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Effect of Temperature on life table statistics of Bracon *hebetor* say. (Hymenoptera: Braconidae)

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ABSTRACT: The effect of different temperature variations on the life table statistics of *Bracon hebetor* was observed. Longevity of male parasitoid was shorter than females at all temperature levels taken for experimentation. The progeny sex ratio was female biased at lower temperature variants in comparison to high temperature levels. The net fecundity rate (R_0) and total fecundity rate (R_t) were higher at 30°C followed by 20°C & 40°C. At 10°C though the longevity was increased tremendously but the parasitoid failed to produce any progeny. The innate capacity of increase in number (r.c.), the intrinsic rate of increase (r_m), the finite rate of increase (λ_m) and weekly multiplication rate (r_w), was highest on 30°C followed by 20°C & 40°C. The doubling time (D.T.) was shortest on 30°C than 20°C & 40°C showing an inverse ratio to (r_m) and (r_w). On the basis of life table statistics of *Bracon hebetor*, a gregarious ectoparasite, the temperature levels can be placed in order of their suitability for parasitoid population growth as 30°C > 20°C > 40°C.

KEYWORDS: *Bracon hebetor, Corcyra cephalonica*, Life table, Parasitoid, temperature.

1 INTRODUCTION

Studies of the dynamics of insect population are often concerned with interaction between a host and its parasite or predator, potential agent of biological control that may contribute significantly to host mortality in a natural population. *Bracon hebetor* Say is a gregarious ectoparasite of the larvae of a number of stored product lepidopterans and other hosts in the field [8].

Although important attributes of potential natural enemies are many, thermal adaptations are one of the easiest to measure and are essential to successful biological control [7]. Enzymes function efficiently within a limited range of temperature and for this reason temperature is of great importance in life of all insects. The temperature influences the biology of all trophic levels and exert important limiting effect on the insect population, distribution and abundance [9]. It affects the parasitoid in several ways directly or indirectly by reducing survivals, retarding development or suppressing its reproduction [5], [6], [16], and likely to influence the successful use of parasitoid. Therefore, sex ratio, longevity and different life table parameters of *Bracon hebetor* was compared at different temperature levels with an aim on mass production of the parasitoid for its successful utilization in biological control.

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2 MATERIAL AND METHODS

The rearing technique for *C. cephalonica* (Lepidoptera: Pyralidae) and *B. hebetor* described herein, is a technique followed by [3] and [2]. To maintain the mass culture of ricemoth, its eggs were kept with coarsely ground favour (*Sorghum vulgare* Pers*)* seeds in large plastic container (45x25x15 cms). After adult emergence, equal number of males and females were paired in a beaker (250 ml) covered with a black muslin cloth. The eggs were collected from the beaker and were again placed with fresh nutrients. Full grown larvae from this culture were taken to feed and rear the parasitoid.

For the culture of *B. hebetor*, one male end one female insects were paired in a beaker (250 ml) covered with a fine muslin cloth. The adults were provided 30 percent honey solution as food and 10 full grown 5^{th} instar larvae of rice moth were placed in a beaker for parasitization. The parasitized larvae were kept for further development of wasp. To avoid any carry over effect, adults were utilized for experimentation only after third generation.

The performance of the parasitoid was observed at four constant temperatures, 10, 20, 30 and 40 ^{0}C. A freshly emerged male and female *Bracon hebetor* were released in a reproductive glass chamber (7 cm diameter; 10 cm height) having 10 healthy full grown *Corcyra* larvae. The adult wasps were provided 30% honey solution through a cotton swab. The parasitoids were transferred to a new reproductive chamber on each day at a specific time until the death of the parasitoids. The age of the parasitoids and the number and sexes reproduced by them were observed for each day of their reproductive life at above constant temperatures. Five replicates were arranged for each temperature at 70±10% relative humidity and 12h L:D.

Life table parameters like innate capacity for increase in number (r.c = logeR_0/T.c), where R_0 = net fecundity rate and T.c = mean generation time), the finite rate of increase ($\lambda_m = \exp^{rm}$), weekly multiplication rate ($r_w = \lambda_m^7$) and doubling time (D.T. = ln2/λ_m) were calculated from life tables (Birch, 1948) of insect for different temperature levels. The arbitrary r_m = r.c was corrected graphically using values of r_m in the Lotka-Euoler equation [1].

$$\Sigma l_x m_x . \exp^{-r m x} = 1$$

The data were subjected to F-test and LSD (Least significant Difference)-test [15] for interpretation.

