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AFFECT OF TEMPERATURE ON AGE-SPECIFIC FECUNDITY OF THE LADYBIRD BEETLE *MICRASPIS DISCOLOR* (FABRICIUS)

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ABSTRACT

The influence of temperature on the age-specific fecundity of an aphidophagous ladybeetle, *Micraspis discolor* (Fabricius) (Coleoptera: Coccinellidae) feeding on the maize aphid, *Rophalosiphum maidis* (Facht,) (Homoptera: Aphididae) at four different temperatures, *viz.,* 20, 25, 27 and 30°C, was investigated. The age-specific fecundity function was triangular and oviposition rate (No. of eggs/day) increased with increase in reproductive age of the ladybeetle, attaining a peak then gradually decreasing before finally ceasing. Young adults were more efficient at converting aphid biomass into eggs than older ones. The oviposition peak tended to shift towards younger females and the oviposition rate increased with increase in temperature from 20 to 27°C. The maximum fecundity and percent egg viability was 750 eggs/female and 95 ± 25.71 % at 27°C and minimum 385 ± 5.20 eggs/female and 65 % at 20°C, respectively.

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INTRODUCTION

Ladybeetles are important biological control agents, as majority of them are predaceous on several groups of insect pests, including aphids, coccids, adelgids and aleyrodids. Ninety percent of the known 4200 coccinellid species are predaceous (Iperti and Paoletti, 1999), and Indian coccinellid diversity includes 119 predaceous species (Omkar and Pervez, 2000c). Of these, *Micraspis discolor* (Fabricius) is native to India (Agarwala and Ghosh, 1988; Gautam, 1994). The beetle has distinct sexual dimorphism (Omkar and Pervez, 2000a) and a wide range of aphid prey provides effective biological control of certain aphid species, viz. *Aphis gossypii* Glover and *A. craccivora* Koch (Agarwala, 1987; Omkar and Pervez, 2000b).

Reproduction is a crucial factor governing the ability of ladybeetles to successfully invade new habitats (Phoofolo and Obrycki, 2000). A perusal of the literature revealed that age-specific fecundity is the most overlooked aspect of reproduction in ladybeetles, although female age plays an important role in progeny production and influences reproductive vigour (Jalali *et al.,* 1999). The age-specific life fecundity table of *Coccinella septempunctata* Linn. has been studied under field and laboratory conditions (Singh and Singh, 1994) and it was found that even a slight deviation in temperature from the optimum affects the reproductive period and performance of the female ladybeetle (Ponsonby and Copland, 1998). This article reports the results of experiments that were conducted to investigate the influence of temperature on the age-specific fecundity of *M. discolor*.

MATERIALS AND METHODS

Adults of *M. discolor* were collected from agricultural fields in and around the Gauhati University, Guwahati North East India and a stock culture of the beetles was maintained in the laboratory condition (at 27.45 $\pm$ 2.25°C temperature and 65.55 $\pm$ 4.50 % RH). Ten pairs of newly emerged beetles were collected randomly from the stock culture and kept in Petri dishes (9 cm diameter x 1 cm height) with one pair in each at 20°C. The pairs of ladybeetles were fed on aphids, *Rhopalosiphum maidis,* infested on maize (*Zea maize*). Leftover aphids and wilting leaf were replaced daily to avoid contamination. The experiment was conducted for the rest of their life. The non-reproductive and reproductive periods, fecundity and percent viability of the female were recorded and entered into a data sheet. Similar experiments were conducted at 25, 27 and 30°C.

The data obtained were subjected to analysis of variance (ANOVA) using the statistics software SPSS 16 and comparison of means was done using Bonferroni's method. Age-specific fecundity trend lines were plotted, which exhibited the relationship between the mean oviposition rate and the mean reproductive period at different temperatures.

RESULTS

Figure 1 shows the age-specific fecundity trends for *M. discolor* at four different temperatures. An increase in oviposition rate with increasing mean reproductive age was seen, reaching a peak then slowly decreasing with further increase in reproductive age. At 20°C there was a slow increase in oviposition rate with a peak of 14.35 $\pm$ 2.50 (range 9 - 22) eggs per day at 25 days of reproductive age. At 25°C maximum oviposition was 32.50 $\pm$ 3.35 (range 14 - 38) eggs/day at mean reproductive age of 18 days, while at 27°C and 30°C, oviposition peaked at 15 and 16 days, with 34.50 $\pm$ 1.15 (range 28 - 53) eggs and 24.50 $\pm$ 5.75 (range 18-30) eggs/day respectively. The peaks ovipositions were followed by a decline in the oviposition rate with further increase in the mean reproductive age at all the tested temperatures. Figure 1 reveals that young adults were more fecund than their older counterparts.

