Size on Parasitoids Adult Emergence and Sex Ratio

The total number of adults (F_1) was found 24±5.29 and 21±3.22 in large host and small host sizes respectively (Fig. 1B). There is no significant difference between the total number of adult emergence due to large and small host sizes. However, the sex ratio of F_1 was significantly affected due to different host sizes ($\sum \chi^2 = 19.76$, df=3) (Fig. 2A).

3.3 Effect of Host Size on Parasitoids Developmental Period

The data (Fig. 2B.) on developmental period varied non-significantly with host size The larval period of F_1 was observed 5.94±0.08 and 5.71±0.08 days in large and small host sizes respectively The pupal period of F_1 was RECORDED 8.67±0.88 and 8.33±1.33 days in small and large host sizes respectively. However, the total developmental period of F_1 males was recorded 13.45±0.15 and 14.62±0.14 days in small and large host sizes respectively (F_1 females, 14.62±0.27 and 14.5±0.62 days in small and large host sizes respectively) (Fig. 2B).

3.4 Effect of Host Size on Parasitoids Longevity and Size

The data on adult longevity of parasitoids also varied non-significantly with host size. The longevity (without food) of male has 3.67±0.67 and in 3±0 days in small and large host size respectively while the longevity of female was 8.33±0.33 and 7±0.58 days in small and large host respectively (Fig. 3A).

The data (Fig. 3B) among sizes of parasitoids due to large and small host sizes varied significantly. In the case of large hosts the total length, thorax length, abdominal length, head width and wingspan of F1 parasitoid were 2.65±0.04, 1.1±0.03, 1.1±0.04, 0.47±0.03 and 2.62±0.07 mm respectively. On the other hand, the total length, thorax length, abdominal length, head width and wingspan of F1 parasitoid were 2.417±0.048, 0.98±0.06, 1.05±0.02, 0.37±0.02 and 2.42±0.04 mm respectively in the case of small hosts.

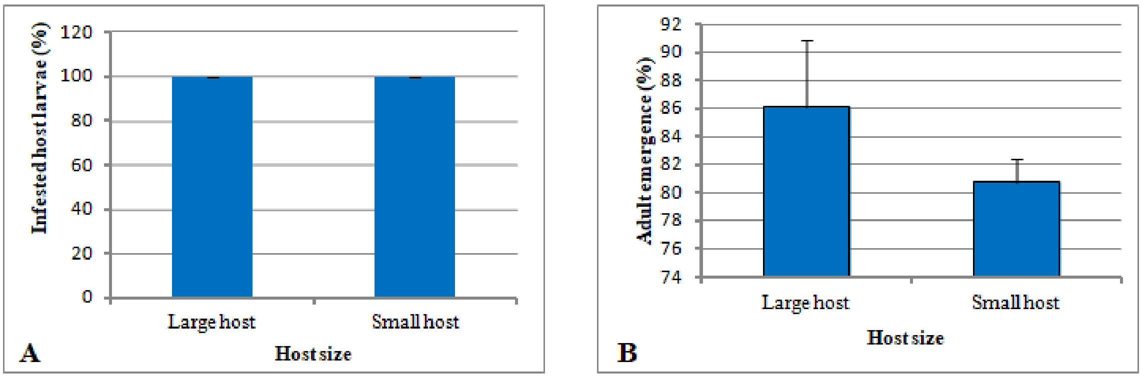

Fig. 1. Effect of host size on the percentage of parasitism (A) and adult emergence (B) of *B. hebetor*

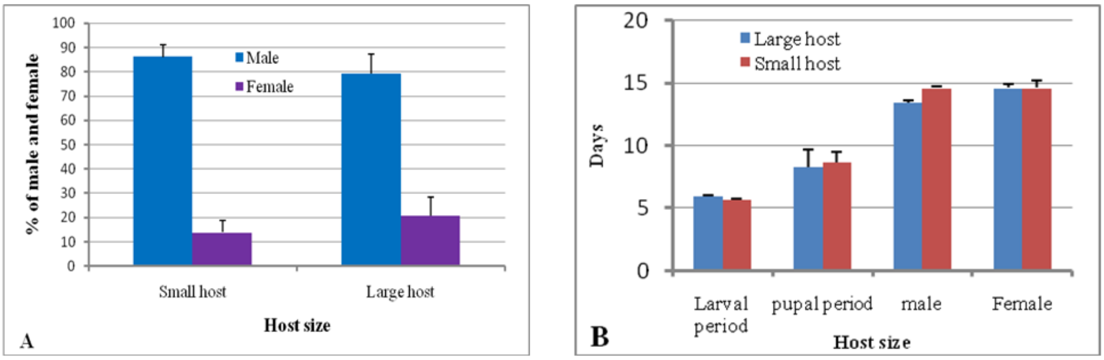

Fig. 2. Effect of host size on the sex ratio (A) and developmental period (B) of *B. hebetor*

