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Biology and morphometric variation within local species of *Kharif* grasshopper, *Hieroglyphus nigrorepletus* Bolivar in South-western Rajasthan

Pradeep Singh Rathore, Shravan M. Haldhar* and R. Swaminathan

Maharana Pratap University of Agriculture and Technology, Udaipur - 313 001, Rajasthan, India

ABSTRACT

The mean development period from egg to adult was 62.2 days and the adult males lived a little longer (52.10 days) than the females (43.60 days). A single female could lay about 2 egg pods with nearly 32 eggs per pod that had a hatchability of 66.40 per cent. The duration of nymphal stage I was the shortest (5.80 ± 0.35), while that of the nymphal stage VI was the longest (11.20 ± 0.42). The observed linear morphometric variation within the local species of the *H. nigrorepletus* was evident as per mean values for the different traits measured. The lengths of antennae, tegmina, hind wing, body up to genitalia / wing tip, pronotum, and the sternal region were relatively more for the females than the males; similarly the width of tegmina, body, pronotum, and the sternal region were also relatively more for the females. The maximum coefficient of variation was noted for the length of hind pretarsus (male) 16.75% and minimum was recorded in width of body (male) 2.81% in *H. nigrorepletus* (*brachypterus*). In *H. nigrorepletus* (*trachypterus*), the maximum coefficient of variation was found in length of fore pretarsus (male) 17.61 and minimum variation was recorded in length of hind legs (female) 3.84%.

Key words : *Kharif* grasshopper, *Hieroglyphus nigrorepletus*, biology and morphometrics.

INTRODUCTION

In grassland faunal surveys, grasshoppers are among the most conspicuous insects, and they often constitute one of the dominant groups of arthropods in terms of their contributions to diversity, abundance and biomass (Watts, 1989; Joern and Gaines, 1990; Lockwood, 1997). It is generally established that the occurrence of acridid species primarily depends on the presence of host plant species (Kemp *et al.* 1990a; 1990b). Records of grasshopper fauna representing 17 genera in Rajasthan desert zones in the thirties and the need for intensive studies on this group, which comprise a wide spectrum pest complex, was emphasized by Ramchandra Rao (1960). Kushwaha (1968) conducted a survey of insect pests of pastures that included 35 species of Acridids.

Hieroglyphus nigrorepletus Bolivar is the *kharif* grasshopper, popularly known as "*Phadka*", distributed throughout India, Pakistan and Bangladesh. Of late, it has attained economic importance due to the serious damage caused by this pest to various crops. The detailed biology of this insect has been worked out by a few workers. Pradhan and Peswani (1961) recorded the univoltine nature of the insect indicating that the eggs laid during one season never hatch during same season. Similar observations were recorded by Roonwal (1976) and Roonwal (1978). Siddiqui (1985) on studying the mating behaviour of *H. nigrorepletus*, indicated that the males and females mature for mating after 7.1 ± 0.39 days following emergence with the typical riding-type of mating commonly observed in grasshoppers.

*Corresponding author's present address: CIAH, Bikaner - 334 006, Rajasthan, India. E-mail: haldhar80@gmail.com

MATERIALS AND METHODS

Studies on biology and morphometrics of *H. nigrorepletus* were carried out under laboratory conditions for two successive *kharif* seasons. The grasshopper was reared in the laboratory maintaining the room temperature at 28 ± 2°C with a relative humidity of 60 ± 5 percent.

