

Notes on Taxonomy, Distribution and Ecology of *Hieroglyphus nigrorepletus* I. Bolivar, 1912 (Hemiacridinae: Acrididae: Orthoptera), a Major Paddy Pest in Pakistan*

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Abstract.- In addition to our previous work, further incidences of *Hieroglyphus nigrorepletus* I. Bolivar, 1912 were reported from different climatic zone of Pakistan. This pest is injurious to sugarcane, wheat, millets and fodder crops in some area but cause severe defoliation of maize and rice all over the country. A fairly large number of specimens were recorded from N.W.F.P for the first time. Collection of single female from desert area Nagar Parkar (Thar) constituted the first record for this area of Sindh province. *H. nigrorepletus* based on a reticulum of black lines on the lateral side of pronotum. The pest occurred in brachypterous (short-winged) and macropterous (long-winged) forms, but brachypterous form was more common. This species also occurs in two color forms *i.e.* brown and green; brown spots found on the abdomen were reported for the first time. Furthermore, apical diverticulum showed great intra-specific variations both in size and shape. Hoppers usually emerge in the field in July immediately after the monsoon begins. During their early stages (I to III) hoppers vigorously feed on *Penicum tergidum*, *Digitaria* sp. and other grasses. After a fortnight they enter fields of maize and paddy. The adults preferred to feed on fresh and new leaves of rice and maize. Population of adults was at its peak from August to October. However, it rapidly decreased in months of November and there was no adult found in the month of December.

Key words: Brachypterous, macropterous, severe defoliation, maize, rice, *Penicum tergidum*, N.W.F.P, Nagar Parkar.

INTRODUCTION

The acridid grasshopper *Hieroglyphus nigrorepletus* I. Bolivar, 1912 is reported as a major pest of rice, sugarcane, wheat, maize and a minor pest of millets and fodder crops in Pakistan and India (Roonwal, 1978; Riffat *et al.*, 2007). It is considered a pest of great economic importance. Ghouri and Ahmed (1960) reported a medium-sized swarm (500 specimens) of *H. nigrorepletus* from Malir and smaller swarm was also examined from Bela, Karachi, Malir and Thatta and parts of Hyderabad. Similarly Moizuddin (2001) and Jhala and Sisodiya (2003) reported incidences of *H. nigrorepletus* in desert area of Lasbela, Balochistan, Pakistan and the Gujrat district of India. Qadri (1971) recorded irregularly or regularly occurring outbreaks in Pakistan caused by 4 orthopteran

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species including *H. nigrorepletus*. Several authors made casual reference to *Hieroglyphus* spp. (Bhatia *et al.*, 1965; Singh, 1972; Mason, 1973; Alam and Alam, 1977; Irshad, 1977; Irshad *et al.*, 1977; Hashmi, 1994; Moizuddin, 1988; Karim and Riazuddin, 1999). Breeding habits of *Hieroglyphus* spp. have been studied by Roonwal (1945, 1976a, b, 1978), Srivastava (1956), Janjua (1957), Pradhan and Peshwani (1961), Rizvi and Khan (1970), Jotwani and Butani (1978), Siddiqui (1986, 1989), Wagan and Riffat (2006) and Riffat and Wagan (2007).

Recently, Riffat *et al.* (2007) carried out extensive work on the distribution of *H. nigrorepletus* from Pakistan but did not study the concealed genital, morphology and ecology of this pest. It is therefore, imperative to conduct a critical study of *H. nigrorepletus* from this region. The present study augments our knowledge on the current status of this pest and the variation in the concealed genitalia components. Furthermore, a

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comprehensive account on the habits and habitat of this pest in field will be instrumental in understanding and devising population management strategies, which could help avoid or prevent any possible future outbreak.

