

Morphology and Burrowing Behaviour of *Schizodactylus minor* (Ander, 1938) (Grylloptera: Schizodactylidae: Orthoptera) of Pakistan

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Abstract.- The genus *Schizodactylus* Brulle comprises seven species throughout the world. Of these *S. monstrosus* (Drury) and *S. minor* (Ander) occur along the shores of River Indus in Pakistan. At the present, *S. minor* is recorded for the first time from this area and female is described for the first time in the world. Present study deals with morphology, distinctive characters regarding their roll up of the winged margin, ecology with burrow habitat and carnivorous behaviour. However, during burrow formation *S. minor* damaged the under ground roots of the plants. The intervals between the individual burrow varied between 12 to 30 cm on an area of 20-30 m wide and 550 m long. The deepest burrow of an adult was recorded at 35.25±8.50 cm in depth and the shortest burrow was recorded only at 23.2±4.36 cm, depth due to wet soil and the low altitude.

Key words: *Schizodactylus minor*, burrow habitat, roll up winged margin.

INTRODUCTION

The members of *Schizodactylus* Brulle are (generally) found in India, Pakistan, Ceylon and Burma. They were first described as the cricket of Bengal, although they are not true cricket (Khattar 1972). *Schizodactylus* are very peculiar regarding their habitat, they live inside the burrow during day time and came out from burrow at the night. They appear to be exclusively carnivorous in habit. Previously, seven species of this genus *i.e.*, *Schizodactylus monstrosus* (Drury), *S. inexpectatus* Werner (1901), *S. burmanus* Uvarov (1935), *S. minor* Ander (1938), *S. tuberculatus* Ander (1938), *S. hesperus* Bei-Bienko (1967) and *S. brevinotus* Ingrisch (2002) were described. Of these *S. monstrosus* (Drury) and *S. minor* (Ander) occur along the shores of River Indus in Pakistan.

Lot of work has been done on morphology, burrow excavating behavior, external genitalia, postgenital segments and other important taxonomic features of orthopteran species including *Schizodactylus monstrosus* (Walker, 1919, 1922, 1949; Crampton, 1929; Ramme, 1931; Hubbell, 1936; Snodgrass, 1937, 1957; Rague, 1957; Imms, 1957; Khattar, 1958, 1959, 1960, 1972; Khattar and Srivastava, 1962; Randell, 1964). Its sub-social

behavior was studied by Chouduri and Bagh (1974) and Riffat and Wagan (2010, 2012). However, none of these authors included *S. minor* in his or her (their) studies except Ander (1938). He described the single male from River Ganga (India). He gave insufficient information on the external morphology without describing the measurement of different body parts of this insect. However, the ecology of this insect has not been studied yet. Presently, *S. minor* is recorded for the first time from this area and female is described for the first time in world. This current study was initiated on the detailed morphology, ecology and various body parameters of male and female. This study could be valuable to understand the peculiarity of this species among the insect fauna.

MATERIALS AND METHODS

Collection and preservation of specimens

Specimens of *S. minor* were collected from 4 km away from the Jamshoro bypass on the left bank of River Indus near Hussainabad, Hyderabad and Sindh, during the years 2006-2009 in the months of January to December. The material was collected on moderate slopes or level in deep layers of fine sand, with or without thin semi-desert vegetation or at places where layers of this fine soil were deposited by wind.

The collected material was transferred in polythene bags to bring to the laboratory where they were put in properly labeled small glass jars

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0030-9923/2013/0005-1191 \$ 8.00/0

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containing 70% alcohol. After a couple of weeks, 70% alcohol was changed for longer preservations.

Study of burrow excavating behaviour

The burrows of insects were dug out with a single long stick. The stick was put inside each burrow until it touches the end of it. Then the digging would start carefully with the upper part of the stick while being directed towards the end of each burrow, in order to avoid any insect injuries. Burrows were identified for excavation by locating the talus piles left at entrance. In order to determine the contents of burrows, excavations of 508 burrows were conducted in 2006-2009. A straw, trimmed to 20cm length and with a diameter less than that of an average adult burrow was placed in the hole to prevent caving in of burrows during digging, and the sand was carefully removed around it with a garden trowel. The removed sand was inspected for presence of any eggs, nymphs and insect parts such as elytra and wings in order to determine the food preference of *S. monstrosus*. The variances between body length of nymphs and adults were compared using one-way analysis of variance (ANOVA) (SPSS 10.0) and variation was tested using LSD (1%) (Cochran and Cox, 1957).

