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Biology and Life table studies of *Dirhinus anthracia* Walker (Hymenoptera: Chalcididae) a parasitoid of *Exorista bombycis* Louis (Diptera: Tachinidae) at various constant temperatures

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ABSRACT: Biology of *Dirhinus anthracia* Walker was investigated on its natural host, *Exorista bombycis* Louis at six constant temperatures (10-35°C). The lower threshold for development for male and female was 10.5° and 11°C, respectively. Entire development from egg to adult required 475.05 and 550.96 day degrees, respectively for male and female. Sex ratio was in favour of female at all temperatures except 35°C where a reversal of sex ratio was observed. Reduction in doubling time and generation time was observed as temperature increased.

KEY WORDS: *Dirhinus anthracia, Exorista bombycis*, parasitoid, temperature, *uzi fly*

Indian uzi fly, *Exorista bombycis* Louis (Diptera: Tachinidae) is a serious pest of mulberry silkworm, *Bombyx mori* L. (Lepidoptera: Bombycidae) in India. In Karnataka up to 80 per cent of the crop is lost due to the pest infestation. Various physical and chemical control measures have been adopted to control this pest with limited success (Devaiah *et al.*, 1993). In recent years efforts have been made towards achieving biological control of uzi fly through its parasitoids (Jyothi, 1994). However, there is a dearth of information on the biology of the parasitoids of uzi fly and their potential in biological control. Present study was conducted to determine the relation between temperature and development, and to evolve a day degree model for *D. anthracia* Walker (Hymenoptera: Chalcididae), a solitary, ectopupal parasitoid of *E. bombycis*.

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MATERIALS AND METHODS

Laboratory Culture

Culture of *D. anthracia* was started from the natural population found parasitising the host (uzi fly) population in the laboratory. The culture was stabilized after rearing the parasitoid for 20 generations in the laboratory. These colonies were maintained at room temperature that varied between 23 and 27°C and a relative humidity of 60 - 70 per cent. Adult parasitoids were held in 1000ml conical flasks, covered with muslin cloth and were provided with a mixture of 10 per cent sucrose in water and honey in equal proportions as a source of food. For the purpose of propagation of culture 5 pairs of the adult parasitoids were provided with 200 host puparia for oviposition. These infested hosts were removed from the flask and maintained separately. The immature parasitoids were allowed to develop on the host puparia and the adult parasitoids emerging from these hosts were used for the present studies.

Effect of temperature on the biology

Individual pairs of *D. anthracia* were placed in 500 ml conical flasks, immediately after emergence and were maintained in environmental chambers at 10, 15, 20, 25, 30, 35 and 40°C and a relative humidity of 65 - 75 per cent with a photoperiod of 12:12 (L: D) in ten replications, separately. The insects were fed with 10 per cent aqueous mixture of sucrose and honey.

Each adult female was provided with twenty healthy and unparasitised host pupae for oviposition. The hosts were replaced every 24h till the death of the female parasitoid. These parasitised pupae were maintained separately and the parasitoids were allowed to develop at the same temperature as that of their mother. The host pupae exposed for infestation were observed daily for the emergence of the adults of the parasitoid as well as the host. Eclosed adult parasitoids were counted and sexed. Time taken for development for both the male and the female was recorded. Uneclosed host pupae were dissected at the end of the studies to determine the presence of parasitoids, dead or developing.

Preparation of life table

Data obtained while studying the biology of the parasitoids were used for the construction of the life tables. Age specific life tables were prepared according to Birch (1948). Capacity for increase was calculated using, the life table prepared, according to Laughlin (1965).

$$r_c = \ln R_o / T_c$$

where, $T_c = x\, l_x m_x / l_x\, mx$, $R_o = l_x\, m_x$, x is the pivotal age, l_x is the fraction of females surviving at age x out of an initial population of 1, and m_x is age specific fecundity.