MATERIALS AND METHODS

Collection, killing and preservation of grasshoppers

The stock of *H. nigrorepletus* was collected from the paddy fields surrounded by grasses with the help of traditional insect hand-net (8.89 cms in diameter and 50.8 cms in length) as well as by hand picking. The collection was made during the year 2005-2006 in the months of July-November from various provinces of Pakistan. The collected material was transferred to the laboratory in polythene bags and killed in standard entomological bottle containing KCN. The specimens were stretched on the stretching board till they dried. Later the insects were stored in insect's boxes with the labels showing locality, date and collector's name.

Dissection of phallic complex

For the study of male genitalia the method described by Kevan *et al.* (1969) was adapted. The method of softening the abdominal terminalia was not followed by immersing these in hot water, but by relaxing the whole insect for 24 hours over water in a small dessicator to which a few drops of phenol /70% alcohol was added to prevent fungal growth. The supra-anal plate of the specimen was, later raised with a needle and cut laterally to take out the whole phallic complex. The phallic complex was then immersed in 10% hot KOH 5-10 hours in order to remove unsclerotized and non-chitinous tissues before being transferred to microvials for storage. The microvials were pinned through their rubber stoppers beneath the insects from which the phallic structure had originally been extracted. Difficulty in maintaining proper orientation of the specimens was overcome by supporting them in the required position with small pieces of absorbent cotton fiber.

The female genitalia was studied according to Randell (1963). After relaxing the insect as per method mentioned above, with the help of fine scissors an incision was made on each side of the

abdomen where the tergum meets the subgenital plate, and was continued just far enough anteriorly to allow easy removal of the extra plate. The spermatheca which lies just above the vagina was also removed. The dissected subgenital plate and spermatheca was then washed with 10% KOH and examined in water. The diagrams were drawn with the help of "Ocular Square Reticule". The terminology of Dirsh (1956, 1957) with regard to the phallic complex and female genitalia is adopted. Identification of specimen was carried out under the dissecting stereoscopic microscope. All measurements are given in millimeter.

Material examined

Sindh: Larkana; Naw Dero, Shikarpur, Gari Yaseen, Madegi, Badin; Thando Bago, Telhar Golarchi, Hyderabad, Tando Mohammed Khan, Serri, Tando Allahyar, Khairpur, Sukkur Ghotki, Jacobabad, Thatta, Sujawal, Mirpur; Sukkaro, Umerkot, Nagarparkar, Tarparkar Maati, Tharparkar, Ali Bunder Nawabshah, Kotri; Karachi; Lakhi Shah Saddar, Malir, Dadu, Jamshoro. Punjab: Rawalpindi, Seraykharboza, Islamabad, Serai, Simly Dam, Faisalabad, Lahore, Behawalpur, Chakwal. N.W.F.P: Mansehra, Shinkari, Hajjiabad, Battle, Dadual, Mara, Buffa, Abbotabad, Qulanderabad, Haripur, Sokka Swat; Balochistan: Barkhan, Lasbela, Uthal.

RESULTS

Hieroglyphus nigrorepletus I. Bolivar, 1912

Male (Fig. 1A)

Size large, robust, integument shallow, pitted shiny. Hairy on three distal abdominal sternites. Antennae (25-28) segments. Fastigium of vertex one-and-a-half time as broad as long; frontal ridge parallel, widening at ocellus. Pronotum with weak median carina dorsum crosses by three deep sulci, posterior margin of pronotum obtuse-angular sides expanded in metazona. Prosternal process (Fig. 3A) conical slightly curved apically, mesosternal interspace slightly open; metasternal interspace closed. Tegmina and wings extending up to 3rd abdominal terga. Hind femur moderately slender.

Supra-anal plate angular, with subacute apex. Cercus (Fig. 3B) simple longer than supra-anal plate slightly incurved, apex oblique, acute. Subgenital plate subacute.