The terminology regarding different body parts was adopted from Khattar (1972). All the measurements have been taken in mm with the help of ocular square reticule.

RESULTS

Description of female (Figs. 1b,d)

The adult female is large (29.31 ± 0.68 ♀ mm long) thick, and prominent appearances. The head is large conical, frons long-ovoid, vertex arched, steeply sloping between compound eyes, fastigium of vertex small, deeply furrowed, lying between dorsal margins of antennal scrobae. The antennae are very long (each about 6.2cm) and filiform, comprising on more than 300 segment. Mandibles long, its lateral margins sinuate. Pronotum transverse, very short, anterior margin concave, lateral margin sinuate, posterior margin roughly concave and sinuate; Dorsal surface of pronotum with dark brown patches, transverse suture on the dorsal side with a corresponding ridge on the ventral

side (these look like as clip). Tegmina and wings greatly surpassing body. When at rest are coiled into a tight spiral angles to the substrate. Spirally rolled up at end.

Anterior femur with 5-8 small spinules and mid femur with 8-9 small spinules, post femur with 14-20 small spinules on both ventral margins of femur. Anterior tibia with 4 long ventro- internal and 4 long ventro external spines and with 2 apical spurs at each side, the internal spurs longer than the external ones. Mid- tibia with 4 long ventro-external and 3-4 short ventro internal spines, 4 long dorso-internal spines and 1 shorter dorso-external spines just above the apical spurs; 2 apical spurs at each side, the internal spurs longer than the external ones, the dorso-internal spur being the longest one. Post-tibia with 3 dorso-external and 4 dorso-internal spines of medium length; with 3 apical spurs at each side, the internal spurs longer than the external ones; of these spurs, 1 external and 2 internal ones distally widened; ventro-apical margin of post-tibia with 4 short spines just below apical spurs and with 1 longer spines at internal angle. Tarsi of all with 4 segments and a pair of apical claws, 2nd and 3rd segment very short and provided each with a pair of large plantulae first segment of hind tarsus with a pair of large, dense, triangular lateral projections. Ovipositor is (0.5mm) with abbreviate apex (Fig.2c). The cerci are elongated, plank without any segmentation.

Coloration

The general body coloration is bright whitish with creamish yellow with dark brown or greyish patches dorsally and creamish green ventrally. The head is whitish cream with brown or green tinge light yellowish laterally and with dark brown patches dorsally. The base of antennae is brown, while the rest of antennae are yellowish or pale brown. Tegmina and wings brown dorsally, and light brown laterally. The fore, mid, and hind femora are light pinkish or light green in color, with murky brown patches on the outer lateral sides. The fore and mid tibia are light green, while hind tibia is light pinkish in color. The claws on the legs are long, curved and brown in color with black apices. Tergites of the abdomen are off-white or pale in color with dark-brownish patches on their mid