Data on pre-oviposition, oviposition and post-oviposition periods, fecundity and percent viability of *M. discolor* at four different temperatures are presented in Table 1. The pre-oviposition, oviposition and post-oviposition period were significantly longer at 20°C than at the higher temperature tested. The pre-oviposition

Table 1: Effect of temperature on certain reproductive attributes of a ladybeetle, *Micraspis discolor*

Temp. (°C)	Pre-oviposition (days)	Oviposition period (days)	Post-oviposition (days)	Fecundity (No.)	Egg Viability(%)
20	18.50 ± 1.73a	53.00 ± 0.84a	18.20 ± 0.80a	385.70 ± 49.28a	65.03 ± 7.20b
25	11.70 ± 0.66b	49.00 ± 2.51ab	9.60 ± 0.40b	553.00 ± 37.83ab	82.35 ± 9.74a
27	8.80 ± 0.51b	43.80 ± 1.11ab	5.70 ± 0.37c	750.60 ± 25.71bc	95.60 ± 0.60a
30	9.50 ± 0.37b	38.00 ± 2.92b	7.80 ± 0.51c	601.60 ± 38.49c	80.31 ± 7.50a
F-value	24.24*	5.29*	80.93*	12.91*	14.69*

Values are mean ± SE. *Significant at $p = 0.001$. Means within a column followed by the same letter are not significantly different at $p < 0.001$.

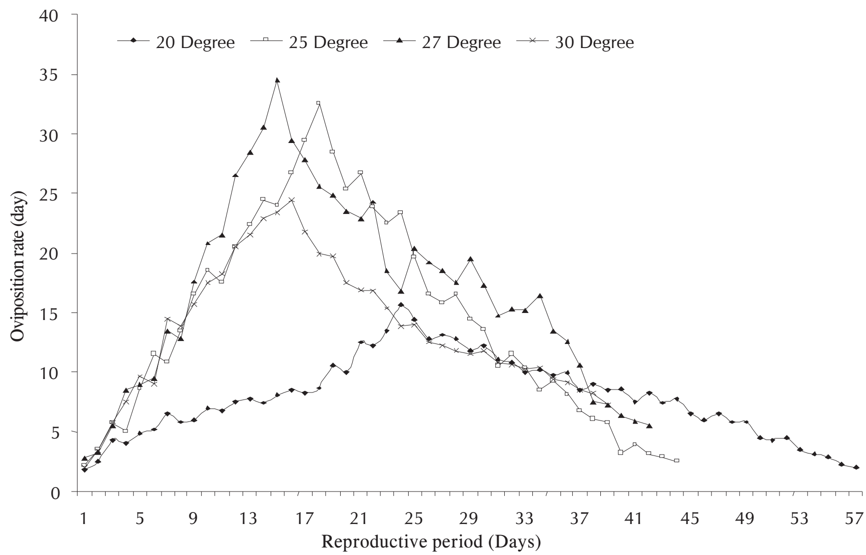

Figure 1: Age specific fecundity of *Micraspis discolor* at (A) 20, (B) 25, (C) 27 and (D) 30°C, showing variability in the form of error bars

period decreased significantly with increase in temperature, from 18.50 ± 1.73 days at 20°C to 8.80 ± 0.51 days at 27°C, then increased to 9.80 ± 0.37 days at 30°C ($F = 24.24$; $p < 0.001$). The oviposition period decreased from 53.00 ± 0.84 days at 20°C to 38.00 ± 2.92 days at 30°C ($F = 5.29$; $p < 0.001$). The post-oviposition period decreased significantly from 18.20 ± 0.80 days at 20°C to 5.70 ± 0.37 days at 27°C, then went up to 7.80 ± 0.51 days at 30°C ($F = 80.93$; $p < 0.001$).

