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LIFE-FERTILITY TABLES OF *BRACON HEBETOR* SAY (HYMENOPTERA: BRACONIDAE) REARED ON *HELIOCHEILUS ALBIPUNCTELLA* DE JOANNIS (LEPIDOPTERA: NOCTUIDAE)

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Abstract—Life-fertility tables were described for *Bracon hebetor* Say (Hymenoptera: Braconidae) developing on the millet head caterpillar (MHC), *Heliocheilus albipunctella* de Joannis (Lepidoptera: Noctuidae). Mated *B. hebetor* females lived an average of 24.7 days, oviposited ca. 22 days, and produced 173.7 adult progeny with a 1:1 sex ratio. The estimated innate capacity of increase (r_c) and net reproductive rate (R_0) were 0.26 and 86.5, respectively. The mean generation time was 17 days.

Key Words: Life-fertility tables, *Bracon hebetor*, millet head caterpillar, *Heliocheilus albipunctella*, West Africa, Niger

Résumé—Les tables de vie et fécondité ont été décrites pour *Bracon hebetor* Say (Hymenoptera: Braconidae) se développant sur la mineuse de l'épi du mil, *Heliocheilus albipunctella* de Joannis (Lepidoptera: Noctuidae). En moyenne, les femelles fécondées de *B. hebetor* vécurent 24,7 jours, ont pondu pour une durée de 22 jours, et ont produit une progéniture de 173,7 adultes avec un sexe ratio de 1:1. Le taux d'accroissement (r_c) de la population et le taux reproductif net (R_0) étaient de 0,26 et 86,5, respectivement. La durée moyenne d'une génération était de 17 jours.

Mots Clés: Tables de vie, fécondité, *Bracon hebetor*, mineuse de l'épi du mil, *Heliocheilus albipunctella*, Afrique de l'ouest, Niger

INTRODUCTION

Bracon hebetor Say (Hymenoptera: Braconidae) is a gregarious and cosmopolitan ectoparasite that attacks many lepidopterous species of stored grains (Richards and Thomson, 1932) and field crops (Ullyett, 1943; Harakly, 1968; Gerling, 1969, 1971). *Bracon hebetor* also is a parasite of millet head caterpillar (MHC), *Heliocheilus albipunctella* De Joannis (Lepidoptera: Noctuidae). It is reported from MHC in Senegal (Bhatnagar, 1987) and in Niger (Guevremont, 1983; Youm, 1990). Though considerable research is available on *B. hebetor* attacking other hosts, life-fertility tables are not available for *B. hebetor* attacking MHC. This kind of information is needed to better understand the potential of *B. hebetor* for biological control of MHC. The present studies on *B. hebetor* were conducted as a basis for developing rearing methods to study the parasite's potential for biological control of MHC in the Sahelian region.

MATERIALS AND METHODS

Life-fertility studies of *B. hebetor* were conducted in 1987 at the Kolo laboratory in Niger. Ambient temperature and humidity in the laboratory were not controlled, averaging 30.8°C (range 27–35°C) and 56.7% r.h. (49–65% r.h.), respectively. Experimental procedures consisted of transferring newly emerged

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male:female pairs of *B. hebetor* to separate 3.8-l Fonda[R] paper containers, each about 16 cm in dia. The lid to each container was replaced with a fine mesh screening, consisting of polyester organza secured to the paper ring portion of the original lid. A 10 cm dia. hole was cut on one side of each container and a cylindrical cloth sleeve was secured to the hole to allow access to cages without parasite escape. Cotton was soaked with 20% glucose-water solution and placed daily on the mesh of the container top to provide a nutrition source for parasite adults. MHC for exposure to female parasites were collected as small larvae from millet fields. Larvae were held on commercial artificial diet (BIOSERV[R]/Mix #9782) at the Kolo laboratory to a late instar.

A single large MHC larva was exposed to each mated *B. hebetor* female for 24 hr, and then removed. MHC larvae were replaced daily with a new larva until each respective female parasite died. After exposure, larvae were removed from sleeve cages and placed in labelled 30 ml empty plastic cups. Cups were checked daily for emergence of adult parasites. Elapsed time from egg to adult parasite emergence was recorded for each parasite progeny, as was the sex of progeny. Day-zero was considered as the day on which larvae were removed from exposure to parasites. Because field-collected *H. albipunctella* larvae were unavailable during the last few days of the experiment, female parasites remaining alive were offered a single larva of *C. ignefusalis* daily as an alternate host. The study included a total of nine heterosexual pairs, and data in the analyses was collected from nine females, each being considered as a replication.

