

Mating Behaviour of *Hieroglyphus* Species (Hemiacridinae: Acrididae: Orthoptera) from Pakistan

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Abstract.- A comparative study has been carried out on reproductive activities of three grasshopper species *Hieroglyphus perpolita* (Uvarov) *Hieroglyphus oryzivorus* Carl and *Hieroglyphus nigrorepletus* I.Bolivar at laboratory conditions. All the activities from maturation to copulation have been discussed. Average maturation period of male was 5.6 ± 0.9 , 6.26 ± 1.48 and 6.13 ± 1.12 days for *H. perpolita*, *H. oryzivorus* and *H. nigrorepletus* respectively. Similarly for the females it was 8.13 ± 1.8 , 10.93 ± 2.6 and 9.6 ± 1.59 days respectively. These values indicated that males mature earlier than female. Total mating duration was significantly highest in *H. oryzivorus* (139.06 ± 55.36 hours) followed by *H. nigrorepletus* (70.86 ± 30.01 hours) and *H. perpolita* (9.93 ± 6.25 hours). Present study also showed that there was significant difference in the length of copulation and number of matings among these species. It was also observed that female required mating before each oviposition. However, prolonged copulation occurred in *H. oryzivorus* and *H. nigrorepletus* compared with *H. perpolita* which mates for short time and lives lesser. The reproductive activities were at its maximum in *Hieroglyphus* spp. from 2nd week of August to mid November. The longevity of males was recorded 26.46 ± 12 , 46.86 ± 21.34 and 40.4 ± 16.10 days for *H. perpolita*, *H. oryzivorus* and *H. nigrorepletus* respectively, whereas in females it was 21.13 ± 4.79 , 38.13 ± 15.29 and 35.93 ± 17.09 days indicating that males live longer than females. However, fecundity of females in these three species has been discussed in our previous paper.

Key Words: *Hieroglyphus*, Mating behaviour, Comparative study, Hemiacridinae, Acrididae, Orthoptera.

INTRODUCTION

The species of *Hieroglyphus* are major pests of rice, sugarcane, wheat, maize and minor pest of millets and other grasses are generally found in Pakistan during June to mid December. Beside, its economic importance; these are the pests of considerable biological interest. Their complex mating behaviour (Siddiqui, 1989) and prolonged egg-viability (Roonwal, 1976a) has obtained the much attention of researchers.

Earlier studies conducted in *Hieroglyphus* spp. (Ghouri and Ahmed, 1960; Bhatia *et al.*, 1965; Singh, 1972; Mason, 1973; Alam and Alam 1977; Irshad, 1977; Moizuddin, 1988; Hashmi, 1994; Riffat *et al.*, 2007) mostly centered upon the incidence of this pest in various localities. However, there is no such data available on the breeding habits of *Hieroglyphus* species except Roonwal (1945, 1976a,b, 1978), Srivastava (1956), Janjua (1957), Pradhan and Peshwani (1961), Rizvi and Khan (1970), Jotwani and Butani (1978), Siddiqui

0030-9923/2008/0001-0019 \$ 8.00/0

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(1986, 1989), Moizuddin (2001), Wagan and Riffat (2006) and Riffat and Wagan (2007a,b) who worked on different aspects of these species.

In fact some earlier studies with locusts and grasshopper were conducted exclusively with individuals reared under crowded condition by Uvarov (1966), Reinhardt *et al.* (2001) and Zhu and Tanaka (2002). Moreover; a comprehensive account of Faber (1929, 1932, 1936, 1953) and Jacobs (1953) include a mass of data on the behaviour of acridoids before, during and after copulation, but they are mostly based on observation of a limited number of European species. No extensive work has been done in Pakistan. Present investigation has been carried out for the first time from this region.

Taking into consideration the economic importance of the genus *Hieroglyphus*, the present study is an attempt to determine the mating behaviour of these three species under laboratory conditions. Such studies would be instructive in understanding the life parameters and finding weak spots to restrict the damage.

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MATERIALS AND METHODS

Study area

The stock of *Hieroglyphus* nymphs were randomly collected from the fields of rice, maize, jowar, wheat and fodder crops and their surrounding vegetation of grasses with the help of traditional insect hand-net (8.89 cms in diameter and 50.8 cms in length) and by hand picking during the period of June 2003 to September 2005.