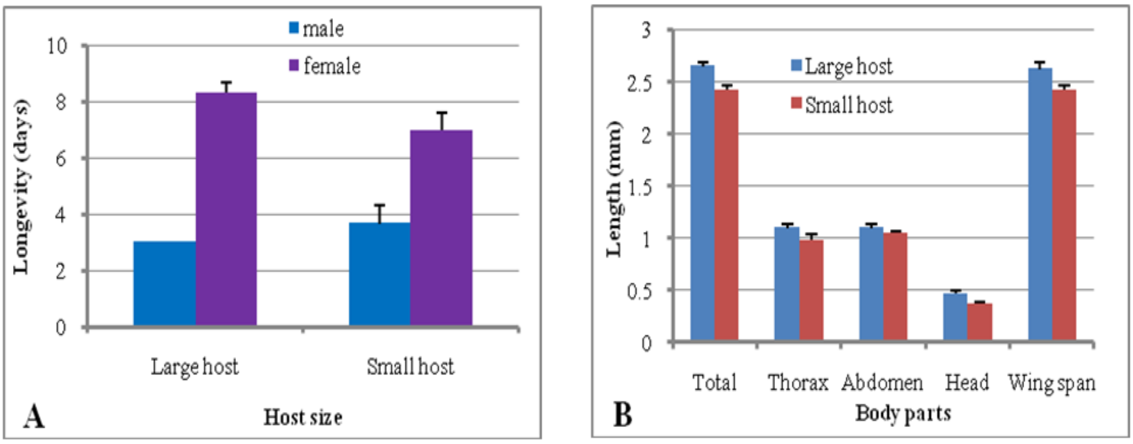

Fig. 3. Effect of host size on the longevity (A) and size (B) of *B. hebetor*

The present result shows that there is no significant difference in the total number of pupae and adult progeny, developmental periods, adult longevity due to large and small host size, but the sex ratio and size of the parasitoids vary significantly with the host size (P<0.05) which is in line with the study of Rasool et al. [20]. Similarly, the results are in agreement with the findings of Milonas [21], who also found that survival on *P. interpunctella* was significantly affected by egg density but not by the host weight of *B. hebetor*. He further reported that larval host weight of *P. interpunctella* and *Adoxophyes orana* had a significant effect on the size of emerging adult parasitoids mainly at the higher egg densities used in these experiments and the size of emerging parasitoids was smaller on smaller hosts especially at the higher densities examined which is also supported by the present investigation. The same findings were also reported in a study on ectoparasitoid *Colpoclypeus florus* parasitizing *A. orana* [22]. The experiment is also in agreement with Milonas [21], who found host size had no significant effect on time to emergence.

Our findings showed a significant effect of host size on the sex ratio (P<0.05). There are many pieces of researches that have found the significant effect of host size on the sex ratio of the parasitoid and there is a tendency to get females from large hosts and males from the smaller ones [23-24]. The same response was also reported by Charnov et al.[15], Anam et al. [25], and Tillman and Late [26]. This result is also in line with the study of Joyce et al. [27] who found more female parasitoid i.e. *Syngaster lepidus* (up to 80% female) from larger and older host (*Phoracantha* spp.) larvae.

Our result showed a highly significant interaction between the host and parasitoid size. This interaction explains that the larger hosts are responsible for the production of larger parasitoids. Several studies have been conducted regarding this interaction [12,16,28], and all of the findings are in close agreement with present study.