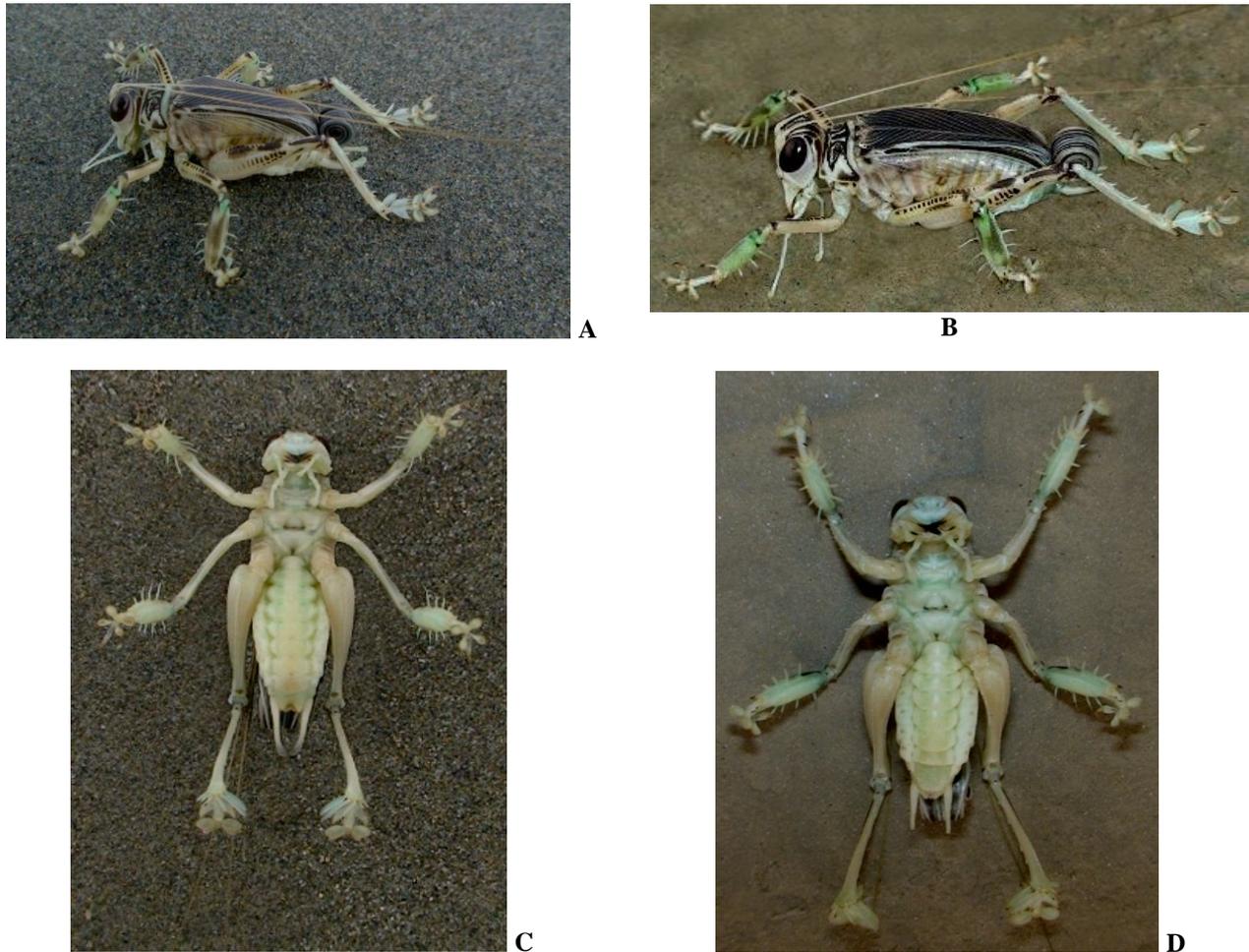


Fig. 1. *Schizodactylus minor*; A, male; B, same but female; C, ventral view of male; D, ventral view of ventral view of female.

posterior margins. Ventrally the abdomen is creamish green and bulges slight downward. The cerci are off-white in color.

Description of male (Figs. 1a,c)

The male is medium size (25.12 ± 0.36 mm long). Pronotum is usually with distinct dark pattern, containing a fine longitudinal stripe in the middle; maximum width of pronotum (5.17 ± 2.07 mm) greater than its median (2.02 ± 0.09 mm) length. Elytra and wings fully developed, apical part rolled; basal part of elytera without transverse light stripes. The armament and number of spines and spurs on all legs as in female

but the expanded external spurs of hind tibia fluctuate in following manners : upper spur less sharpened apically, median spur slightly incurved with lower margin somewhat concave, apex shortly and asymmetrical sharpened, apex of the lower spur more sharpened than in median spur. A pair of thick elongate titillators (0.7mm) (Fig. 2d) prognostic from underneath the plate; their apex mammiform, strongly up curved furnished with two dark sharp tooth these are (0.2mm) long. Cerci condensed, especially in apical area with a tapering basal and a digitiform apical area, apex insensitive. Minute dots present on the ventral side of abdomen other general coloration is similar with female.

