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Effects of temperature and humidity on growth and development of *Acrida gigantea* (Orthoptera: Acridoidea: Acrididae)

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Abstract. The present study was conducted to investigate the effect of temperature and humidity on the growth and development of *Acrida gigantea* under laboratory conditions. The grasshoppers were reared at two different levels of temperature and humidity, 37°C±1°C and 70%-80% relative humidity, and 27°C±1°C and 50%-60% relative humidity. This work has been carried out to get knowledge of biology, postembryonic development and morphometrics of *Acrida gigantea*, which is an economically important species. It is a polyphagous pest found in tall grasses and bushes, and usually feeds on crops such as rice, maize, millet, etc.

Key words. Temperature, relative humidity, *Acrida gigantea.*

Introduction

Grasshoppers sometimes called short-horned grasshoppers belonging to the suborder Caelifera are divided into four super families, Acridoidea, Tetrigoidea, Tridactyloidea and Eumastacoidea. Acridoidea is characterized by short antennae (usually shorter than the body), a short ovipositor and three-segmented tarsi. It is the most diverse super family. The families Pyrgomorphidae, Catantopidae and Acrididae are widely distributed. The species under study belongs to the family Acrididae and can easily be identified. The head is either slightly longer or shorter than the pronotum. The color of the body is usually green, but pale-colored specimens also occur. The head and pronotum bear two or three pale pink bands on each side. The tegmina bear two broad longitudinal light pink bands often separated by a whitish line generally broken in to long spots with blackish rim; the wings are hyaline. Lateral carinae of the pronotum are edged with a black line on inner side.

The members of the family Acrididae are commonly known as locusts and grasshoppers. They constitute an economically important group of orthopterous pests infesting a number of cultivated and noncultivated agricultural crops. They are phytophagus and cause a considerable damage to agricultural crops. Locusts and grasshoppers are distributed throughout the world up to the sub polar regions, but the number of genera and species increases towards the equator. They flourish most in tropical and subtropical countries. Their distribution depends upon the vegetation prevailing in the forests, agricultural lands, temperature, seasonal rainfall and soil conditions.

Previously Hussain & Ahmad (1936) studied the biology of *Schistocerca gregaria* with special relation to temperature. Hussain & Mathur (1944) further observed the influence of temperature on the weight and size of *Schistocerca gregaria*. Hafez & Ibrahim (1964) studied the behavior of *Sphingonotus carinatus* Saussure towards humidity and temperature. Greathead (1966) studied the effect of biotic factors on population of the desert locust *Schistocerca gregaria*. Grewal & Atwal (1968) studied the affect of different levels of temperature and humidity on the development of *Chrotogonus trachypterus* Blanchard. Khan & Aziz (1973) observed the influence of different levels of temperature and humidity on the development and hatching of eggs of the *Oedaleus abruptus* Thunberg. Iqbal & Aziz (1973) studied the effect of different levels of temperature and humidity on the development of

Spathosternum prasiniferum Walker. Sanger (1973), Khan & Aziz (1974a, b, c), Parihar & Pal (1978) and Majeed (1990) studied the impact of temperature and humidity on growth, development, incubation period etc. of different grasshopper species.

In the present study, we have concentrated on the impact of variations in temperature on the development of *Acrida gigantea*.

Material and methods

The present study was carried out under laboratory conditions in the Department of Zoology, AMU Aligarh. Field observations and collections were made from areas adjacent to Aligarh for a period of one year, from April 2010 till March 2011.

Collection and maintenance of stock:

Mature and immature stages of *Acrida gigantea* were collected from the fields of rice, sugarcane, wheat, grasses and bushes by using sweeping nets. They were reared in wooden cages. Three sides of the cage were made up of wood with glass panels on the front side. Either of the two sides of wooden panels was provided with small windows covered with wire-mesh wire gauge and the third side with an outlet for the purpose of feeding, cleaning, placing the insects, watering of egg-laying tubes and harvesting of egg-pods after egg laying. The central portion of the cage floor was provided with wire mesh for proper ventilation, while sides of the floor were made of wood. One side of the cage floor was provided with holes for egg-laying tubes. The wooden roof also had a lid. An electric bulb was fitted in one corner of the roof to provide light and regulate temperature. The legs of cages were placed in glass bowls filled with mixture of water and kerosene oil or phenol to keep away predators such as ants and lizards.

The adult male and female grasshoppers were fed *Cynadon* grass. The egg-laying tubes were checked regularly for eggs. The tubes were replaced by fresh ones. The tubes containing egg pods were labelled (species name, date of egg-laying) and placed in jars covered with muslin cloth and transferred to BOD at 37°C±1°C. When the second egg laying took place, it was kept at 27°C±1°C. The egg pods were moistened regularly.