Biology : Adults of *H. nigrorepletus* were collected from the farmer's fields of sugarcane, maize and sorghum within 25 km radius of Udaipur. The collected *kharif* grasshoppers were maintained in wooden frame wire gauge cages (50 cm × 50 cm

× 60 cm) with a glass covered top. One pair of adults was kept in one cage and a total of 10 such cages were maintained. Fresh food comprising maize leaves was provided regularly. The leaves were kept fresh by using distilled water and food was provided every day. In order to facilitate climbing, moulting, basking, *etc.* a dry twig with branches was also provided in the cage. Sterilized, sieved dry desert sand with 15 percent moisture was kept in every cage with depth of at least 10 cm for oviposition. The egg pods laid by the females were kept in glass vials (100 ml) separately (one in each vial) and replicated 10 times. The pods were covered with sand (medium) and kept in a BOD incubator at 30°C and 70 percent R.H., as suggested by Pradhan and Peswani (1961). Care was taken to keep the soil moist using distilled water. The duration and number of nymphs that hatched out were recorded. Immediately after hatching young nymphs were transferred into the rearing cages. Ten nymphs were confined to one cage and two such sets were maintained. The rearing cages were maintained at 28 ± 2°C and relative humidity 60 ± 5 percent. The date of each moulting was recorded carefully by observing the exuviae to ascertain the number of instars and duration of each nymphal period till it matured.

After attaining maturity, one pair each of male and female was transferred to rearing cage described earlier and five such cages were maintained providing the oviposition media. The date of first oviposition by female was noted. After initiation of oviposition, the plastic container with moist soil was replaced every day and number of egg pods laid by female, if any, was counted and the date of egg-laying was also recorded. The eggs were laid in an egg pod, the coat of which was hard. In order to study the egg and number of eggs per pod, the freshly laid eggs within the pod were kept in distilled water over night in a Petri dish. The next day (after 24 - 26 hrs) the Petri dish along with egg pod was shaken gently to separate the soil particles glued. The eggs were collected and counted. Ten egg pods were examined in this way to know the number of eggs per pod.

Morphometrics : Linear measurements of various body parts of male and female grasshoppers were measured under Stemi 2000 C Stereo Binoculars (Carl Zeiss) using the Axio Vision LE 4.5 software. The terminology used by Albrecht (1955) was adopted for denoting different parts of the body of the grasshopper. Similarly, counting of number of antennal segments and hind tibial spurs was done using the binocular. Ten specimens of each brachypterus and full winged (trachypterus) grasshopper species were observed for the study during the monsoon season (*kharif*). The major linear measurements taken have been tabulated hereunder:

S. No.	Body Parameters	Defined as
1.	Length of the antenna (A)	The distance from the basal segment, the scape up to the terminal segment
2.	Length of the tegmina (T)	The distance from the base of the radius and media to the apex of the tegmina
3.	Width of the tegmina (t)	The distance between the two parallel lines touching the anterior and the posterior boundaries of the tegmina
4.	Length of the wing (W)	The distance from the base of the costa to the apex of the wing
5.	Width of the wing (w)	The distance between the two parallel lines touching the anterior and posterior boundaries of the wing when fully stretched
6.	Length of the body up to wing tip (BW)	The distance from the anterior end of head to the apex of the tegmina
7.	Length of the body up to genitalia (BG)	The distance from the anterior end of head to the apex of the genitalia
8.	Width of the body (b)	The widest part of the thorax near the first abdominal segment
9.	Length of the pronotum (P)	The distance from the anterior end to the posterior end of the pronotum, measured along the medial pronotal carina
10.	Width of the pronotum (p)	The distance between the tips of the lateral edges of the pronotum
11.	Length of the fore leg (FL)	The distance from the base of the trochanter to the tip of the claw
12.	Length of the middle leg (ML)	The distance from the base of the trochanter to the tip of the claw
13.	Length of the hind leg (HL)	The distance from the base of the trochanter to the tip of the claw

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S. No.	Body Parameters	Defined as
14.	Length of fore femur (FF)	The maximum length from base to the apex
15.	Length of middle femur (MF)	The maximum length from base to the apex
16.	Length of hind femur (HF)	The maximum length from base to the apex
17.	Width of the hind femur (hf)	The maximum width of femur from margin to margin
18.	Maximum head length (H)	The distance between the vertex to the posterior end of labrum
19.	Maximum head width (h)	The maximum width of head at the genal region
20.	Vertical diameter of eyes (VD)	The length of eyes in longitudinal direction
21.	Horizontal diameter of eyes (HD)	The length of eyes in horizontal direction