Housing conditions and measurements

Nymphs were raised up to the adulthood under laboratory conditions where the temperature at morning fell to $28\pm 2^{\circ}\text{C}$ to $39\pm 2^{\circ}\text{C}$ (by the late afternoon the room temperature reached $30\pm 2^{\circ}\text{C}$ to $41\pm 2^{\circ}\text{C}$). In the room the average relative humidity was about 26-51% at 9 O'clock in the morning and in the afternoon it was 28-61% at 2 O'clock during the months of June to December. Cultural conditions were identical for all the nymphs housed in cages (length $16\frac{1}{2}$, width $13\frac{1}{2}$ cms). Approximately sixty nymphs of each species were kept in each cage. On reaching maturity, all individual were segregated (one male and one female) in separate glass jars and *Zea mays* cuttings immersed in water were supplied as food and were replaced daily.

In order to study the mating behaviour of *Hieroglyphus* spp. the activities of 15 pairs (one male and one female) of same age of each species were examined thoroughly after their emergence. The observations at night were also recorded. Insects under experimentation were maintained till they died. The age of maturation, duration of copulation, total number of matings and longevity of male and female of each species were studied.

Statistical analyses

Data obtained from experimental groups were subjected to one-way analysis of variance (ANOVA). The significant differences between means were determined using Duncan's New Multiple Range Test (DNMRT).

RESULTS

When both the male and female attain sexual maturity, the male advances towards the female with

its antennae directed towards female. The male sets its hind legs in vibration both side-ways up and down. Frequently the male protrudes its external genitalia and sometimes maxillae diverge. Lastly, the male touches the female with its antennae, and often with its mouth parts. However, these behavioural responses of the males did not occur in any fixed sequence. The female at that time generally keeps on sitting motionless but some show vibration in their hind legs like that of the males. The male suddenly jumps and mounts over the back of the female and starts copulation in a typical acridid riding style. During courtship the antennae of the male are kept stretched at an angle of little more than 90° with the head and are occasionally used to touch the head and the pronotum of female. When the copulation is over female jerks its hind legs repeatedly. The male is disturbed due to such action of female and is dislodged.

The males of the genus *Hieroglyphus* mature earlier than females (Table I). Age of maturation of males was significantly highest in *H. oryzivorus* (6.26 ± 1.48 days) followed by *H. nigrorepletus* (6.13 ± 1.12 days) and *H. perpolita* (5.6 ± 0.9 days). Similarly the females of *H. oryzivorus* took significantly prolonged time (10.93 ± 6.25 days) for maturation compared with the females of *H. nigrorepletus* (9.6 ± 1.59 days) and *H. perpolita* (8.13 ± 1.8 days), respectively. Total duration of mating hours during the entire life was significantly highest in *H. oryzivorus* (139.06 ± 55.36 hours) compared with *H. perpolita* (9.93 ± 6.25 hours) and *H. nigrorepletus* (16.70 ± 4.37 hours) indicating that *H. perpolita* mated for the shortest time. Similarly the length of copulation was also significantly highest in *H. oryzivorus* (33.26 ± 13.92) followed by *H. perpolita* (3.69 ± 1.63) and *H. nigrorepletus* (16.70 ± 4.37), while the total number of matings were significantly less in *H. perpolita* followed by the other two species. However, the survival rate of males was significantly higher as 26.46 ± 12.13 , 46.86 ± 21.34 and 40.40 ± 16.10 days for *H. perpolita*, *H. oryzivorus* and *H. nigrorepletus* respectively, whereas that of the females was 21.13 ± 4.79 , 38.13 ± 15.29 and 35.93 ± 17.06 days, respectively. Hence, both sexes in *H. perpolita* live for significantly shorter time.

Presently it was also observed that during the

short interval of mating, males immediately start feeding, whereas, females continue to feed even during the mating. The observations further showed

Table I.- A comparative data on reproductive activities of the *Hieroglyphus* spp.