Other life table statistics were calculated as follows:

Finite rate of increase (λ) = e^r, Generation time (T) = $\ln R_o / r_c$, Doubling time DT = $\ln 2/r_c$

Survivorship curves

Survivorship pattern of *D. anthracia* was recorded at various constant temperatures by fraction of living females at a given age (l_x), against the age (x). These curves were compared with standard curves described by Slobodkin (1962).

Developmental threshold and day degree requirement

The relationship between the rate of development and the temperature was obtained by simple linear regression of the developmental rate over temperature. The day degree requirement for the development was calculated as 1/b and developmental threshold as -a/b, using the regression equation y = a + bx where y is the rate of development and x is the temperature (Mc Calin *et al.*, 1990). The regression co-efficient was tested for its significance at 5 per cent level (Sokal and Rohlf, 1969).

RESULTS AND DISCUSSION

Effect of temperature on the biology

In the present study average longevity of both males and females was inversely related to temperature. *D. anthracia* male and female lived 2 and 2.5 times longer at 15°C compared to 30 and 35°C, respectively. It was also observed that female of *D. anthracia* out lived male at all the temperatures studied. Male lived for 64.6 ± 25.25 days and female for 81.8 ± 22.68 days at 15°C which was maximum longevity for *D. anthracia* during the present study. Shortest longevity was observed at 35°C with male and female surviving for 25.7 ± 8.23 and 36.7 ± 7.77 days, respectively (Table 1). Temperature affected the longevity of the parasitoids, resulting in the reduced longevity at higher temperatures (Tingle and Copeland, 1989).

The parasitoid showed a great deal of variation regarding progeny production at

Table 1. Effect of temperature on the biology of *D. anthracia*

Temperature (° C)	Adult longevity(in days) Male	Female	Fecundity (Mean ± SD)	Infestation (%) (Mean ± SD)	Sex ratio M: F
15	4.6 ± 25.25	81.8 ± 22.68	16.4 ± 8.33	2.57 ± 0.80	1: 0.28
20	44.3 ± 0.67	46.4 ± 00.69	97.6 ± 8.40	22.96 ± 0.60	1: 1.79
25	38.5 ± 0.50	40.0 ± 00.21	107.9 ± 3.08	32.19 ± 1.00	1: 1.41
30	29.0 ± 3.85	39.7 ± 12.64	216.9 ± 60.05	24.47 ± 4.54	1: 1.37
35	25.7 ± 8.23	36.7 ± 07.70	139.5 ± 35.11	19.95 ± 2.80	1: 0.19
CD (P=0.05)	5.3	6.9	28.2	10.82	

various constant temperatures. Optimum temperature for maximum progeny production (216 ± 60.08) and highest rate of infestation (24.47 ± 4.54%) was found to be 30°C. At 15°C percentage of infestation and progeny number was minimum (2.59 ± 0.80, 16.4 ± 8.38, respectively). Sex ratio (M:F) was female oriented at 20, 25 and 30°C (1:1.79, 1:1.41 and 1:1.37, respectively). At 15 and 35°C a male dominated progeny was produced (1:0.28, 1:0.19, respectively) (Table 1).

Absence of partially or fully developed larvae of *D. anthracia* at 10°C on uzi fly pupae revealed that no oviposition occurred at this temperature. This reduced (zero) fecundity at lower temperatures may have resulted from temperature effects. At 10°C behavioural activities such as locomotion and feeding were greatly reduced in *D. anthracia* adults and would have resulted in lack of searching and probing the hosts and subsequent failure in oviposition itself. In contrast at 35°C rate of false strikes was high which is reflected in the reduced number of the progeny 139.5 ± 35.11, in relation to rate of infestation.

Duration of development was longest at 15°C with male emerging earlier than female (27.3 ± 0.43 days and 28.4 ± 0.51 days, respectively). At 35°C development was fastest with male and female requiring duration of 17.0 ± 0.81 days and 19.0 ± 0.74 days, respectively (Table 1).