RESULTS AND DISCUSSION

Based on the biological parameters of the *phadka* grasshopper, *H. nigrorepletus*, it could be observed that the mean development period from egg to adult was 62.2 days (Table 1). The adult males lived a little longer (52.10 days) than the females (43.60 days). A single female could lay about 2 egg pods with nearly 32 eggs per pod that had a hatchability of 66.40 per cent. The morphometric variations in both forms of the grasshopper, *trachypterus* and *brachypterus*, have been depicted in Tables 2 to 5. It was notable that, irrespective of the form (*trachypterus* or *brachypterus*), the females were relatively larger than the males in their body length measured from tip of head to tip of genitalia (Fig. 1). During the present study it was clear that *H. nigrorepletus* has only one generation during the year and that it passes through six nymphal stages to become an adult. The mean duration of different nymphal stages from I through VI was 46.5 days. The duration of nymphal stage I was the shortest (5.80 ± 0.35), while that of the nymphal stage VI was the longest (11.20 ± 0.42). The survival recorded was as low as 23 percent. The mean adult longevity was 52.10 ± 2.55 and 43.60 ± 2.75 for the males and females, respectively.

Morphological description of hoppers : The first instar hoppers have reddish brown eyes; antennae 10 - 14 segments, filiform, thin apically; pronotum cylindrical, markings not clear; prozona larger than metazoan; abdomen yellowish green in colour; hind femur and tibia yellowish green, tibia with spines. The second instar hoppers have brown eyes; antennae with 14 - 20 segments; frontal ridge with strong

Table 1. Biology of *Hieroglyphus nigrorepletus* Bolivar.

S. No.	Biological parameters	Period (Days)		
		Minimum	Maximum	Mean ± S.Em.
1.	Adult longevity:			
	Male	30	67	52.10 ± 2.55
	Female	20	66	43.60 ± 2.75
2.	Pre oviposition period	3	9	05.30 ± 0.32
3.	Oviposition period	9	27	14.90 ± 0.82
4.	Number of egg pods/female	1	4	01.75 ± 0.20
5.	Number of eggs/pod (Hatching %)	24 (49)	45 (77)	31.95 ± 1.15 (66.40 ± 1.88)
6.	Incubation period	11	18	14.40 ± 0.46
7.	First Instar	3	8	05.80 ± 0.35
8.	Second Instar	5	9	06.90 ± 0.26
9.	Third Instar	6	9	07.85 ± 0.24
10.	Fourth Instar	6	9	07.90 0 ± 0.21
11.	Fifth Instar	6	10	08.15 ± 0.22
12.	Sixth Instar	8	14	11.20 ± 0.42

Table 2. Morphometric variation in *Hieroglyphus nigrorepletus* (*brachypterus*).

S. No.	Body parts measured (mm)		Male		Female	
			Mean ± S. Em	CV (%)	Mean ± S. Em.	CV (%)
1	Length of antenna		17.81 ± 0.59	10.44	14.13 ± 0.55	12.21
2.	Length of parts of antenna	Scape	0.76 ± 0.03	10.96	0.62 ± 0.03	14.24
		Pedicel	0.51 ± 0.02	12.26	0.46 ± 0.01	9.11
		Flagellum	16.55 ± 0.58	11.04	13.04 ± 0.55	13.29
3.	Length of body up to genitalia		36.40 ± 1.10	9.53	43.20 ± 0.92	6.71
4.	Width of body		7.44 ± 0.07	2.81	9.96 ± 013	4.04
5.	Length of pronotum		8.41 ± 0.30	11.13	9.93 ± 0.21	6.59
6.	Width of pronotum		6.43 ± 0.21	10.25	7.92 ± 0.19	7.37
7.	Length of head		4.72 ± 0.13	8.67	5.78 ± 0.18	10.01
8.	Width of head		5.58 ± 0.17	9.53	6.75 ± 0.14	6.31
9.	Width of vertex		1.62 ± 0.05	10.44	2.40 ± 0.06	7.74
10.	Vertical diameter of eye		3.13 ± 0.07	6.69	3.08 ± 0.09	8.85
11.	Transverse diameter of eye		2.17 ± 0.04	6.09	2.09 ± 0.05	7.29
12.	Length of sternum region		9.46 ± 0.30	9.87	10.65 ± 0.22	6.51
13.	Width of sternum region		6.11 ± 0.18	9.27	8.42 ± 0.18	6.57
			Body parts counted (No.)			
1.	Tibial spines on fore leg	Inner	7.50 ± 0.17	7.03	7.40 ± 0.22	9.45
		Outer	5.30 ± 0.15	9.11	5.10 ± 0.18	11.13
2.	Tibial spines on middle leg	Inner	10.10 ± 0.38	11.85	10.20 ± 0.29	9.00
		Outer	4.50 ± 0.22	15.71	4.50 ± 0.16	5.49
3.	Tibial spines on hind leg	Inner	9.40 ± 0.16	5.49	10.00 ± 0.15	4.71
		Outer	8.80 ± 0.25	8.96	9.30 ± 0.26	8.85