A



B

Fig. 1. *Hieroglyphus nigrorepletus* I. Bolivar, 1912; A, male (brachypterous form); B, female (macropterous form)

Phallic complex (Fig. 2)

Epiphallus (Fig. 2D) very large, upper margin extending upward and inner margin curved upper, lophi large robust, ancorae small pointed curved inwards (Figs. 2A-C). Apodemes slightly larger than the basal valves of penis, broad, narrowing to obtuse apices (Fig. 2A). Zygoma of cingulum narrow; rami broad. Arch of cingulum somewhat rectangular (Fig. 2B). Penis with apical valves narrowing at apex; shorter and broader than valves of cingulum valves of cingulum narrow, upcurved, basal valves of penis robust and broad, dorsal ridge of valves smooth; gonopore process narrowing towards acute apex (Fig. 2C).

Coloration

Buff with yellowish buff patches; first, third and fourth sulci of pronotum with broad black bands on sides of pronotum. Third sulcus joins first laterally, two broad black parallel bands connect all sulci on dorsum; wing hyaline, veins dark brown or pale buff; hind knee black on inner and outer side, a black patch continues on tibia. Spurs of tibia black, tips of spines black; rest of tibia bluish buff. Brown and green color is more common.

Female (Fig. 1B)

As the male, but larger. Differs in fastigium of vertex being two-and-a-half time as broad as long; mesosternal interspace more open, subgenital plate with acute median lobe (Fig. 3C), spermatheca (Fig. 3D), small apical diverticulum long, narrow, curving back at basal end preapical diverticulum elongate, half length of apical diverticulum.

Measurements

Measurement of different body parts of brachypterous and macropterous forms has been shown in Table I. There was no significant difference in the antennal segments and length and the head in the male and female except that distance between two compound eyes was significantly greater in female compared with male. Length of pronotum, tegmina, femur and total body length was highest in female than male (Table I). As far as measurements of macropterous form is concerned (Table I) there was significant difference in antennal length and length of tegmina compare with measurement of brachypterous female while other all parameters were insignificant in both macropterous as well as in brachypterous forms of *H. nigrorepletus*.

Comparative account

This species was mentioned in literature as *H. furcifer* by Cotes (1891) and Lefroy (1906, 1907, 1909), who confused it with *H. banian*, but it has such characteristic marking and shape of the male cercus, that it is difficult to understand the confusion. It varies greatly in body-size and tegmina-form; the brachypterous form is more common and frequently more robust. Variation is also found in general coloration, from greenish buff

to buffish brown. The degree of black marking on the pronotum is also variable. The hind tibia varies