Life-fertility table parameters were determined and summarized using simple procedures described by Southwood (1978). In Southwood's (1978) method, the net reproductive rate (R_0) is a measure of the number of females produced per female per generation. The innate capacity of increase (r_c) (an approximate value of r_m), is the number of females produced per female per day. T_c is the cohort generation time and λ_c the finite rate of increase is a measure of the number of times the population multiplies per day. These values were computed as follows:

$$R_0 = \Sigma l_x m_x;\quad T_c = \frac{\Sigma x l_x m_x}{\Sigma l_x m_x};\quad r_c = \frac{\log_e R_0}{T_c};\quad \lambda_c = e^{r_c}$$

Life-fertility tables were constructed by recording for each age interval (x) the fraction of the initial sample of individuals remaining alive (l_x), and the mean number of progeny produced by adult females (m_x) remaining live at such age interval.

RESULTS AND DISCUSSION

Results on longevity, oviposition period, fecundity, and sex ratio of *B. hebetor* are shown in Table 1. Life table parameters and their values computed from data using above formula are: $\Sigma x l_x m_x$ (1476.6), R_0 (86.5), T_c (17), r_c (0.26) and λ_c (1.3). Mean life expectancy of ovipositing *B. hebetor* females was 24.7 (range 7–37) days (Table 1; Fig. 1 A & B). Hagstrum and Smittle (1977) reported an average longevity of 23 days for *B. hebetor* when reared on *E. cautella* at 27°C, 14:10 (L:D), and 50% r.h. Clark (1963) reported an average longevity of 26 days for *B. hebetor* when reared on *A. kuehniella*, and Benson (1973) reported an average adult longevity of 3 weeks for *B. hebetor* when fed on honey.

An average of 173.7 (range 98–223) adult progeny was produced per female (Table 1). The sex ratio of the progeny was highly variable, averaging 1:1 (male:female) (range 0.18:1–4.63:1). An average of

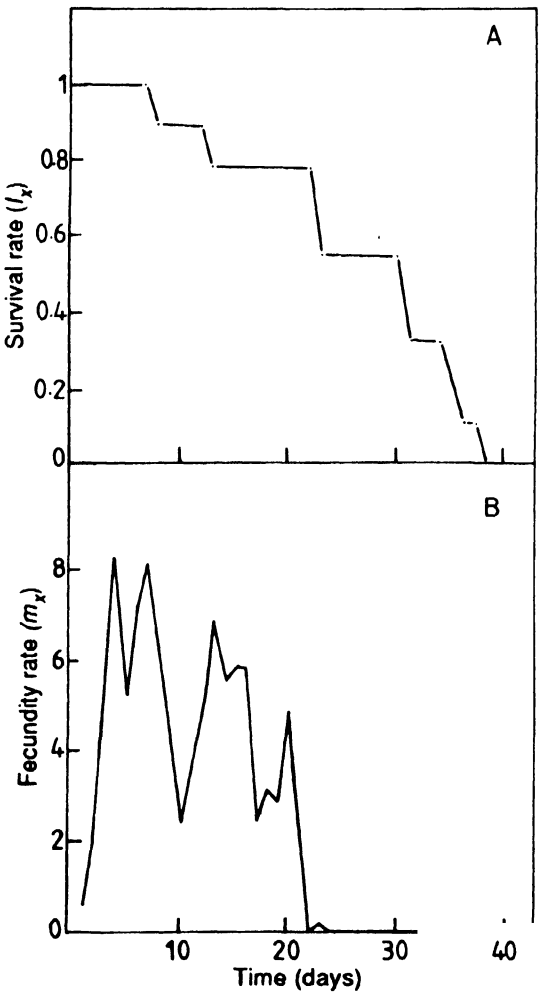

Fig. 1. Survival (A) and fecundity (B) rates of *Bracon hebetor* adult females.

Table 1. Longevity, oviposition period and fecundity of nine mated females of *B. hebetor*

Female parasite	Longevity days	Oviposition period (days)	No. hosts exposed	Parasite progeny			
				Males	Females	Total	Ratio male:female
A	22	18	23	62	151	213	0.41:1
B	7	6	8	32	100	132	0.32:1
C	23	21	24	116	61	177	1.90:1
D	12	11	13	15	83	98	0.18:1
E	34	30	35	72	80	152	0.90:1
F	22	21	23	95	64	159	1.48:1
G	37	30	38	140	72	212	1.94:1
H	30	28	31	91	132	223	0.69:1
I	35	33	36	162	35	197	4.63:1
Mean	24.7	22.0	25.7	87.2	86.4	173.7	1.01:1
(SE)*	(3.5)	(3.1)	(3.5)	(16.0)	(12.1)	(14.0)	

*Standard error of the mean.