depression; elytron and wing rudiments visible; abdomen yellowish green without markings; tibia yellowish green with spines more distinct. Third instar hoppers are very active; antennae have 14 - 24 segments; clypeus divided by a thin yellowish line; frontal ridge with deep depression; elytron and wing rudiments more distinct; tarsi with dark/ blackish tip. Fourth instar hoppers are very active, antennae with more than 20 segments (20 - 25); fastigium of vertex extended; meso- and meta-notum with brown dots; cerci well developed. In fifth instar hoppers, the antennae with more than 20 segments (25 max.); frontal ridge withslight depression; eye pigment more prominent; prozona slightly rounded than metazoan; elytron and wing rudiments developed and conspicuous; male - female genitalia developed. Sixth instar hoppers have antennae with 24 - 26 segments; lateral side of pronotum with prominent yellowish colour where the sulci develop; four sulci distinct laterally on pronotum; elytron and wing rudiments more clear; genitalia developed, the male genitalia extending beyond the hind end of the sternum; in female the ovipositor valves extending backwards (Table 6). The structural details of the adult grasshopper head and thoracic parts have been presented in Figs. 2 and 3.

Pruthi (1949) stated that *H. nigrorepletus* undergoes five moults to develop as an adult; Srivastava (1956) recorded seven moults; Pradhan and Peswani (1961) observed a variation in the number of moults being 6 to 7 times; Roonwal (1976) opined that there were 6 hopper stages with usually 6 moults, but sometimes an occasional 7th moult could occur. From the present study and from the available literature it has become increasingly clear that considerable variation in the number of moults occurs, which might be due to the effect of prevailing climatic conditions of the region. One of the plausible reasons for irregularity of growth rate all through the instars might be due to the different

