

Temperature dependent hopper development period of *Acrida exaltata* Walker (Orthoptera: Acrididae) in Kashmir, India.

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Abstract: This paper is based on experimental studies carried out in the laboratory with the aim to study the effect of temperature on hopper development period of *Acrida exaltata*. The species under study was subjected to two different temperatures viz. 25°C and 30°C in B.O.D. cabinets. At 25°C males emerged after 96.01 days and that of females after 111.15 days while as at 30°C males and females emerged after 82.77 and 93.59 days, respectively. Increase in temperature not only decreases the overall development period but also of individual instars proportionally. The ANOVA results were significant clearly indicating that the development period is decreased by increase in temperature.

[S. Tariq Ahmad. **Temperature dependent hopper development period of *Acrida exaltata* Walker (Orthoptera: Acrididae) in Kashmir, India.** *N Y Sci J* 2014;7(4):36-39]. (ISSN: 1554-0200). <http://www.sciencepub.net/newyork>. 7

Keywords: Temperature, hopper development, *A. exaltata*, Kashmir

1. Introduction

Temperature plays an important role in the life processes of many organisms. This is especially true in poikilothermic ectotherms which rely on outside sources of heat to maintain internal body temperature. Temperature affects the rate at which biochemical processes take place and can affect metabolism, developmental rate, reproduction and body size. The Insects are particularly sensitive to changes in temperature. Extremes in temperature can have severe negative effects on an organism (e.g. desiccation and deactivation of enzymes) causing thermal death. The temperatures at which severe negative effects occur define the tolerance range of an organism which estimates the range of temperatures over which survival is possible (Huey and Stevenson 1979). While temperatures outside of the tolerance range lead to death, the effects of less extreme sub-optimal temperatures are usually more subtle (e.g., prolonged developmental time and diapause and decreased fecundity and body size). The effects of temperature on development and reproduction in grasshoppers can be substantial and have been well documented. A study by Begon (1983) showed that when 4th instars of *Chorthippus brunneus* were exposed to a radiant heat source, developmental rate could be 5.6 times greater than when the grasshoppers were not exposed. The same study also showed that adult females held in cages with longer periods of radiant heat laid more egg pods than females in cages with shorter periods of radiant heat. Putnam (1963) conducted a study that shows development time in three species of grasshopper ranging from 53 days at 24°C to 17 days

at 38°C. In another study by Willot (1992) on four species of Acrididae, development and reproduction were either zero or very low at temperatures below 25°C, while the optimum temperature for growth and development was between 35°C and 40°C. *Taeniopoda eques* required 60 days from nymph to adult at 25°C and only 35 days at 30°C (Whitman 1986). Parker (1930) showed an increase from 27°C to 32°C reduced length of larval development by 27 days in *Melanopus mexicanus*. While these studies show that temperature increases as small as 4°C can cut development time in half, it is likely that the more important parameter is how close the temperature approximates the optimal temperature. Almost all studies show that increases in temperature can increase development but the amount of increase and actual benefits associated with these increases depend highly on the thermal biology of the organism in question. Temperature increases development by increasing biological processes in general but this can also have a negative side effect. Increased metabolic rates tend to shorten an organism's life span. In one study conducted on *Camnula pellucida*, adults survived for 16 days at 37°C and 32.6 days at 27°C (Uvarov 1966a).

2. Material and Methods

To study the effect of temperature on development, grasshoppers were reared in cages under laboratory conditions. Cages with dimensions 51×51×61 cms having aluminium bottom and screen sides and top were stocked with 100 1st instars, hatched within the last 24 hours. Newly hatched hoppers were kept in cages for observations on

hopper development at 25°C and 30°C. Nymphs were provided with fresh food twice daily. Grasshoppers were monitored daily for moulting. Each day grasshoppers were counted and the number surviving and the number at each stage were recorded. The stage of any dead grasshopper was also recorded. Males and females were reared in separate cages.

3. Statistical Analysis

Data obtained from experimental groups were subjected to one-way analysis of variance (ANOVA), (MS Excel 2007, PRIMER software) with repeated measures and significant means were determined using Tukey's Multiple Comparison Test (TMCT). Separate histograms for different temperature treatments were produced using MS Excel.