7 days (range 6–9 days) was required for parasite progeny to develop from egg to adult emergence. Previous studies report *B. hebetor* life cycle completion in 9 days when reared on *H. undalis* (Rawat et al., 1968), 7 days at 36°C and 30 days at 15°C when reared on *A. kuehniella* (Payne, 1933), and 12 to 14 days when reared at 25°C and 70% r. h. (Benson, 1973).

The maximum daily mean female progeny per female was 8.22 on the 4th day (Fig. 1B). The innate capacity of increase was 0.26 female per female per day, and the experimental population multiplied 86.5 times in a mean generation time of 17 days. The fecundity rate of *B. hebetor* is very low when females are three weeks or older (Fig. 1B), and males were the dominant progeny of older parent females. Therefore, *B. hebetor* produced few female progeny late in the reproductive cycle. Similar findings were reported by Rotary and Gerling (1973) after rearing *B. hebetor* on *A. kuehniella*.

Among the exposed host larvae, 69.7% (161 of 231) were parasitized and produced *B. hebetor* adult progeny. Less than 1% (2 of 231), produced parasite progeny which died in immature stages. Paralysis without egg deposition occurred in 18.2% (42 of 231) of the exposed hosts, and 11.2% (26 of 231 including two which escaped) were not attacked. Thus, 88.7% of exposed larvae were successfully attacked and paralysed by *B. hebetor*. MHC larvae which were paralysed without being parasitized were probably used by females for host feeding between oviposition activities. Similar findings have been reported for *B hebetor* when reared on *A. kuehniella* (Ullyett, 1945), *Plodia interpunctella* (Hübner) (Reinert and King, 1971), and on *E. cautella* (Hagstrum and Smittle, 1977).

When adult parasite progeny from a given female's daily production included both sexes, one

Table 2. Frequency of first emergence of *B. hebetor* adult progeny per parasitized host larva based on sex

Female parasite	Number of parasitized millet head caterpillar larvae with			
	Female progeny emerged first	Male progeny emerged first	Male and female progeny emerged at same time	Total
A	1	1	14	16
B	1	0	2	3
C	1	2	9	12
D	1	0	4	5
E	3	1	3	7
F	2	2	10	14
G	0	4	14	18
H	2	0	10	12
I	2	2	5	9
Total	13	12	71	96
% Total	13.5	12.5	74	100

Table 3. Distribution of sexes for *B. hebetor* progeny per parasitized millet head caterpillar larva

Female parasite	Number of MHC larvae with parasite progeny			
	Male and female	Female only	Male only	Total
A	16	1	0	17
B	3	1	1	5
C	12	0	4	16
D	5	5	0	10
E	7	2	10	19
F	14	0	2	16
G	18	2	8	28
H	12	6	6	24
I	9	3	14	26
Total	96	20	45	161
% Total	59.6	12.4	28	100

or more females emerged in 13.5% of larvae before a male emerged. In 12.5% of parasitized hosts one or more males emerged before emergence of a female. The number of male and female progeny was about the same in 74% of parasitized hosts which produced both sexes (Table 2). Table 3 shows that 59.6% of parasitized larvae produced parasite adults of both sexes; whereas 12.4% of parasitized larvae produced only female progeny, and 28% of parasitized larvae produced only male progeny. Thus, the number of parasitized larvae producing both sexes was much greater than those producing a single sex. However, the number of parasitized larvae producing only male progeny was twofold the number producing only females. Benson (1973) reported that developing *B. hebetor* larvae are subjected to intraspecific competition which leads to direct mortality, variation in size, and changes in sex ratio. Furthermore, when parasite density increases per host, the proportion of males increases due to differential mortality among parasite larvae. Additionally, the size of the surviving progeny decreases (Benson, 1973). Rotary and Gerling (1973) reported that differential mortality favours males due to cannibalism.

In the field, up to 11.5% parasitism of MHC larvae by *B. hebetor* was recorded in 1986–1987, and *B. hebetor* was the most common among MHC larval parasites, accounting for 74.5% of parasitized MHC larvae (Youm, 1990). In Maradi (Niger), field parasitism of MHC larvae ranged from 9% in late August to 54% in September; and *B. hebetor* accounted for 95% of parasitized MHC larvae (Guevremont,1982; Gahukar et al., 1986). Thus, *B. hebetor* is a very common parasite and would appear to have potential in regulating MHC. *B. hebetor* has a short generation time, a high rate of population increase, and is easy to culture in the laboratory. Thus, feasibility for mass production and releases of *B. hebetor* in an inundative biological control, against MHC, should be explored in Sahelian countries.