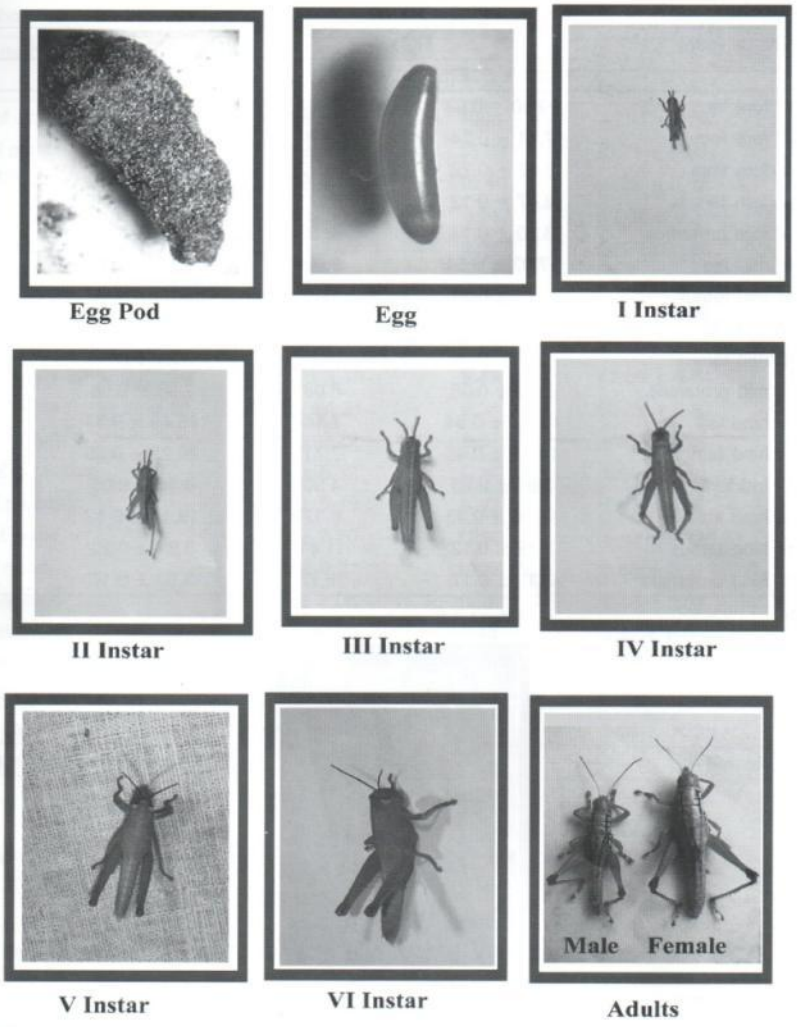

Fig. 1. Biology of Hieroglyphus nigrorepletus Bolivar

rates of growth between the various body parts and between the instars for the same body part. There are of course some individual variations within species as well as different species due to sex. As far as colour morphism is concerned, explanation for this variation is due to different ages and sexes of the insect under different culturing condition, habitat and season of the region.

Roonwal (1945) observed that *H. nigrorepletus* undergoes only one generation each year. Our studies also conform to this fact and eggs laid in September hatch out in the following year during June/ July after initiation of monsoon showers. According to the earlier workers it is well known that earlier and uniformly distributed rains create favourable conditions for the species. However, Riffat and Wagan (2007) have opined that their findings slightly differ with that of Roonwal (1945) and hatching is delayed for the reason that monsoon rains begin in June-July in India, whereas monsoons

Table 3. Linear variations in Legs of *Hieroglyphus nigrorepletus* (*brachypterus*).

S. No.	Measurements (mm)	Male		Female	
		Mean ± S. Em.	CV (%)	Mean ± S. Em.	CV (%)
1.	Length of fore legs	19.50 ± 0.63	10.27	18.12 ± 0.36	6.33
2.	Length of fore femur	7.91 ± 0.24	9.61	7.08 ± 0.15	6.55
3.	Length of fore tibia	5.82 ± 0.22	13.22	5.62 ± 0.12	6.93
4.	Length of fore tarsus	2.47 ± 0.13	16.21	2.44 ± 0.08	9.86
5.	Length of fore pretarsus	3.30 ± 0.14	13.09	2.99 ± 0.08	8.21
6.	Length of mid leg	17.93 ± 0.51	9.02	18.17 ± 0.29	5.04
7.	Length of mid femur	6.70 ± 0.21	10.07	6.72 ± 0.11	5.10
8.	Length of mid tibia	6.25 ± 0.23	11.69	6.38 ± 0.15	7.23
9.	Length of mid tarsus	1.96 ± 0.06	10.26	2.09 ± 0.04	5.73
10.	Length of mid pretarsus	3.02 ± 0.08	8.08	2.98 ± 0.06	6.90
11.	Length of hind leg	41.67 ± 0.94	7.16	46.49 ± 0.87	5.90
12.	Length of hind femur	18.45 ± 0.45	7.71	20.25 ± 0.36	5.85
13.	Width of hind femur	3.95 ± 0.05	4.00	4.10 ± 0.08	5.89
14.	Length of hind tibia	16.90 ± 0.43	8.12	19.10 ± 0.43	7.17
15.	Length of hind tarsus	3.19 ± 0.12	11.41	3.64 ± 0.20	17.74
16.	Length of hind pretarsus	3.13 ± 0.17	16.75	3.50 ± 0.17	15.46