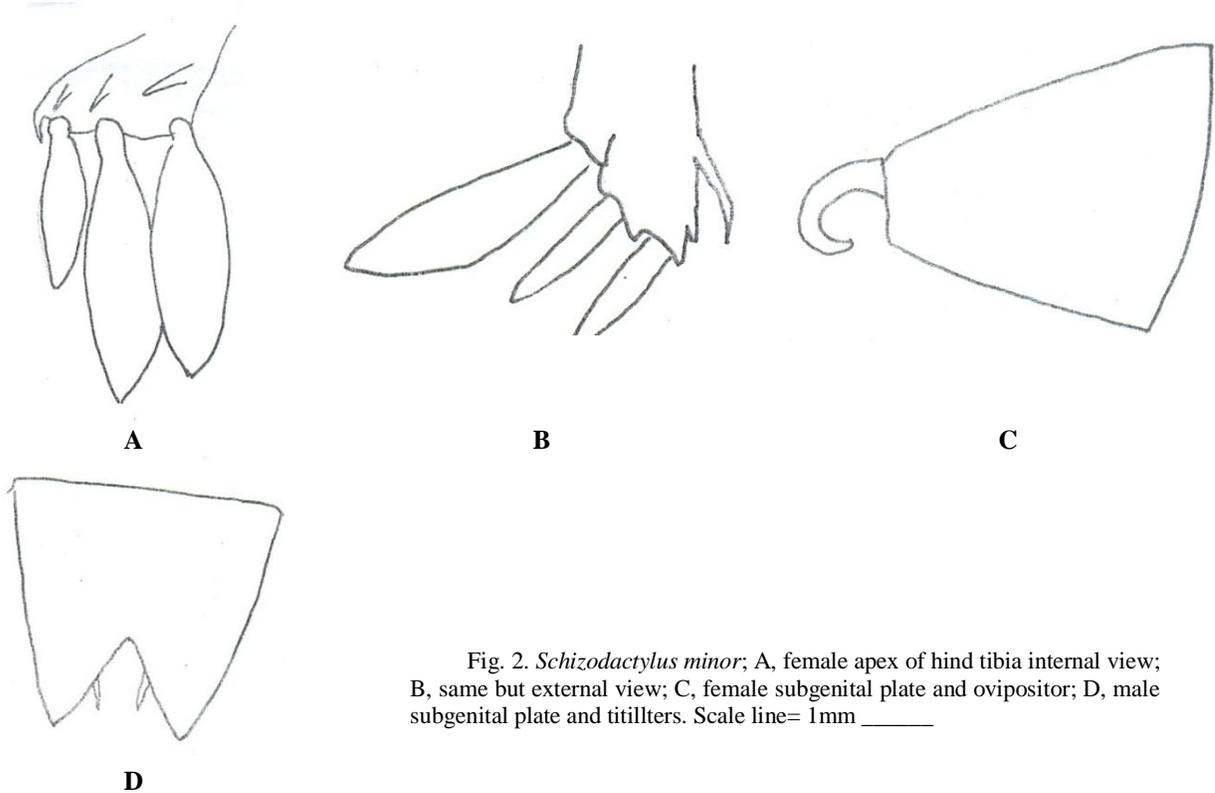


Fig. 2. *Schizodactylus minor*; A, female apex of hind tibia internal view; B, same but external view; C, female subgenital plate and ovipositor; D, male subgenital plate and titillators. Scale line= 1mm _____

Material examined

Hussainabad, Hyderabad, Sindh, 38 ♀♀
10.vii. 2006. (Channa, Riffat & Wagan).

Habitat

Both adults' male and female have been collected from the sandy bed area of River Indus.

Depository

The type material on which this study is based is deposited in the Museum of Entomology, Department of Zoology, University of Sindh-Jamshoro.