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REFERENCES

Benson J. F. (1973) Intraspecific competition in the population dynamics of *Bracon hebetor* Say (Hymenoptera: Braconidae). *J. Anim. Ecol.* 42: 105–124.

Bhatnagar V. S. (1987) Conservation and encouragement of natural enemies of insect pests in dry land subsistence farming: problems, progress and prospects in the Sahelian zone. *Insect Sci. Applic.* 8, 791–795.

Clark A. M. (1963) The influence of diet upon the adult life span of two species of *Bracon*. *Ann. Entomol. Soc. Am.* 56, 616–619.

Gahukar R. T., Guevremont H., Bhatnagar V. S. Doumbia Y. O., N'doye M. and Pierrard G. (1986) A review of the pest status of the millet spike worm *Raghuva albipunctella* (De Joannis) (Noctuidae: Lepidoptera) and its management in the Sahel. *Insect Sci. Applic.* 7, 457–463.

Gerling D. (1969) The parasites of *Spodoptera littoralis* Boisd (Lep.: Noctuidae) eggs and larvae in Israel. *Israel J. Entomol.* 4, 73–81.

Girling D. (1971) Occurrence, abundance and efficiency of some local parasites attacking *Spodoptera littoralis* (Lepidoptera: Noctuidae) in selected cotton fields in Israel. *Ann. Entomol. Soc. Am.* 64, 1373–1376.

Guevremont H. (1982) Etude de la mineuse de l'epi et autres insects du mil. *Rapport Annuel de Recherches Pour l'Année 1981*. Centre National de Recherches Agronomiques (CNRA); Tarna (Maradi), Niger.

Guevremont H. (1983) Recherches sur l'entomofaune du mil. *Rapport Annuel de Recherches Pour l'Année 1982*. Centre National de Recherches Agronomiques (CNRA); Tarna (Maradi), Niger.

Hagstrum D. W. and Smittle B. J. (1977) Host finding ability of *Bracon hebetor* and its influence upon adult parasite survival and fecundity. *Environ. Entomol.* 6, 437–439.

Harakly F. A. (1968) Biological studies of the cabbage web-worm, *Hellula undalis* F. (Lepidoptera: Crambidae: Pyraustinae). *Bull. Soc. Entomol. Egypte* 52, 294–298.

Payne N. M. (1933) The differential effect of environmental factors upon *Microbracon hebetor* Say (Hymenoptera: Braconidae) and its host *Ephestia kuhniella* Zeller (Lepidoptera: Pyralidae). *Biol. Bull.* 2, 187–205.

Rawat R. R., Rathore Y. S. and Saxena D. K. (1968) Bionomics of *Hellula undalis* Fb., the cabbage borer (Pyralidae: Lepidoptera) at Jabalpur. *Indian J. Entomol.* 30, 235–237.

Reinert J. A. and King E. W. (1971) Action of

Bracon hebetor Say as a parasite of *Plodia interpunctella* at controlled densities. *Ann. Entomol. Soc. Am.* 64, 1335–1340.

Richards O. W. and Thomson W. S. (1932) A contribution to the study of the genera *Ephestia* Gn. (including *Strimax* Dyar), and *Plodia* Gn. (Lepidoptera: Phycitidae) with notes on the parasites of the larvae. *Trans. R. Entomol. Soc. Lond.* 80, 169–250.

Rotary N. and Gerling D. (1973) The influence of some external factors upon sex ratio of *Bracon hebetor* Say (Hymenoptera: Braconidae). *Environ. Entomol.* 2, 134–138.

Southwood T. R. E. (1978) Ecological methods, with particular reference to the study of insect populations. Chapman and Hall, New York.

Ullyett G. C. (1943) Some aspects of parasitism in field populations of *Plutella maculipennis* Curt. *J. Entomol. Soc. Sth. Afr.* 6, 65–80.

Ullyett G. C. (1945) Distribution of progeny by *Microbracon hebetor* Say. *J. Entomol. Soc. Sth. Afr.* 8, 123–131.

Youm O. (1990) Evaluation of natural enemies associated with the millet stalk borer, *Haimbachia ignefusalis* (Hampson) (Lepidoptera: Pyralidae) in Niger. *Ph.D. dissertation*, Texas A&M University, College Station, Texas USA.