3 RESULT

Longevity of male parasitoid was shorter than females at all temperature levels, female wasp showed a significant difference between their mean longevity periods, however, there was no significant difference between mean longevities of the parasitoid recorded at 30 & 40 °C. The progeny sex (proportion of males) ratio was affected significantly by variation in temperatures (F=31.25; P<0.01). The progeny was female biased at 20°C (41.05%) but male biased at 30°C (61.66%) and 40°C (75.15%). LSD test shows a statistically high significant difference between any two values of progeny sex ratio obtained at 20, 30 and 40 °C. Thus, there was an increase in the proportion of males and decrease in proportion of females in progeny population with increase in temperature (Table 1).

The net fecundity rate (R_0) and total fecundity rate (R_t) of *Bracon hebetor* were highest at 30 °C (R_0 = 92.00; R_t = 240.00) followed by 40 °C (R_0 = 47.40; R_t = 189.40) and 20 °C (R_0 = 29.00; R_t = 49.20). A significant difference was noticed between R_0 (F = 37.86; P<0.01) and R_t (F = 29.756; P<0.01) calculated at 20, 30 and 40 °C. LSD test show a significant high value of R_0 of the parasitoid at 30 °C than those at 40 and 20°C. LSD test performed for R_t shows a significant difference between values of R_t calculated at 20 and 30°C (Table 2).

The innate capacity of increase (r.c.) of the parasitoid was highest at 30 °C (0.2613) followed by r.c. at 40 °C (0.2348) and 20 °C (0.1847). Graphically corrected intrinsic rate of increase (r_m) was highest at 30 °C (0.27521) followed by values at 20 °C (0.19382 and 40°C (0.24522) respectively. Corrected generation time (G.T.) showed a shortening in its length with increase in temperature, 17.37 days at 20°C, 16.43 days at 30°C and 15.74 at 40°C. The finite rate of increase (λ_m) and weekly multiplication rate (r_w) were highest at 30°C (λ_m = 1.3168; r_w = 6.8649). The λ_m value at 20 and 40 °C were 1.2139 and 1.2779 and r_w at 20 and 40 °C were 3.8840 and 5.3651 respectively. When doubling time was calculated, its value on 20, 30 and 40 °C were 3.58 days, 2.52 days and 2.83 days showing suitability of 30°C temperature for growth of population of *Bracon hebetor* in comparison to other variants.

4 DISCUSSION

Adult female longevity significantly decreased with an increase in temperature as it is general phenomenon reported for the parasitoids [12], [14] and may occur due to increased activities and water loss with increasing temperature. On high temperature insects become vigorously active and high expense of energy may lead into their low longevity.

Though the mean longevity of *Bracon* female was highest at 10 °C, there was a failure to produce any progeny. Such check exercised by the female in the release of fertile or infertile eggs is presumably an inevitable, nonetheless, essential ethological adjustment arising as a consequence of action of cold stress on the physiology of egg production through disturbances in enzymatic reaction associated with egg maturation [4].

A significant increase in sex ratio was observed with increase in temperature. The increase in temperature shifted these ratio towards more male production. More male production at higher temperature is result of release of more unfertilized haploid eggs [10].

The net fecundity rate (R_0) and the total fecundity rate (R_t) varied significantly with variation in temperature. The R_0 and R_t value were highest at 30°C followed by 40°C and 20°C. It suggests that optimal temperature at which parasitoid can reproduce maximally is nearer to 30 and 10 °C change in temperature may result in significant effect on female - and total - off spring produced per female. Temperature dependent parasitism in *Bracon* is similar to other parasitoids [11].

The intrinsic rate of natural increase (λ_m) of the population was highest at 30 °C than 40 and 20 °C. The value of λ_m and r_w were also highest at 30 °C whereas D.T., the time taken to double the number of parasitoid was less at 30 °C than that on 40° & 20°C.

The increased value of R_o, R_t, r_m & r_w with increase in temperature up to 30 °C may be an output of increased metabolic rate and activity of enzyme with increase in temperature. Further high temperature retards the activities of enzyme thereby causing a decrease in values of population growth indices.

The overall study provided information fundamental to development of models to stimulate and predict population dynamics. The highest value of R_o, R_t, r_m & r_w and minimal value of DT of parasitoid developed at 30 °C temperature suggest an ideal condition of mass rearing of *Bracon hebetor* for its use in Biological control programmes.