On hatching, the hoppers were transferred to separate jars and two different sets of experiments were prepared, one at 37°C±1°C and the other at 27°C±1°C, and both were fed *Cynodon dactylon* grass. The moulting period of each instar varies at both temperatures. The instar duration was recorded after each moulting. Morphometry was also done at every stage of the instar. Temperature extremes were tested at 10ºC and 45ºC.

Morphometrical analysis:

Morphometry was carried out for each successive stage in both conditions with the help of vernier calliper. At least five individuals of each instar were measured and then the mean was calculated.

Results and discussion

The life cycle of *Acrida gigantea* is about 90-100 days at 37°C±1°C (70%-80% RH) and 110-130 days at 27°C±1°C (RH 50%- 60%). The newly emerged nymphs take about 60-65 days to become adult at 37°C and 80-90 days at 27°C (females take longer to reach adulthood than males). The duration varies according to temperature (Table 1). A female lays about

30-70 eggs each time in an egg pod. It was observed that the incubation period of eggs that were kept at 37°C and 70-80% RH was about 25-30 days, while those kept 27°C took 35-45 days and sometimes the duration increased to 50-60 days. The larval duration varies in different instars. The newly hatched nymphs are called vermiform larvae. The 1st instar moults after 7-8 days and transforms into 2nd instar, whose average duration is about 8-9 days; the duration of the 3rd instar is 8 days, that of the 4th instar is about 9 days, and the 5th instar takes 9-10 days to become an adult. Males reach adulthood after four moults, while females became adult after six and sometimes seven moults. It means under favourable conditions an individual normally takes 40-60 days to become an adult, but as the conditions change the length of the development is affected.

During the study more females were obtained at 37°C, while at 27°C the number of males exceeded that of females.

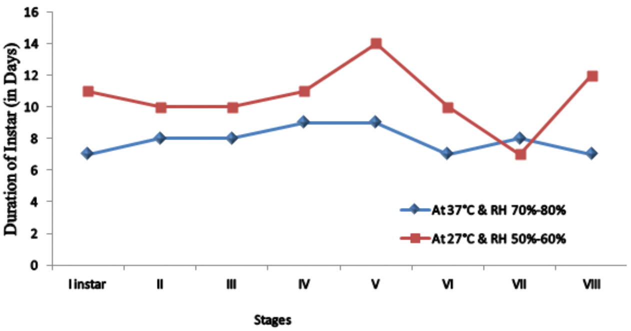
The extremes of temperatures were also tested at 10ºC and 45ºC. No hatching was observed at either extreme. The hoppers became inactive at 10ºC and died within 36-72 hours, while 90-95% of the population died within 24-36 hours at 45ºC and above during hot summers.

There are slight differences in the morphometry of hoppers at both tested levels of temperature (Tables 2, 3). At 37°C, the size was slightly larger than at 27°C. It appears that rather than the temperature and humidity, the size is affected by the amount of food supply.

The phenomenon of cannibalism was also observed in this species during the course of the study. Among sexes the females, and among instars the 4th, 5th and older hoppers exhibited the maximum potential for cannibalism. The strong and healthy individuals, especially females, fed on relatively weak individuals holding their bodies with the forelegs, feeding from the apical side of the abdomen and leaving portions of the head and thorax.

Table 1. Development of *Acrida gigantea* (in days) at 37°C±1°C and 27°C ±1°C.

Instars / Temperature& RH	I	II	III	IV	V	VI	VII	VIII	Total no. of days for females	Total no. of days for males
At 37°C ±1 & RH 70-80%	7	8	8	9	9	7	8	7	63	41
27°C ±1 & RH 50-60%	11	10	10	11	14	10	7	12	85	56



Graph showing variation in duration (in days) of nymphal instars of *Acrida gigantea* at different temperature ranges.

Table 2. Morphometry of *Acrida gigantea* (37°C±1°C).

S. no.	Body parts	I instar	II instar	III instar	IV instar	V instar	VI instar	VII instar	Adult female	Adult male
1.	Body length	9.2	10.05	10.59	20.63	21.00	40.00	42.6	49.4	33.0
2.	Max. width of head	1.1	1.2	1.35	1.6	1.62	2.6	2.8	3.6	1.8
3.	Length of antenna	2.87	3.07	4.4	5.9	6.9	10.05	11.5	12.25	9.05
4.	Width of vertex b/w eyes	0.81	0.86	0.9	1.05	1.2	1.3	1.35	1.35	0.95
5.	Vertical dia. of eyes	1.25	1.3	1.6	1.95	2.1	2.3	2.5	2.75	2.1
6.	Horizontal dia. of eyes	0.63	0.65	0.78	0.97	1.2	1.3	1.35	1.45	1.03
7.	Max. width of pronotum	1.07	1.2	1.4	1.7	1.9	2.6	3.1	4.05	2.35
8.	Min. width of pronotum	1.0	1.1	1.3	1.4	1.7	2.5	3.0	3.9	2.1
9.	Length of pronotum	0.96	1.2	1.73	2.15	2.3	3.7	4.5	6.2	4.15
10.	Height of pronotum	0.91	1.14	1.3	1.6	2.4	3.4	3.9	4.6	2.35
11.	Length of profemur	1.28	1.8	2.2	3.5	3.7	5.1	5.5	7.25	4.55
12.	Length of mesofemur	1.37	1.94	2.33	3.65	4.1	6.0	6.6	10.0	5.25
13.	Length of metafemur	4.46	5.84	7.6	9.72	12.4	20.1	20.7	31.05	15.1
14.	Length of metatibia	4.46	5.81	8.2	9.75	19.0	20.0	22.0	29.2	14.8
15.	Length of elytron	-	-	-	-	-	-	-	34.75	23.3