Species	Age of maturation (days±SD)		Mating duration (Hrs±SD)	Length of copulation (Hrs±SD)	Number of matings	Longevity (Days±SD)	
	Male	Female				Male	Female
<i>H. perpolita</i>	5.6±0.90 ^a	8.13±1.8 ^a	9.93±6.25 ^a	3.69±1.63 ^a	2.8±0.68 ^a	26.46±12.13 ^a	21.13±4.79 ^a
<i>H. oryzivorus</i>	6.25±1.48 ^b	10.93±2.6 ^c	139.06±55.3 ^c	33.26±13.9 ^c	12.17±4.12 ^c	46.86±21.34 ^c	38.13±15.29 ^c
<i>H. nigrorepletus</i>	6.13±1.12 ^b	9.6±1.59 ^b	70.86±30.01 ^b	16.70±4.37 ^b	7.94±1.69 ^b	40.40±16.10 ^b	35.93±17.06 ^b
F _(0.05)	(5.99)09.60*	(9.55)16.58 ^{ns}	(73.28)28.28*	(17.88)32.29*	(7.64)14.84 ^{ns}	(37.90)67.20*	(31.73)56.72*

Means in the same column followed by the same letters are not significantly different from one another at 5% level of probability (DNMRT)

*=p< 0.05

ns =not significant p= 0.05

that mating could occur round the clock particularly at daytime (with exception of few cases). Generally the mating was not resumed immediately after egg-laying and the oviposition also took place a few hours after mating.

It was studied that the reproductive activity was at its maximum in August to middle of September in *H. perpolita*, August to middle of October in *H. nigrorepletus*, whereas mid September to November in *H. oryzivorus*.

DISCUSSION

Copulation was of typical acridid style found to be similar in all species of *Hieroglyphus* except for the timing of maturation, duration and frequency of mating. Present study does not agree with Srivastava (1956) who reported that feeding was suspended completely during the act of copulation. In present study it was noticed that female kept on feeding whereas the male did not. This finding correlates with that of Uvarov (1966).

Previously Pradhan and Peswani (1961) reported maturation period of 10.6 days for males and 10.7 days for females in *H. nigrorepletus*. Contrary to this, Siddiqui (1989) found it to be 7.0±0.39 and 8.3±0.2 days for males and females respectively. In the present study this period was 6.13±1.12 and 9.6±1.56 days for males and females, respectively. Present study suggests that this disparity might be due to feeding on different host plant varieties or different climatic conditions of the

region, which certainly affect the fertility of insects. Maturation period was determined based on number of days lapsed from the day of last instar's ecdysis to adults.

It was also noted that there was significant difference in the duration of copulation among these species although housing and feeding conditions were identical for all. Present study suggests that this variation might be due to differences in the process of formation and transformation of spermatophore in these species. It was also found that the females of *Hieroglyphus* spp. required mating before each oviposition indicating that most probably single copulation is not sufficient to fertilize an egg-batch in one time. On the contrary, Norris (1954) reported that in *Schistocerca* single copulation is sufficient to fertilize a number of successive egg-pods.

Unsuccessful attempt of fifth instars male for copulation suggests that male gonad mature earlier than female gonad and this might be the reason for this sexual behaviour. However, this fact was actually explored by dissection.

A significant difference between the survival period of male and female was observed. Mostly in Acrididae female die before males towards the end of oviposition period, with the exception of few cases) where females died during the act of prolonged copulation. It might be one of the reasons for longer survival of males. The period of longevity of insect was calculated from emergence of adults to death of insects.

Overall, it is concluded that, in the life of *Hieroglyphus* spp., maximum activity is mating during which pairs are usually very sluggish. They are not disturbed easily by cage movement. Even the sound has very little effect in intercepting mating. Therefore, present study strongly recommends that mating period is the most suitable time to adopt control measures.

ACKNOWLEDGEMENTS

The authors are grateful to Dr. M. Irshad, Principal Scientific Officer (NARC) Islamabad for critical review of this manuscript. We also acknowledge the financial assistance of Pakistan Science Foundation, Islamabad for research grants (Project No. PSF S-SU/Bio 338)