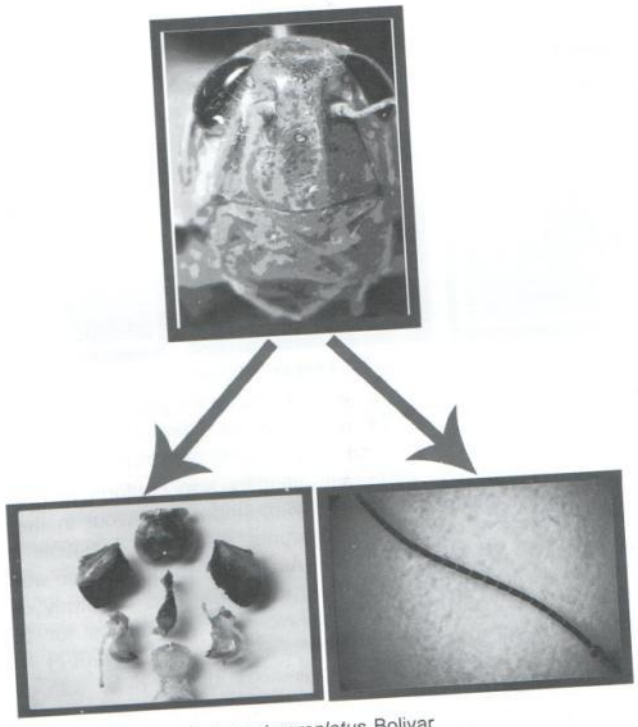

Fig. 2. Structural details of head of *Hieroglyphus nigrorepletus* Bolivar

Table 4. Morphometric variation in *Hieroglyphus nigrorepletus* (*trachypterus*).

S. No.	Body parts measured (mm)		Male		Female	
			Mean ± S. Em.	CV (%)	Mean ± S. Em.	CV (%)
1	Length of antenna		15.9 ± 0.30	6.00	13.91 ± 0.34	7.68
2.	Length of parts of antenna	Scape	0.68 ± 0.03	13.39	0.71 ± 0.03	11.19
		Pedicel	0.53 ± 0.02	10.40	0.52 ± 0.02	14.92
		Flagellum	14.74 ± 0.29	6.24	12.68 ± 0.31	7.63
3.	Length of tegmina		34.9 ± 1.09	9.88	37.7 ± 0 .56	4.69
4.	Width of tegmina		7.34 ± 0.10	4.57	9.0 ± 0.02	0.87
5.	Length of wing		30.9 ± 0.88	9.08	35.0 ± 0.49	4.47
6.	Width of wing		13.9 ± 0.21	4.81	16.6 ± 0.24	4.65
7.	Length of body up to genitalia		38.65 ± 1.16	9.49	42.56 ± 0.74	5.46
8.	Length of body up to wing tip		47.54 ± 1.21	8.04	50.38 ± 0.83	5.21
9.	Width of body		7.28 ± 0.22	9.57	8.90 ± 0.23	8.21
10.	Length of pronotum		9.42 ± 0.32	10.63	9.80 ± 0.28	9.06
11.	Width of pronotum		7.37 ± 0.15	6.42	7.91 ± 0.16	6.33
12.	Length of head		4.88 ± 0.20	12.99	5.19 ± 0.12	7.47
13.	Width of head		6.28 ± 0.21	10.75	6.68 ± 0.11	5.41
14.	Width of vertex		1.91 ± 0.08	13.07	2.46 ± 0.07	9.00
15.	Vertical diameter of eye		3.27 ± 0.09	8.44	3.17 ± 0.09	9.37
16.	Transverse diameter of eye		2.40 ± 0.06	8.03	2.12 ± 0.06	8.18
17.	Length of sternum region		10.74 ± 0.23	6.63	11.87 ± 0.17	4.47
18.	Width of sternum region		7.17 ± 0.26	11.43	8.69 ± 0.23	8.26
	Number of tibial spines		Male		Female	
1.	Fore leg	Inner	7.40 ± 0.16	6.98	7.40 ± 0.16	6.98
		Outer	4.20 ± 0.13	8.78	5.20 ± 0.13	8.11
2.	Middle leg	Inner	10.20 ± 0.49	15.19	10.60 ± 0.34	10.14
		Outer	3.80 ± 0.13	11.10	4.00 ± 0.21	16.67
3.	Hind leg	Inner	10.00 ± 0.21	6.67	10.00 ± 0.23	5.26
		Outer	9.20 ± 0.13	4.58	9.20 ± 0.25	8.57