Table3. Morphometry of *Acrida gigantea* (27°C±1°C).

S. no	Body parts	I instar	II instar	III instar	IV instar	V instar	VI instar	VII instar	Adult female	Adult male

1.	Body length	8.81	10.00	10.2	20.6	20.8	38.00	41.6	47.0	32.4
2.	Max. width of head	0.98	1.0	1.05	1.5	1.6	2.5	2.8	3.5	1.7
3.	Length of antenna	2.41	2.53	3.88	5.65	6.8	10.00	11.00	12.0	9.05
4.	Width of vertex b/w eyes	0.65	0.71	0.78	0.90	1.00	1.2	1.3	1.3	1.00
5.	Vertical dia. of eyes	1.23	1.24	1.3	1.75	2.0	2.3	2.5	2.7	2.1
6.	Horizontal dia. of eyes	0.54	0.6	0.65	0.85	0.93	1.1	1.19	1.3	1.0
7.	Max. width of pronotum	1.0	1.1	1.2	1.45	1.5	2.3	3.0	3.9	2.2
8.	Min. width of pronotum	0.85	0.9	0.95	1.3	1.4	1.9	2.3	3.8	2.0
9.	Length of pronotum	0.96	1.17	1.5	1.9	3.0	3.5	4.0	7.3	4.05
10.	Height of pronotum	0.88	0.97	1.3	1.55	2.4	3.4	3.9	4.55	2.3
11.	Length of profemur	1.19	1.4	2.06	2.87	3.3	4.5	5.0	7.2	4.4
12.	Length of mesofemur	1.26	1.82	2.0	3.6	4.0	6.0	6.6	9.8	5.1
13.	Length of metaemur	4.41	5.0	6.38	7.46	12.4	20.0	20.5	30.8	15.1
14.	Length of metatibia	4.5	5.3	7.7	9.75	15.5	17.8	20.0	29.0	14.6
15.	Length of elytron	-	-	-	-	-	-	-	34.0	23.1

The effects of temperature and humidity on hoppers' development must be discussed together because it is very difficult to separate the two factors in experimental work. The temperature and humidity have marked influence on the development. On the one hand, the relative humidity of the air varies with temperature, and on the other the hopper's metabolism is possibly more affected by the water content of food than by air humidity, both of which may influence the quantity of food consumed and therefore the rate of growth. Nevertheless, some evidence of temperature effect should be mentioned. Parker (1930) in his extensive experiments with *Melanoplus mexicanus mexicanus* Saussure and *Camnula pellucida* Scudder clearly indicated a shortening of hopper period and an accelerated rate of development with rising in temperature. Shamshad (1982) also described the same conditions when applied on *Acrida exaltata*, while Hamilton (1936, 1950) studied the relation of temperature and humidity to the development of *Locusta migratoria migratorioides, Schistocerca gregaria* and *Nomadacris septemfasciata*.

The rate of development increases at high temperature and high humidity with the least hopper duration, while the rate of development decreases and hopper duration increases with decrease in temperature and humidity. The moulting period of each instar varies from 7 to 9 days at 37ºC±1°C (70-80% RH), while at 27ºC±1°C (50-60% RH) the number of days varies from 8 to 12 days (Table 1and Graph 1). The extremes of temperature were also tested at 10ºC and 45ºC. It was concluded that the hoppers could not survive these extreme temperature in lab conditions, while in the fields they are found around the year but flourish mostly during the monsoon period.

As far as the morphometry of hoppers is concerned, it was observed that the individuals reared at 37°C are somewhat larger than those reared at 27°C (Tables 2 and 3).

The phenomenon of cannibalism was also observed in this species during the course of the study. This phenomenon was dominant in females as compared to males. The rate of cannibalism also increases with the increase in temperature and scarcity of food.

During the whole study more females were obtained at 37ºC while more males were obtained at 27ºC.

The average longevity of adults at 37ºC and 70-80% RH was about 40-50 days, while at 27ºC number of days decreased to 20-30.

Hence the temperature and humidity affect the duration of the life cycle, incubation period, rate of moulting, and rate of development of *Acrida gigantea*.

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