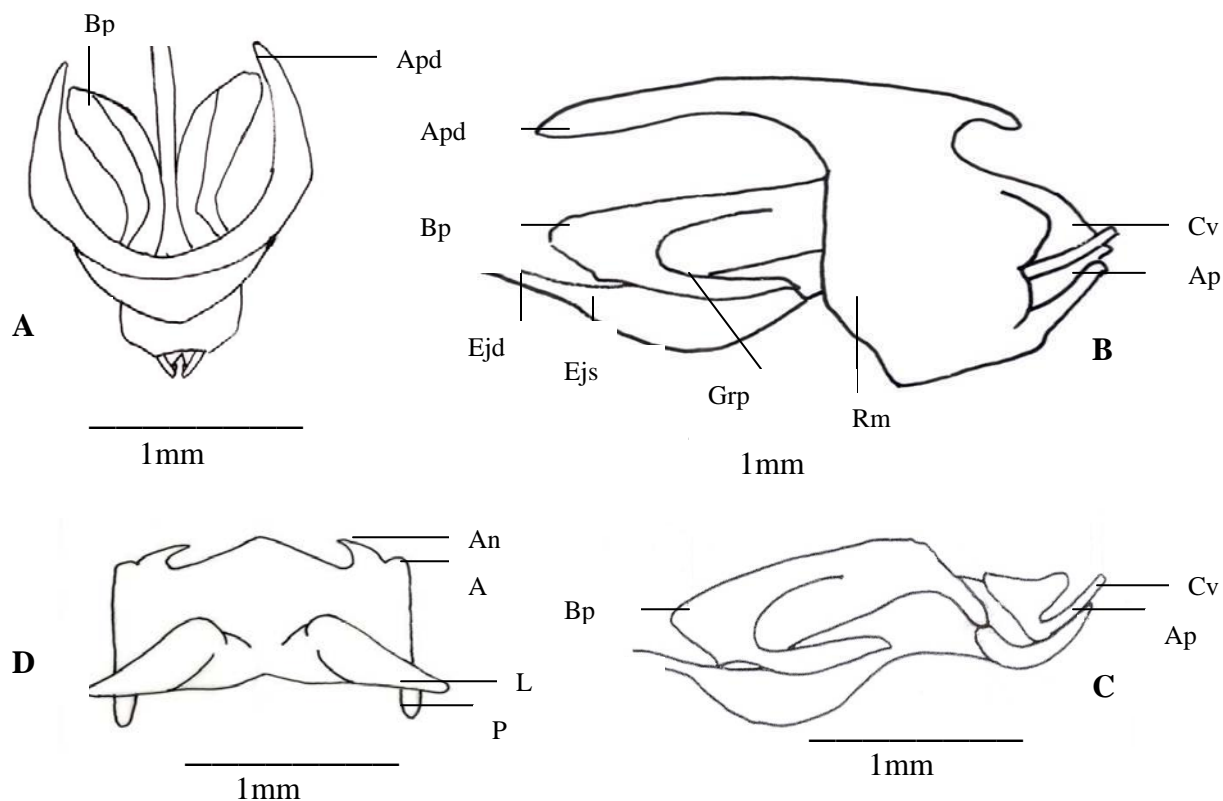


Fig. 2. Phallic complex of *Hieroglyphus nigrorepletus* A, with epiphallus and ectophallic membrane removed; B, same lateral view; C, Endophallus, lateral view; D, Epiphallus, dorsal view.
A, anchorae; Ac, arch of cingulum; An, anterior process of epiphallus; Ap, apical valves of penis; Apd, apodemes; Bp, basal valves of penis; Cv, valve of cingulum; Ejd, ejaculatory duct; Ejs, ejaculatory sac; Grp, gonopore process; P, posterior process; L, lophus; Rm, ramus of cingulum.

Table I.- Measurements (mm) of different body parts of *H. nigrorepletus*.

	Male (brachypterous form) (n=30)		Female (brachypterous form) (n=30)		Female (macropterous form) (n=1)
	Mean±SD	Range	Mean±SD	Range	
Antennal segment	26.44±0.6	25-28	26.64±0.6	25-28	24.00
Antennal length	10.31±0.5	9.1-11.2	10.44±0.6	9.1-11.55	13.65
Length of head	4.05±0.40	3.5-4.9	4.75±0.50	3.85-6.3	4.9.0
Distance between two compound eyes	1.69±0.30	1.4-2.8	2.49±0.41	1.75-3.15	1.75
Length of pronotum	7.72±0.60	6.3-9.1	9.25±0.46	8.4-10.5	8.40
Length of tegmina	13.93±1.8	11-19	15.51±1.6	13-19	35.00
Length of femur	17.03±2.7	11-21	21.03±1.9	19-24	18.00
Total body length	33.9±3.6	27-38	39.73±3.3	36-45	38.00

from bluish green to pale buff. In the general simple shape and oblique apex of the male cercus, this

species is related to *H. africanus*, but differs from it in the robustness of the body, the characteristic

more acute apices. The phallic complex is also more robust. The female subgenital plate has a small narrow median lobe with an acute apex, unlike *H. africanus*, which has a broad median lobe with a