Survivorship curves

Survivorship curves of adult *D. anthracia* at 15 , 25, 30 and 35°C follow Slobodkin's type - III curve indicating that the mortality rate is constant. At 20°C the survivorship follows type - I curve indicating that the parasitoid adults attain full age at this temperature and mortality acts heavily on older individuals (Fig 1). Survivorship was highest at 15°C, and least at 35°C. Linear regression equation of female longevity on temperature was y = 97.302-1.93x. The regression coefficients obtained thus were found to be statistically non- significant at 5 per cent level.

Life Table

Age specific life table statistics of *D.anthracia* at various constant temperatures are presented in Table 2. Net reproductive rate R_o, capacity for increase r_c and finite rate of increase l were highest at 30°C (R_o = 131.90, r_c = 0.143 and λ = 1.154). Generation time was longest at 15°C (44.89 days) and shortest at 35°C (32.54 days). Doubling time was least at 30°C (4.83) and longest at 15°C (23.33 days). In *D. anthracia* net reproduction rate was highest at 30°C with shortest doubling time. The generation time was shortest at 35°C. A similar observation has been made in case of *Catolaccus grandis* (Burks), where net reproductive rate decreased with increasing temperature from 25 to 35°C (Morales - Ramos and James, 1992).

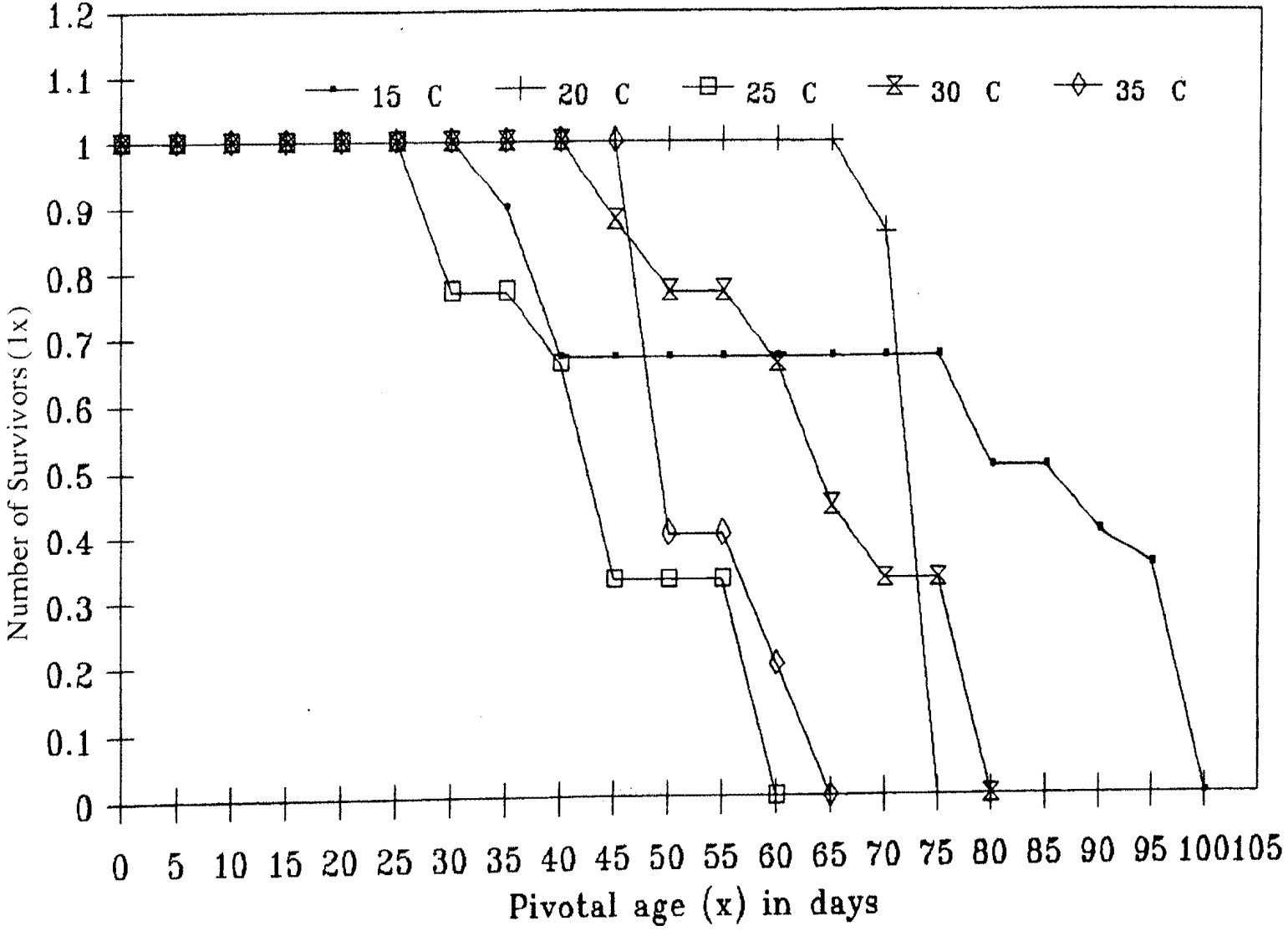

Fig. 1. Survival curves of *D. anthracia* at different constant temperatures

Table 2. Life table statistics of *D. anthracia* at different constant temperatures

Temperature (°C)	R_o	r_m	λ	T	DT
5	-	-	-	-	-
10	-	-	-	-	-
15	3.80	0.0297	1.030	44.89	23.34
20	59.61	0.0980	1.104	41.31	6.93
25	56.20	0.1120	1.118	35.95	6.18
30	131.90	0.1430	1.154	34.03	4.83
35	24.44	0.0980	1.103	32.54	7.07

Developmental threshold and day degree requirements

There is a positive correlation between the rate of development, as evidenced by linear regression equation of temperature over rate of development. Minimum development thresholds, day degree requirements and linear regression equation for rate of development of *D. anthracia* male, female and both together, on *E. bombycis* are given in Table 3. The regression equations