4. Results

Temperature played an important role in the development of *Acrida exaltata*. In general increase in temperature decreased the developmental period of hoppers and vice-versa. Newly hatched hoppers were kept individually in rearing cages (51×51×61 cms) for observations on hopper development (both males and females) at 25°C and 30°C, respectively. The mean development period for Ist instar larva (male) was 12.4±1.07 at 25°C and 9.2±0.63 at 30°C ($p < 0.05$) while as that of the mean development period for IInd instar larva (male) was 14.2±0.788 at 25°C and 13.2±1.22 at 30°C ($p < 0.05$), respectively. Similarly, the mean development period for IIIrd instar larva (male) was 18.2±1.135 at 25°C and 16.6±1.34 at 30°C ($p < 0.05$) while to that of the IVth instar larva (male) was 22.77±0.97 at 25°C and 19.66±1 at 30°C ($p < 0.05$). Finally, the mean development for Vth instar larva (male) was 16.22±1.20 at 25°C and 12±0.86 at 30°C ($p < 0.05$). The total development period in case of males was 96.01 days at 25°C and 82.77 days at 30°C. The mean development period for Ist instar larva (female) was 13.6±0.96 at 25°C and 11.4±1.07 at 30°C ($p < 0.05$). The mean development period for IInd instar larva (female) was 17.6±1.34 at 25°C and 12.2±1.22 at 30°C ($p < 0.05$). The mean development period for IIIrd instar larva (female) was 20.4±1.17 at 25°C and 16.4±1.42 at 30°C ($p < 0.05$). The mean development period for IVth instar larva (female) was 25.33±1.32 at 25°C and 21.66±1.22 at 30°C ($p < 0.05$). The mean development period for Vth instar larva (female) was 19.11±0.92 at 25°C and 17.33±1.22 at 30°C ($p < 0.05$). Total development time in this study was 96.01 days and 111.15 days at 25°C for males and females, respectively. At 30°C, the total development time for males and females was respectively, 82.77 and 93.59 days. Minimum development time of 12.22±0.83 days were taken by Vth instar male to transform into

the adult at 25°C while at 30°C in case males it was Ist instar which showed faster development. In other words, it took significantly 9.2±0.63 days to transform into IInd instar. In case of females at 25°C, Ist instar took the least time of 13.6±0.96 days to form IInd instar while at 30°C least development time 11.4±1.07 days was again taken by Ist instar. Among males and females subjected to two different temperatures, least development time was taken by Ist instar male (9.2±0.63 days) at 30°C while the highest time taken during development was taken by IVth instar female (25.33±1.32 days) at 25°C (Fig.1 and Fig.2). Both males and females were affected by the temperature significantly although to the different extent. Study revealed that temperature affected development process of males, females as well as hopper development period significantly. The results are summarised in tables I and II.

Table I: Effect of temperature on the development of male instars at 25°C and 30°C.

Hopper instars	AT 25°C Males	AT 30°C Males
I st Instar	(12.40±1.070) ^a	(9.20±0.630) ^b
II nd Instar	(14.20±0.788) ^a	(13.20±1.220) ^b
III rd Instar	(18.20±1.135) ^a	(16.60±1.340) ^b
IV th Instar	(22.77±0.970) ^a	(19.66±1.000) ^b
V th Instar	(16.22±1.200) ^a	(12.00±0.860) ^b
V th Instar-Adult	(12.22±0.830) ^{n.s.}	(12.11±1.050) ^{n.s.}

Values within each row that do not share the same superscript are significantly different ($^{a-b}P < 0.05$). The data was evaluated by one-way ANOVA followed by Tukey's test to detect the effect of temperature on development. Differences were considered to be statistically significant if $p < 0.05$.