Burrowing behaviour

Both adults and nymphal stages of *S. minor* are burrow makers. They hide themselves in burrow during day time, but they came out at night from burrows and performed their all activities *i.e.* copulation, reproduction and feeding etc. The adult stage prefers to make burrows in higher sand bank area than the nymphal stages, while the immature stage mostly prefer to dig their burrows in low altitudes and located close to lagoons and river

banks. Both adults and nymphs lived as single individual inside their burrow. But surprising, outside the burrow they gathered in pairs during copulation process. Although these are carnivorous but during the mating they compromised with each other until the mating is completed. The diameters of burrows increased from one nymphal stage to another, while the depths of burrows did not show any statistically significant correlation with body size. Their burrows were generally straight and smooth. The sizes of burrows at the beginning varied because of difference in the body size of each immature stage.

During the burrow formation this insect uproots agricultural crops for searching the insects. Due to this destructive behavioral of *S. minor* plants become feeble day by day. This behaviour has been reported for the first time. The intervals between the individual burrow varied between 2 to 12 m on an area some 10 to 24 m wide wise and some 300-400 m long. It is very interesting to note that once they came out from their burrow they never used it again. They dig fresh burrow for further activities *i-e*

oviposition and feeding. According to our field observation, the deepest burrow of an adult was recorded at 35.25 ± 8.50 cm in depth; however, the shortest burrow was recorded only at 23.2 ± 4.36 cm depth due to soil moisture conditions and the low altitude.

Table I.- Comparison of measurement (Mean \pm SD) of different body parts of male and female adults of *Schizodactylus minor*.

Body Parameter (mm)	Male (n=30)	Female (n=30)
Head width	5.30 \pm 0.14	6.45 \pm 0.12*
Pronotum central length	2.02 \pm 0.09	2.02 \pm 0.16
Pronotum lateral side length	3.21 \pm 0.08	3.25 \pm 0.09
Pronotum right side length	3.21 \pm 0.08	3.25 \pm 0.09
Pronotum width	5.17 \pm 2.07	6.90 \pm 0.13*
Distance between two eyes	2.74 \pm 0.12	3.31 \pm 0.16
Fore femur	7.50 \pm 0.07	8.5 \pm 0.15
Fore tibia	6.37 \pm 0.06	7.50 \pm 0.07
Fore tarsus	1.70 \pm 0.03	3.144 \pm 0.001*
Mid femur	7.37 \pm 0.06	8.40 \pm 0.25
Mid tibia	6.59 \pm 0.08	7.54 \pm 0.13
Mid tarsus	2.39 \pm 0.08	3.42 \pm 0.07
Hind femur	13.72 \pm 0.18	15.32 \pm 0.10
Hind tibia	10.35 \pm 0.06	11.50 \pm 0.16
Hind tarsus	2.65 \pm 0.63	3.40 \pm 0.06
Cercus	5.06 \pm 0.01	5.51 \pm 0.10
Body length	25.12 \pm 0.36	29.31 \pm 0.68*

*Significantly different ($P < 0.01$) according to LSD test.

DISCUSSION

The representatives of *Schizodactylus* are rather unique members of the family Schizadactylidae as it displays an extraordinary combination of characters suggesting affinities with several divergent groups of Saltatoria (Khattar 1972). The systematic position of *Schizodactylus* reported much controversial: Ramme (1931) and Hubbell (1936) placed it in the subfamily Schizadactylinae of the Gryllacrididae; Ander (1938) established a separate family for the genus, based on studies of the internal anatomy; Imms (1957) also placed the insect in a separate family of Tettigonoidea; Ragge (1957) while describing the polygenetic origin of Schizadactylinae recommended the correction of the latter with early Grylloidea on the basis of wing morphology. The present study supports the view of Ragge (1957). Ander (1938) gave inadequate account on the morphology of male, therefore, in this manuscript a

detail description of male is being provided.