are late in July-August in the NWFP of Pakistan. Maximum population of the hoppers as well as the adults has been reported during the warmer months of the year (July and August) by many workers, as cold temperatures are unfavourable for the species. The males of *H. nigrorepletus* show sexual behaviour a week after their final ecdysis with the peak sexual activity between 15th to 20th day of adult life, while the females become receptive to courting males 3 to 5 days after their final moult (Singh *et al.* 1998). In another study, Singh *et al.* (2002) have observed the effect of different levels of temperature and relative humidity on the development of *H. nigrorepletus*. Reportedly, hoppers appear to be more epidemic than adults (Riffat and Wagan, 2007). Recently, report on the detailed study on the biology and bionomics of the rice grasshopper, *H. nigrorepletus* at Sardakrushi Nagar, Gujarat has been made by Muralidharan and Patel (2007).

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Table 5. Linear variations in legs of *Hieroglyphus nigrorepletus* (*trachypterus*).

S. No.	Measurements (mm)	Male		Female	
		Mean ± S. Em.	CV (%)	Mean ± S. Em.	CV (%)
1.	Length of fore legs	19.28 ± 0.44	7.17	16.94 ± 0.27	4.99
2.	Length of fore femur	7.13 ± 0.21	9.49	6.42 ± 0.10	5.13
3.	Length of fore tibia	6.28 ± 0.18	8.97	5.78 ± 0.11	5.93
4.	Length of fore tarsus	1.96± 0.02	3.57	1.95 ± 0.10	16.26
5.	Length of fore pre-tarsus	3.91 ± 0.22	17.61	2.79 ± 0.13	14.58
6.	Length of mid leg	19.19 ± 0.40	6.66	18.19 ± 0.35	6.14
7.	Length of mid femur	7.28 ± 0.13	5.75	6.74 ± 0.13	6.03
8.	Length of mid tibia	6.60 ± 0.15	6.96	6.30 ± 0.20	10.04
9.	Length of mid tarsus	2.07 ± 0.05	7.91	2.21 ± 0.11	15.60
10.	Length of mid pre-tarsus	3.24 ± 0.16	15.27	2.94 ± 0.06	6.45
11.	Length of hind leg	49.56 ± 1.23	7.81	53.15 ± 0.65	3.84
12.	Length of hind femur	19.92 ± 0.52	8.23	21.00 ± 0.33	5.02
13.	Width of hind femur	4.53 ± 0.15	10.74	4.85 ± 0.15	9.82
14.	Length of hind tibia	17.90 ± 0.48	8.41	19.45 ± 0.28	4.61
15.	Length of hind tarsus	3.45 ± 0.19	17.35	4.05 ± 0.05	3.90
16.	Length of hind pre-tarsus	3.76 ± 0.13	10.58	3.80 ± 0.08	6.80

Table 6. Linear morphometric data for nymphal stages of *Heiroglyphus nigrorepletus* Bolivar.