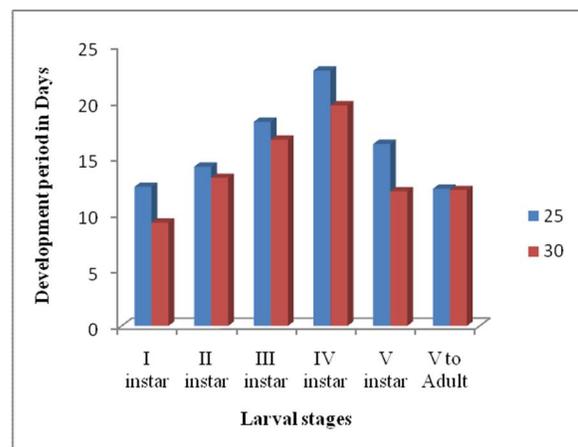


Figure 1: Effect of Temperature on development of Male instars

Table II: Effect of temperature on the development of female instars at 25°C and 30°C.

Hopper instars	At 25°C Females	At 30°C Females
1 st Instar	(13.60±0.960) ^a	(11.40±1.07) ^b
2 nd Instar	(17.60±1.340) ^a	(12.20±1.22) ^b
3 rd Instar	(20.40±1.170) ^a	(16.40±1.42) ^b
4 th Instar	(25.33±1.320) ^a	(21.66±1.22) ^b
5 th Instar	(19.11±0.920) ^a	(17.33±1.22) ^b
5 th Instar-Adult	(15.11±0.927) ^{n.s.}	(14.60±0.86) ^{n.s.}

Values within each row that do not share the same superscript are significantly different ($^{a-b}P < 0.05$). The data was evaluated by one-way ANOVA followed by Tukey's test to detect the effect of temperature on development. Differences were considered to be statistically significant if $p < 0.05$.

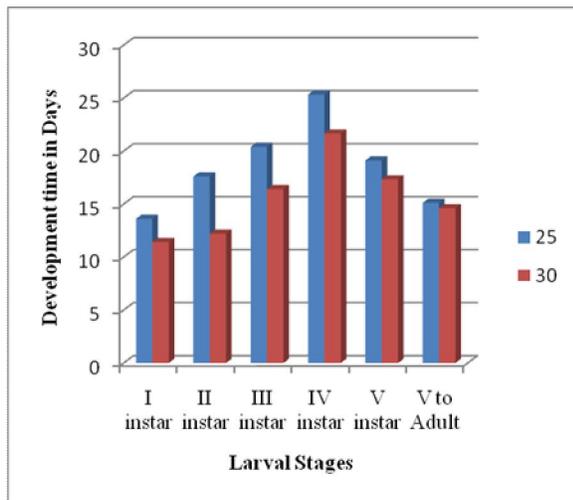


Figure 2: Effect of Temperature on development of Female instars

5. Discussions

Total development time in this study was 96.01 days and 111.15 days at 25°C for males and females respectively. At 30°C the total development time for males and females was respectively 82.77 and 93.59 days. Minimum development time i.e., 12.22±0.83 days were taken by Vth instar male to transform into the adult at 25°C while at 30°C in case males it was Ist instar which showed fast development i.e., it took only 9.2 days to transform into IInd instar. In case of females at 25°C Ist instar took the least time 13.6 days to form IInd instar while at 30°C least development time was also taken by Ist instar i.e., 11.4 days. Among males and females at both the temperature least development time was taken by Ist instar male (9.2 days) at 30°C while the highest time taken during

development was taken by IVth instar female (25.33 days) at 25°C. Both males and females were affected by the temperature significantly although to the different extent. Study revealed that temperature effects development process significantly. More the temperature, faster will be the development. As we know that increase in temperature increases the metabolic rate. Parker (1930) in his extensive experiments with several American grasshoppers also clearly indicated a shortening of hopper period and an accelerated rate of development with rising temperature. Observations made by Symmons *et al.*, (1974) on *Schistocerca gregaria* showed that the temperature range between 30–40°C was favourable for development. Shamsad Ali (1982) carried out observations on the effect of temperature and humidity on the development and fertility-fecundity of *Acrida exaltata*. The results also showed that the increase in temperature decreases the development period in *Acrida exaltata*.

Acknowledgements:

The author is highly thankful to the Head, P.G. Department of Zoology for providing the laboratory facilities.

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4/1/2014