Table 1 suggested that the fecundity increased from 385.70 ± 49.28 eggs at 20°C to 750.60 ± 25.71 eggs at 27°C, then fell to 601.60 ± 38.49 eggs at 30°C ($F = 12.91$; $p < 0.001$). The highest oviposition rate was recorded at 27°C (average of 16.69 eggs/female/day), the lowest was 385.70 with the average of 7.89 eggs/female/day at 20°C. The percent viability of the eggs increased from 65.00 ± 7.20 at 20°C to 95.00 ± 0.60 at 27°C, then it was 80.31 % at 30°C ($F = 14.69$; $p < 0.001$). However, there were no statistically significant differences in viability of egg among the higher temperature of 25°C, 27°C and 30°C, respectively

DISCUSSION

It is evident from our results that reproductive output in *M. discolor* shows a triangular fecundity function, which is temperature dependent. This function indicates the occurrence of a relationship between reproductive age and daily oviposition. In accordance, it may be surmised that the reproductive vigour and response of the female ladybeetle increases with increase in age until a peak, then decreases till cessation of reproductive period. Young adults were more efficient in converting aphid biomass into eggs than older ones. The probability of being alive to reproduce is greater in younger than in older females. This finding is in close agreement with that of Stearns and Koella (1986). The high survival probability of young females may be a reason for the increased reproductive output at the earlier stage of life. The reproductive output in most insects, including the ladybeetle (e.g. *Coccinella sexmaculata*) starts and reaches its maximum during early adult life then declines (Dixon, 2000).

Fecundity trends (oviposition rate vs reproductive age) were similar at all four temperature treatments and the oviposition peak tended to shift left with increase in temperature; the peak moved from 25 days at 20°C to 15 days at 27°C, which suggested that suitable temperature shortens the time between first egg laying and the oviposition peak. The maturation of the gonads due to increased metabolic activities at higher temperature is probably responsible for the expedited oviposition rate (Srivastava, 2000; James, 2001). The early arrival of the peak and the increased number of eggs laid at the peak strongly indicate 27°C to be the ideal temperature for the rapid and effective mass rearing of *M. discolor*.

The pre- and post-oviposition periods decreased with increase in temperature. The significant delay in the oviposition of the ladybeetle at low (20°C) temperature may possibly be ascribed to the lower metabolic rate at that temperature, and accompanying slower maturation of the gonads. This result is in agreement with other findings on the ladybeetles *Cheilomenes sexmaculata* (Fabricius) (Bind, 1998), *Coccinella septempunctata* Linnaeus (Srivastava, 2000) and *Coccinella transversalis* Fabricius (James, 2001).

The overall fecundity of *M. discolor* obtained in this study was higher (750.60 $\pm$ 25.71 eggs) than those reported in the literature on the same beetle, *e.g.*, 327.66 eggs (Gautam, 1994) and 665.16 eggs (Agarwala *et al.,* 1988). The relatively high fecundity in our study may be attributed to: (i) availability of suitable aphid prey, *R. maidis* (Omkar and Pervez, 2000a) and (ii) suitable temperature (27°C), which is not only the most favourable temperature for survival and development, but also for the highest percentage of viable offspring. Similarly, a temperature of 27°C was also optimum for the development and reproduction of *C. sexmaculata* (Bind, 1998) and *C. transversalis* (James, 2001). Increase in temperature from 20 to 27°C also enhances the feeding voracity, thereby increasing the reproductive numerical response of the female ladybeetle (Ofuya and Akinbohungbe, 1988; Veeravel and Baskaran, 1997).

The percent viability was significantly lower at 20°C as compared to other higher temperature 25°C, 27°C and 30°C, which may be attributed to: (i) increased sperm mortality in the spermatheca, or (ii) the inhibition of the spermatogenesis (Ponsonby and Copland, 1998) by low temperature. The egg viabilities at cyclic (14 – 30°C) and constant (20°C) temperatures are known to be almost similar (Ponsonby and Copland, 1998), which implies that exposure to low temperature was the cause of lowered fertility. The significant increase in the percent viability of the eggs at 27°C points to that temperature being the optimum for progeny survivability. In addition to temperature, female reproductive age seems to be an important determinant of reproductive efficiency in *M. discolor*.

In conclusion, the study reported here has established that (i) the fecundity of *M. discolor* is age-specific and triangular in function; (ii) oviposition rate increases with increase in reproductive age and after reaching a peak it gradually declines then ceases; (iii) younger adults are more fecund than older ones; (iv) manipulation of temperature may shift the peak of oviposition rate to either side of reproductive age - this peak is reached early at optimum temperatures; and (v) 27°C is the optimum temperature for maximum reproductive performance of *M. discolor*.

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