Schizodactylus is very famous due to its rolled up capability at winged region. Khattar (1972) observed that they are flightless insects, while Carpentier (1953) reported that these are able to fly at night. At the present we also observed the little flight of this insect. As far as turning up of the wings on the last abdomen segment is concerned it might be the reason for trivial flight ability of insect or it might be folded due to burrowing habit of this insect. Carpentier (1953) also observed that some *S. monstrosus* live in open burrows. Our study showed that *S. minor* did not form an open burrow. In field, it has been observed that adults and nymphal stages are cannibalistic; different individuals attack each other once they find themselves in confined places, or when they are placed in glass-jars for transferring to the laboratory. Mostly the stronger insects eat the weaker ones. Cannibalism in *S. monstrosus* and *S. inexpectatus* was studied by Uvarov (1952), Khatkar (1972), Hazra and Tandon (1991), and Gokhan and Andrey (2008). Due to cannibalistic behaviour the injured insects became easy prey to predators or collectors. Khatkar (1972) determined that burrow of *S. inexpectatus* are excavated at 60° , and the diameter of the burrow can vary depending on different immature stages of the insects. While we reported that burrow of *S. minor* are excavated at 40°C . Choudhuri and Bagh (1974) also found that the female of *S. monstrosus* lays eggs towards the end of the burrow. We observed that females lay eggs at the lateral edges of burrow. However; we could not find any eggs at the ends of burrow excavated by *S. minor*. Khatkar (1972) also reported that the burrow of both adults and immature stages of *S. inexpectatus* are closed after they are completed. The same was reported in *S. minor*. Ramme (1931) had assumed that flexible spurs of hind tarsi of this insect help in digging, while Carpentier (1953) observed that the digging is done exclusively with jaws. The present study agreed with the later one. Presently, it was also observed that *S. minor* is very sensitive to dryness and usually die-off if kept longer in glass jars without moist sand. They prefer high moisture content, cool temperature and specific conditions of sand for the survival. They spend most of their time in burrows. Carpentier (1953) reported that *S. monstrosus* avoid

the direct sunlight contact. Similar behaviour was also recorded for the *S. minor* during the present study.

Apart from their all obliterating activities *S. minor* played a very important role in the local food chain that prevents certain insect population from increasing and becoming dominant in field. Besides this fact, this species is important food source for reptiles (snakes, wall lizards) and birds such as Shaheen, *Alectoris chukar* and *Dendrocygna bicolor* in Pakistan.