Because the larvae of *B. hebetor* depend barely on the host for its food species, size or developmental stages of the host can influence the different biological characteristics of the parasitoid. Host size, species and age are the important biological factors that have impacts on parasitoid fitness. Normally the larger host acts as more food source and its quality is considered to be superior to smaller hosts [20,29]. On the contrary, large hosts may have the greater defensive behavior. That's why it may increase the mortality risk of parasitoids and therefore the parasitoids do not prefer a larger host in every case [30].

4. CONCLUSIONS

The findings of the present experiment illustrate that the parasitism rate, pupae formation, adult emergence, developmental period and adult longevity varied non-significantly due to the difference of host size. However, the sex ratio and adult size were affected significantly. The above investigation preliminary concludes that both the large and small hosts are suitable for the mass rearing of *B. hebetor*, however, the larger hosts are more preferable as it causes to produce the larger parasitoids and more females. This result will help to elevate the mass rearing technique of *B. hebetor* in the laboratory for successful study. Moreover, further investigation should include the walk-in field cage trials.

ACKNOWLEDGEMENTS

The authors are thankful to the Department of Zoology, University of Rajshahi, for providing necessary laboratory facilities during the research work.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Mbata GN, Osuji FNC. Some aspects of the biology of *Plodia interpunctella* (Hübner) (Lepidoptera: Pyralidae), a pest of stored groundnuts in Nigeria. J. Stored Prod. Res. 1983;19(3):141–151. Available:https://doi.org/10.1016/0022-474X(83)90046-2
2. Vukajlovic FN, Predojevic DZ, Miljkovic K, Tanaskovic S, Gvozdenac S, Perisic V et al. Life history of *Plodia interpunctella* (Lepidoptera: Pyralidae) on dried fruits and nuts: Effects of macronutrients and secondary metabolites on immature stages. J. Stored Prod. Res. 2019;83(1–2):243-253.
3. Hossain MF, Hasan MM, Khatun MR. Effect on total protein concentration (mg/g) of host larvae due to the frequent parasitization and time after parasitization by *Bracon hebetor* (Say) (Hymenoptera: Braconidae). J. Entomol. Zool. Stud. 2019;7(6):837-841.
4. Subramanyam B, Hagstrum DW. Sampling. In: Integrated management of insects in stored products (Eds. Subramanyam B, Hagstrum DW). Marcel Dekker, New York, 1995;135–193.
5. Arthur FH, Mohandass S, Zhu KY, Throne JE. Biology and management of *Plodia interpunctella* (Lepidoptera: Pyralidae) in stored products. J. Stored Prod. Res. 2007;43(3):302-311.
6. Balevski N. Use of the parasite *Habro Bracon hebetor* Say for biological control. Rastitelna Zashchita. 1984;32:28–29.
7. Chen H, Zhang H, Zhu KY, Throne J. Performance of diapausing parasitoid wasps, *HabroBracon hebetor*, after cold storage. Bio. Control. 2013;64(3):186-194.
8. Alam MS, Alam MZ, Alam SN, Miah MRU, Mian MIH, Hossain MM. Mass rearing of *Bracon hebetor* (Hym.: Braconidae) on wax moth, *Galleria mellonella* (Lep.: Pyralidae) with varying density of parasitoid and the host. J. Crop. Prot. 2016;5(1):39-48.
9. Watt TJ, Duan JJ, Tallamy DW, Goldstein JH. Effect of parasitoid: host ratio and group size on fitness of *Spathius galinae* (Hymenoptera: Braconidae): implications for mass-rearing. J. Econ. Entomol. 2015;108(3):951–956.
10. Traynor RE, Mayhew PJ. Host range in solitary versus gregarious parasitoids: a laboratory experiment. Entomol. Exp. Appl. 2005;117(1): 41–49. Available:https://doi.org/10.1111/j.1570-7458.2005.00331.x
11. Liu Z, Xu B, Sun J. Host-size mediated trade-off in a parasitoid *Sclerodermus harmandi.* PLoS One, 2011;6(8): e23260. Available:https://doi.org/10.1371/journal.pone.0023260
12. Godfray HCJ. Parasitoids: behavioral and evolutionary ecology. Princeton University Press, New Jersey USA, 1994;xi:473.
13. Yu SH, Ryoo MI, Na JH, Choi WI. Effects of host density on egg disruption and the sex ratio of progeny of *Bracon hebetor* (Hymenoptera: Braconidae). J. Stored Prod. Res. 2003;39(4):385-393.
14. Hossain MF, Hasan MM, Khatun MR. Impact of host density on the performance of the *Bracon hebetor* (Say) (Hymenoptera: Braconidae) parasitizing Indian meal moth, *Plodia interpunctella* (Hübner) (Lepidoptera: Pyralidae). South Asian J. Parasitol. 2021;5(1):32-41.
15. Charnov EL, Hartog RL, Jones WT, Van den Assem J. Sex ratio evolution in a variable environment. Nature. 1981;289(5793):27–33.
16. Ueno T. Reproduction and host-feeding in the solitary parasitoid wasp *Pimpla nipponica* (Hymenoptera: Ichneumonidae). Invert. Rep^{n} and Dev^{n}. 1999;35(3): 231-237.
17. Antolin MF, Ode PJ, Strand MR. Variable sex ratio and ovicide in an outbreeding parasitic wasp. J. Animal Behav. 1995;49(3):589-600.
18. Ueno T. Host-size-dependent sex ratio in a parasitoid wasp. Res.on Pop^{n} Eco. 1999;41(1):47-57.
19. Phillips TW, Strand MR. Larval secretions and food odors affect orientation in female *Plodia interpunctella.* Entomol. Exp. Appl. 1994;71(3):185–192.