S. No.	Measurement (mm)	Mean linear morphometric data for different nymphal instars					
	Instars	I	II	III	IV	V	VI
1.	Length of body	5.672 ± 0.255	10.824 ± 0.213	16.102 ± 0.439	25.107 ± 0.281	31.443 ± 0.397	34.357 ± 0.510
2.	Length of antenna	1.049 ± 0.050	3.326 ± 0.108	4.785 ± 0.154	7.176 ± 0.063	9.585 ± 0.203	10.867 ± 0.225
3.	No. of antennal segments	16.500 ± 0.158	20.500 ± 0.475	23.000 ± 0.316	24.500 ± 0.158	25.900 ± 0.095	26.000 ± 0.000
4.	Length of head	2.551 ± 0.017	3.358 ± 0.140	4.831 ± 0.140	5.985 ± 0.236	6.939 ± 0.247	8.383 ± 0.211
5.	Width of head	1.359 ± 0.043	1.943 ± 0.028	2.401 ± 0.079	3.823 ± 0.040	4.371 ± 0.086	5.000 ± 0.087
6.	Width of vertex	0.566 ± 0.024	0.761 ± 0.006	0.996 ± 0.049	1.095 ± 0.040	1.566 ± 0.101	1.779 ± 0.086
7.	Length of eyes	1.335 ± 0.056	1.598 ± 0.029	1.766 ± 0.054	2.662 ± 0.146	2.580 ± 0.140	2.677 ± 0.055
8.	Length of hind leg	7.766 ± 0.313	13.169 ± 0.234	18.333 ± 0.445	23.698 ± 0.808	33.009 ± 0.756	34.556 ± 1.346
9.	Length of pronotum	1.118 ± 0.056	2.077 ± 0.162	3.078 ± 0.030	4.966 ± 0.214	6.497 ± 0.112	8.187 ± 0.154

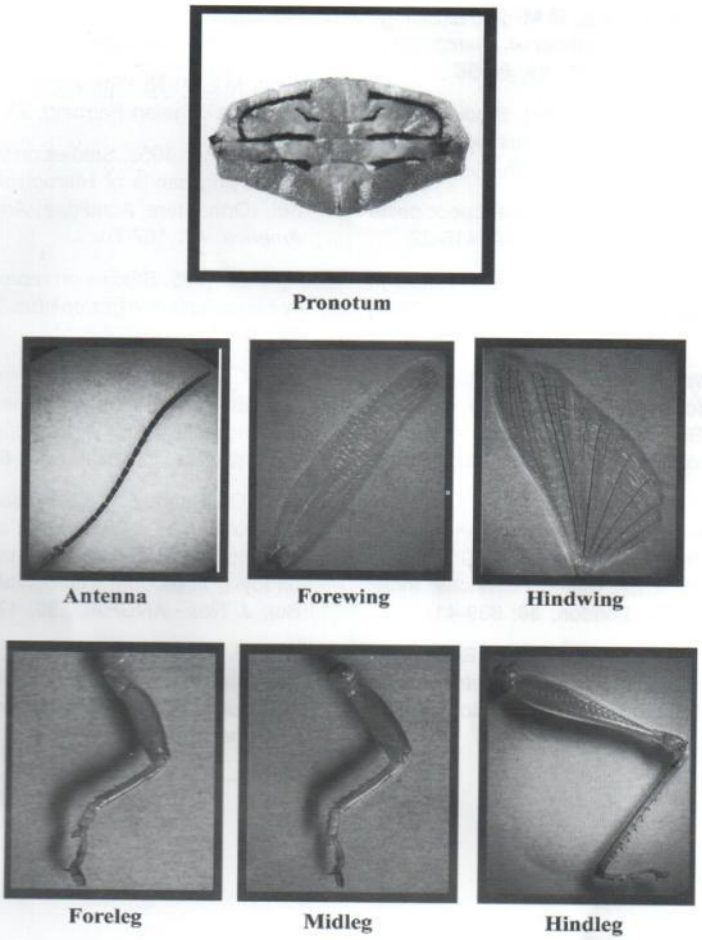

Fig. 3. Structural details of the pronotum, wings and legd of *Hieroglyphus nigrorepletus* Bolivar

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