REFERENCES

- ANDER, K., 1938. Diaganosen Zwei neuer *Schizodactylus* Arten. *Entom. Tidskr.*, **59**:37-150 .
- BEI-BIENKO, G.Y., 1967: On the orthopteroid insects from eastern Nepal. *Entomol. Obozr.*, **47**: 106–130. (In Russian; English transl). *Entomol. Rev.*, **47**: 59–72.
- CARPENTIER, F., 1953. Observation sur *Schizodactylus monstrosus* Dru. (Orthopter: Gryllacridoidea). *Bull. Ann. Soc. Ent. Belgique*, **89**:184-186
- CHOUDHURI, D.K. AND BAGH, R.K., 1974. On the sub-social behaviour and cannibalism in *Schizodactylus monstrosus* (Orthoptera: Schizodactylidae). *Rev. Ecol. Biol. Sol.*, **11**:569-573
- CRAMPTON, G.C., 1929. The terminal abdominal structures of female insects compared throughout the orders from the standpoint of phylogeny. *J. N.Y. ent. Soc.*, **37**: 453-496
- COCHRAN.W. G. AND COX, G.M., 1957. *Experimental designs*. John Wiley and Sone, New York. USA, pp. 611.
- AYDIN, G. AND KHOMUTOR, A., 2008. The biology, nymphal stage and life habits of the endemic sand dune cricket *Schizodactylus inexpectatus* (Werner, 1901) (Orthoptera: Schizodactylidae). *Turk. J. Zool.*, **32**:427-432.
- HAZRA, A.K. AND TANDON, S.K., 1991. Ecology and behaviour of sand Burrowing insects. *Schizodactylus monstrosus* (Orthoptera: Schizodactylidae). In: *Advances in management and conservation of soil fauna* (eds. G.H. Veeresh, D. Rajagopal and C.A. Viraktamath), pp. 805-809. Bombay, Calcutta, New Delhi, pp. 925.
- HUBBELL, T.H., 1936. *A monographic revision of the genus Ceuthophilus (Orthoptera)*. University of Florida Publications Biol. Ser., pp. 551.
- IMMS, A.D., 1957. *A general textbook of entomology*, London. (First Edition)
- INGRISCH, S., 2002. Orthoptera from Bhutan, Nepal, and North India in the Natural History Museum Basel. *Ent. Brasil.*, **24**:123–159.
- KHATTAR, N., 1958. Morphology of head capsule and mouth parts of *Schizodactylus monstrosus* Dru.(Orthopter). *J. zool. Soc. India*, **10**: 68-81.
- KHATTAR, N., 1959. Inter-relationship of *Schizodactylus monstrosus* Dru. (Orthoptera). *Sci. Cult.*, **25**: 275-276.
- KHATTAR, N. AND SRIVASTAVA, R.P., 1962. Morphology of meso-and meta thorax of *Schizodactylus monstrosus* (Drury) (Orthoptera). *J. zool. Soc. India* **14**: 93-108.
- KHATTAR, N., 1972. A description of the adult and nymphal stages of *Schizodactylus monstrosus* (Drury) Orthoptera. *J. nat. Hist.*, **6**: 575-588
- RAGGE, D.R., 1957. The tracheation of the nymphal wing-pads of *Schizodactylus monstrosus* (Drury), with a revised interpretation of the adult venation (Orthoptera: Schizodactylidae). *Proc. zool. Soc. Lond.*, **129**: 301-304
- RAMME, W., 1931 Systmatisches Verbeitung und Morpho-Biologicahes and der Gryllciden des famihe *Schizodactylus* orthoptera. *Z. Morph. Oekol. Tiere*, **22**: 163-172.
- RANDELL, R.L., 1964. The male genitalia in Gryllinao (Orthoptera: Gryllidae) and a Tribal revision. *Can. Entomol.*, **96**: 1565-1607.
- RIFFAT, S. AND WAGAN, M.S., 2010. Comparative study on the immature stages of three *Hieroglyphus* species (Acrididae: Orthoptera) from Pakistan. *Pakistan J. Zool.*, **42**: 809-816.
- RIFFAT, S. AND WAGAN, M.S., 2012. Review of genus *Hieroglyphus* Krauss 1877 (Hmiacridinae: Acrididae: Orthoptera) with description of one new species from Pakistan. *Pakistan J. Zool.*, **44**: 43-51
- SNODGRASS, R.E., 1937. The male genitalia of Orthopteroid insects. *Smithson. Misc. Coll.*, **69**: 1-106.
- SNODGRASS, R.E., 1957. A revised interpretation of the external reproductive organ for male insects. *Smithson. Misc. Coll.*, **135**:1-60.
- UVAROV, B.P., 1935. A new species of the genus *Schizodactylus* from Burma (Orthoptera: Gryllacridae) . *Ann. Mag. Nat. Hist.*, **15**:151-152.
- UVAROV, B.P., 1952. Description of adult *Schizodactylus inexpectatus* (Werner) from Turkey (Orthoptera, Gryllacridactlus). *Ann. Mag. Nat. Hist.*, **12**:772-774.
- WALKER, E.M., 1919. The terminal abdominal structure of Orthopteroid insects: A phylogentic study. *Ann. Ent. Soc. Am.*, **12**:267-316.
- WALKER, E.M., 1922. The terminal abdominal structure of orthopteroid insects: A phylogentic study. Part II. *Ann. Ent. Soc. Am.*, **15**:1-76
- WALKER, E.M., 1949. On the anatomy of *Grylloblatta campodeiformis* Walker.5. The organs of digestion. *Canad. J. Res. D.*, **27**:243-307.
- WERNER, F., 1901. Die Dermatern- and Orthen, fauna Klemascens. *Sitzbs Akad. Wissin Math. Nat. Classe*, **110**:255-306.

(Received 22 April 2010, revised 20 January 2011)