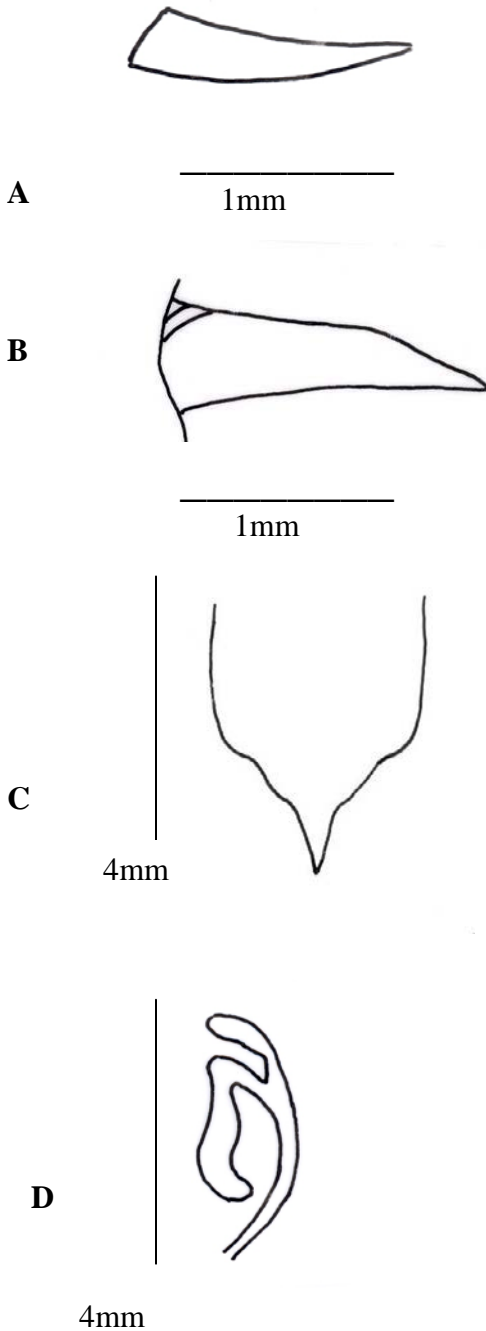


Fig. 3. *Hieroglyphus nigrorepletus*; A, prosternal process; B, cercus, lateral view; C, subgenital plate, ventral view; D, spermatheca.

subacute apex. We confirmed the findings of Uvarov (1922) and Mason (1973) on the basis of a large quantity of material collected and studied from Pakistan.

Ecological account

H. nigrorepletus is more dominant and widely distributed species in Pakistan. Hoppers usually emerge in field in the July immediately after the monsoon begins. They are found in fields having mixed vegetation of herbs and grasses mostly *Desmostachya bipinnata*. *H. nigrorepletus* is most abundant in areas which have huge rainfall annually.

During their early stages (I to III) hoppers vigorously feed on *Penicum tergidum*, *Digitaria* sp. and other grasses. After a fortnight they enter in fields of maize, jowar, and paddy. During the present investigation some observations were made in maize field. As the plants were growing normally until the hoppers reached the fourth or late instar at which time they started feeding vigorously on the leaves and damage to the leaves of maize became prominent and the loss of leaf material could be located from a distance. Their feeding on some plants was so vigorous that they were reduced into bare stems. The nymphs rarely descended down from the plants. These insects get within the leaf whorls where their fecal materials also collect, fungus developing on the rotting faeces results in a bad odour being emitted by the plant. Due to damage, the plant growth is arrested and size of plants reaches hardly four feet and the stems remain lean, with very few leaves.

The egg-pods are laid on bunds surrounding the rice and maize fields. The adults appear in breeding place in the second or third week of August when the grass reached the height of 4-6 feet. The adults gave preference to feeding on fresh and new leaves of rice and maize. Population of adults was at its peak from August to October. However, it rapidly decreased in months of November and there was no adult in the month of December.

Adults and hoppers are very active. They are found on stems and leaves of grasses. They quickly jump to the ground when the grass or plant is touched or disturbed with hands and move swiftly to hide themselves under the leaves of grass. Due to this behavior adults were collected with great

difficulty. Hoppers usually remain associated and confined to grass but some were also collected from the nearby cultivated fields. Since both hoppers and adults remain associated with leaves and stem of long grass and have a habit to jump to the ground and hide themselves under the leaves of grass, this help them to escape from the attack of predatory birds.