between the rate of development for male, female and both together was y = -0.0066 + 0.0021x, y = -0.0063 + 0.0018x, and y = -0.0073 + 0.0019x, respectively. Day degree estimated as 1/coefficient of x, using linear developmental equation showed that the male required lesser day degrees (475.05) and lower threshold for effective development (3.137°C) compared to female which required 550.96 day degrees and a threshold temperature of 3.943°C. The developmental duration decreased with increase in temperature from 20-35°C. Female took more time for development compared to male at all the temperatures studied. Similar effect of constant temperature on the development of male and female in other hymenopteran

Table 3. Regression equations for development of *D. anthracia* from egg to adult at four constant temperatures (20, 25, 30 and 35°C)

Sex	Regression equation (y = a+ bx)	r2	SE of estimated	Lower threshold temperature (-a/b) (° C)	Day degrees 1 /x coeff.
Male	y = -0.0066 + 0.0021x	0.882	0.0091	3.137	475.05
Female	y = -0.0063 + 0.0018x	0.846	0.0091	3.493	550.96
Total Progeny	y = -0.0073 + 0.0019x	0.865	0.0900	3.789	512.82

Note: significant at P=0.05

parasitoids such as *Trichogramma pretiosum* Riley and *Trissolcus enschiosti* Wolaston was reported by Butler and Lopez (1980) and Yeargan(1983). However, in *Oencyrtus anasae* and *Oencyrtus* sp. female emerged earlier than the male at all the temperatures (Tracy and Nicholus, 1987).

In the case of *Apanteles* sp. group ultor, increasing temperatures resulted in a linear increase in the rate of development of each phase and successful development has been reported at 16°C (Al- Maliky *et al.*, 1988). In the present investigation it was observed that *D. anthracia* developed successfully at 15°C though with a prolonged developmental period. However, 15°C is not the optimum temperature for development of *D. anthracia* due to low day degrees available it takes more time. Parasitoids of uzi fly namely, *Nesolynx thymus* and *Pachycrepoideus veerannai* could not develop at 15°C. For these two parasitoids a minimum of 20°C was required for successful development (Jyothi, 1994).

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