Table 1. Effect of temperature on net fecundity rate (R_0), total fecundity rate (R_t) and sex-ratio of B. hebetor

Temperature	Mean ± SE number of female offsprings/ female	Mean ± SE number of total offsprings/ female	Sex-ratio
20°C	29.0^a ± 2.02	49.2^a ± 2.46	0.41^a ± 0.013
30°C	92.0^b ± 6.92	240.0^b ± 25.08	0.61^b ± 0.014
40°C	47.4^c ± 5.54	189.4^c ± 18.70	0.75^c ± 0.013
LSD (5%)	16.18	55.84	0.09
(1%)	22.60	78.30	0.12

Means with same alphabet in a column do not differ significantly at 5% level of significance.

Table 2. The effect of temperature on different life table parameters of B. hebetor

Parameters	Temperature		
	20 °C	**30 °C**	**40 °C**
Innate capacity for increase (r.c)	0.1847	0.2613	0.2348
Corrected intrinsic rate of increase (r_m)	0.19382	0.27521	0.24522
Finite rate of increase (λ_m)	1.1239	1.3168	1.2779
Weekly multiplication rate (R_w)	3.8840	6.8649	5.5651
Doubling time (D.T.)	3.50	2.52	2.83

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REFERENCES

[1] Andrewartha, H.G. and Birch, L.C., *The distribution and abundance of animals*. University Chicago Press, Chicago & London, pp.782, 1954.
[2] Antolin, M. and Strand, M., "Mating system of *Bracon hebetor* (Hymenoptera: Braconidae)," *Ecological entomology*, vol. 17, pp. 1-7, 1992.
[3] Deepak Singh et.al., "Effect of Host diet on life table statistics of *Bracon hebetor* say (Hymenoptera: Braconidae)," *J. Boil. Control*, vol. 20, no.2, pp. 165-168, 2006.
[4] Engelmann, F., *The physiology of insect reproduction*, Pregamon Press, New York, pp. 307, 1970.
[5] Force, D.C. and Messenger, P.S., "Duration of development, generation time and longevity of three hymenopterous parasites of *Therioophis maculata* reared at various constant temperatures," *Ann. Ent. Soc. Amer*., vol. 57, pp. 405-413, 1964a.
[6] Force, D.C. and Messenger, P.S., "Fecundity, reproduction rates and innate capacity for increase of three parasites of *Therioaphis maculata* (Buckton)," *Ecology*, vol. 45, pp. 706-715, 1964b.
[7] Frazer, B.D. and Gregar, R.R., "Temperature dependent. Survival and hatching rate of eggs of seven species of *Coccaninellidae," Can.Ent*., vol. 124, pp. 305-312, 1992.
[8] Gerling, D., "The parasites of *Spodoptera littoralis* Bois (Lep: Noctuidae) egg and larvae in Israel," *Israel. J. Entomology*, vol. 4, pp. 73-81, 1969.
[9] Hoekman, D., "Turning up the heat: Temperature influences the relative importance of top-down and bottom-up effects," *Ecology,* vol. 91, pp. 2819–2825, 2010.
[10] Hollaway, A.K., Heimpel, G.E., Strand, M.R., and Anlotin, MF., "Survival of diploid males in *Bracon* sp. Near *hebetor* (Hymnoptera Braconidae)," *Annals of the Ento. Soc. of Ind*., vol. 92, no.1, pp. 110-116, 1999.
[11] Mackauer, M., "Quantitative assessment of *Aphidius Smithi* (Hym Aphidiidae): Fecundity, intrinsic rate of Increase and functional response," *Can. Entomol.,* vol. 15, pp.399-415, 1983.
[12] Mackauer, M. and Chow. F..J., Parasites and parasite impact on aphid population, In: *Plant virus epidemics: Monitoring, modelling & predicting outbreaks*, Academic Press, Australia, pp. 95-118, 1986.
[13] Messenger, P.S., Bioclimatic inputs to Biological control and pest management programmes, In: Rabb R. L. & Gutherie F. E. (Eds.), *Concepts of pest management*. North Carolina State Univ. Raleigh, pp. 88-94, 1970.
[14] Riggin, T.M., Isenhour, D.J., and Espelie, K.E., " Effect on Cotesia marginiventris (Hymenoptera: Braconidae) when rearing host fall army worm (lepidoptera: Noctuidae) on meridic diet containing foliage form resistant on susceptible corn genotype," *Envir. Ento*., vol. 1, pp. 214-219:40 ref, 1992.
[15] Snedcor, G.W. and Cochran, W.G., *Statistical methods*, Oxford & 1BH Publication Company, 1967.
[16] Thomson, L.J., Macfadyen, S., and Hoffmann, A.A., "Predicting the effects of climate change on natural enemies of agricultural pests," *Biol Control*, vol. 52, pp. 296–306, 2010.