DISCUSSION

Like *H. daganensis* Krauss and *H. oryzivorus* Carl this species also occur in both macropterous and brachypterous forms. The macropterous form seems to be far less common than the brachypterous. According to Uvarov (1922) macropterous form occurs incidentally while Ghouri and Ahmad (1960) reported it in swarms. The specimens studied by the authors were all brachypterous with exception of only one female macropterous. Hence no further observations were made. Earlier Roonwal (1976) reported one macropterous male from India. Collection of large number of brachypterous form shows aggregation but, migration was not found during the present study.

A single female collected from the desert area of Nagar Parkar (Thar) constitutes the first record from this area for Sindh province. Earlier Bhatia *et al.* (1965) reported this pest from desert part of Rajasthan and Kutch district of Gujrat. This species also occurs in two color forms *i.e.* brown and green; brown spots found on the abdomen were not reported previously by Roonwal (1976a).

This species has been collected in large numbers from N.W.F.P as compared to the other provinces of Pakistan it might be due to favorable climatic conditions of this region. Earlier Janjua (1957) reported *H. nigrorepletus* from Hyderabad and Kalat division while Ahmed (1980) recorded it from all provinces of Pakistan. We confirm the presence of this species all over the country and its distribution has been extended to new localities.

Katiyar (1960) while studying on variation in the spermatheca of some Indian grasshoppers include *H. nigrorepletus* and figured preapical diverticulum of spermatheca as a simple tube with medially slightly curved and observed that in the

species to the genus *Hieroglyphus* the apical diverticulum shows great intra-specific variations both in size and shape. Moizuddin (1988) reported distinctly "E" shaped preapical diverticulum. On the other hand much elongated and convoluted lumen of duct in spermatheca has been observed by Mason (1973). Present work is in agreement with Mason (1973). However, the above differences in the spermatheca reported by various workers appear to be variations within the species.

In the male cercus Mason (1973) figured simply curved inner margin and in the epiphallus noted large lophi, but Moizuddin (1988) observed that in male cercus the inner margin is sinuated and apically before the projection and in epiphallus the lopi are small in size. Present work is in agreement with Mason (1973).

The above differences in male genitalia also appear to be variations within the species. Ingrisch (1989) has pointed out that the phallic complex is due to individual variation. Kevan and Lee (1974) have even shown that its form can change in adult grasshopper with age. Small difference in shape, especially when compared drawing of other authors should not be overestimated Ingrisch (1989).

Pradhan and Peswani (1961) and Bhatia *et al.* (1965) reported incidence of this pest from arid-zone regions and state that the young nymphs remain in bunds and mounds for about a fortnight and feed on weeds. They also state that nymphs and adults swim in water. Janjua (1957) stated that young hoppers first feed on grasses on the bunds of paddy field.

H. nigrorepletus is a major pest of rice (*Oryza sativa*), sugarcane (*Saccharum officinarum*), wheat (*Triticum aestivum*), maize (*Zea mays*), Sorghum jowar (*Sorghum vulgare*) and minor pest of millets (*Setaria italua*), bajar (*Pennisetum typhoideum*) and fodder crops in India and Pakistan (Roonwal, 1978). Present authors are also in agreement of this account. However, it is not minor pest for cultivated crops and vegetation as mentioned by Janjua (1957).

Overall, observations on field study of *H. nigrorepletus* show that during the earlier stages hoppers vigorously feed on *P. tergidum*, *C. dactylon*, *D. bipinnata* and other available grasses after that they enter in cultivated field. It was

reported that loss of hoppers was more epidemic than that of adults. Most probably due to lack of functional wings in earlier stages they do not move far and way that's why all the time engage in feeding and become more injurious to crops than adults. The present study strongly recommends that control techniques are being applied to immature stages of insects because these are more injurious to crops than adults.

As far as importance of ecology is concerned usually species vary in their seasonal cycle (period of hatching, development, and reproduction), which in turn affects the timing of control treatments. To achieve an effective control of the insect pest it is an imperative to have information on its incidence and seasonal occurrence in the field. Present study provides greater knowledge to understand the incidence habit and habitat of *H.nigrorepletus*, which definitely helpful to implement control measures in coming future.

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