20. Rasool S, Abdin ZUI, Abbas SK, Ashraf S, Anwer M, Manzoor A et al. Effect of host size on larval competition of the gregarious parasitoid *Bracon hebetor* (Say.) (Hymenoptera: Braconidae). Pak. J. Zool. 2017;49(3):1085-1091.
21. Milonas PG. Influence of initial egg density and host size on the development of the gregarious parasitoid *HabroBracon hebetor* on three different host species. Bio. Control. 2005;50(3):415-428.
22. Dijkstra LJ. Optimal selection and exploitation of hosts in the parasitic wasp *Colpoclypeus horus* (Hymenoptera: Eulophidae). Netherlands J. Zool. 1986;36(2):177-301. Available:https://doi.org/10.1163/002829686X00081
23. Jones WT. Sex ratio and host size in a parasitoid wasp. Behav. Ecol. Sociobiol. 1982;10: 207-210. Available:https://doi.org/10.1007/BF00299686
24. Opp SB, Luck RF. Effects of host size on selected fitness components of *Aphytis melinus* and *A. lingnanensis* (Hymenoptera: Aphelinidae). Annls. entomol. Soc. Am. 1986;79(4):700-704. Available:https://doi.org/10.1093/aesa/79.4.700
25. Anam J, Abdin Z, Arshad M, Falabella P, Abbas SK, Tahir M et al. Multiple effects of host density on egg density and the sex ratio of progeny of *Bracon hebetor* (Say.) (Hymenoptera: Braconidae). Pakistan J. Zool. 2015;47(2):455-460.
26. Tillman PG, Cate JR. Effect of host size on adult size and sex ratio of *Bracon mellitoz* (Hymenoptera: Braconidae). Environ. Entomol. 1993;22(5):1161–1165. Available:https://doi.org/10.1093/ee/22.5.1161
27. Joyce AL, Jocelyn GM, Timothy DP, Lawrence MH. The effect of host size on the sex ratio of *Syngaster lepidus*, a parasitoid of *Eucalyptus* long horned borers (*Phoracantha* spp.). Biol. Control. 2002;24(3):207–213. Available:https://doi.org/10.1016/S1049-9644(02)00031-2
28. Jervis MA, Copland MJW. The life cycle. In: Insects natural enemies: Practical approaches to their study and evaluation. Chapman and Hall, London. 1996;63-161. Available:https://doi.org/10.1007/978-94-011-0013-7
29. Gündüz EA, Gülel A, Işıtan ÖV. İki konukçu türün, larva ektoparazitoiti *Bracon hebetor* (Say, 1836) (Hymenoptera: Braconidae)'da protein, lipit ve glikojen miktarlarına etkisi. Türk. Entomol. Dergisi. 2008;32(1):33-42.
30. Chau A, Mackauer M. Host-instar selection in the aphid parasitoid *Monoctonus paulensis* (Hymenoptera: Braconidae, Aphidiinae): assesing costs and Benefits. Can. Entomol. 2001;133(4):549–564.

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle4.com/review-history/73265