REFERENCES

- ALAM, S. AND ALAM. A., 1977. Minor pests of rice In: *Literature review of insect pests and diseases of rice in Bangladesh*. Dacca, Bangladesh Rice Research Institute. pp. 72-78.
- BHATIA, D.R., SINGH, C. AND AHLUWALIA, P.J.S., 1965. Incidence of *Hieroglyphus nigrorepletus* Bol. (Orthoptera, Acrididae) in the desert parts of Rajasthan and Kutch district of Gujarat. *Indian J. Ent.*, **26**: 464-465.
- SINGH, C., 1972. Further incidence of *Hieroglyphus nigrorepletus* Bol. (Orthoptera: Acrididae) in the desert parts of Gujarat. *Pl. Prot. Bull. India*, **22**: 38.
- FABER, A., 1929. Die Lautausserungen der Orthopteren. (Lauterzeugung, Lautabwandlung und deren biologische Bedeutung sowie Tonapparat der Geradflügler.) Vergleichende Untersuchungen. *I.Z. Morphol. Okol. Tiere*, **13**: 745-803.
- FABER, A., 1932. Die Lautausserungen der Orthopteren II. (Untersuchungen über die biologischen, tierpsychologischen und vergleichend-physiologischen Problem der Orthopterenstridulation Methodik der Bearbeitung und Auswertung von Stridulationsbeobachtungen. Einzeldarstellungen.) *Z. Morphol. Okol. Tiere*, **26**: 1-93.
- FABER, A., 1936. Die Laut- und Bewegungsausserungen der Oedipodinen. biologisch, tierpsychologisch und vergleichend- funktionell beschrieben; mit einem Erstnachweis von tonhaften Lauten bei Acridiiden und mehrfachen Lautformen bei Weibchen. Allgemeines zur Biologie der Paarungseinleitung und Paarung. *Z. wiss. Zool.*, **149**: 1-85.
- FABER, A., 1953. Laut- und Gebardensprache bei Insekten. Orthoptera (Geradflügler) Teil I. Vergleichende Darstellung von Ausdrucksformen als Zeitgestalten und thren Funktionen. *Mitt. Mus. Naturk. Stuttgart*, **287**: 198.
- GHOURI, A.S.K. AND AHMAD, H., 1960. Swarming of *Hieroglyphus nigrorepletus*. *Pl. Prot. Bull. F.A.O.* **8**: 135-136.
- HASHMI, A.A., 1994. *Insect pest management Cereal and cash crops*. PARC pp.41. Asad printers.
- IRSHAD, M., 1977. Grasshoppers on rice in Pakistan. *Int. Rice Res. Newsl.*, **3**: 8-9
- JACOBS, W., 1953. Verhaltensbiologische Studies a Feldeuschrecken. *Z. Tierpsychol. (Beith.)*, **1**: 228.
- JANJUA, N.A., 1957. Insect pest of paddy in Pakistan. *Agric. Pak.*, **8**: 5-21.
- JOTWANI M, G. AND BUTANI, D.K., 1978. Crop pests and their control: pearl millet pesticides (Bombay) **12**: 20-30
- KARIM, S. AND RIAZUDDIN, S., 1999. Rice insect pests of Pakistan and their control: A lesson from past for sustainable future integrated pest management. *Pakistan J. biol. Sci.*, **2**: 261-276.
- MASON, J.B., 1973. A revision of the genera *Hieroglyphus* Krauss *Parahieroglyphus* Carl and *Hieroglyphodes* Uvarov (Orthoptera: Acridoidea). *Bull. Br. Mus. nat. Hist. (Ent)*, **28**: 507-560.
- MOIZUDDIN, M., 1988. Aspects of external morphology of *Hieroglyphus nigrorepletus* Bolivar (Orthoptera: Acridoidea) with special reference to its genitalia and their bearing on classification. *Proc. Pakistan Congr. Zool.*, **8**: 137-146.
- MOIZUDDIN, M., 2001. Studies on the habitats and life cycle of rice grasshopper *Hieroglyphus nigrorepletus* Bolivar (Orthoptera: Acridoidea) in the desert area of Lasbela, Balochistan. *Proc. Pakistan. Congr. Zool.*, **21**: 123-131.
- NORRIS, M.J., 1954. Sexual maturation in the desert locust (*Schistocerca gregaria* Forskal) with special reference to the effect of grouping. *Anti-Locust Bull.*, **18**: 44.
- PRADHAN, S. AND PESHWANI, K.M., 1961. Studies on the ecology and control of *Hieroglyphus nigrorepletus* Bolivar. *Indian J. Ent.*, **23**: 79-105.
- RIFFAT, S., WAGAN, M.S. AND NAHEED, S., 2007. Distribution of *Hieroglyphus nigrorepletus* (Bolivar, 1912) (Hemiacridinae: Acrididae: Orthoptera) in various province of Pakistan. *Int. J. Agri. Biol.*, **9**: 199-201.
- RIFFAT, S. and WAGAN, M.S., 2007a. Life history and Economic importance of *Hieroglyphus nigrorepletus* Bolivar (Hemiacridinae: Acrididae: Orthoptera) from Pakistan. *Pakistan J. Ent.*, **4**: 379-386.
- RIFFAT, S. AND WAGAN, M.S., 2007. Comparative studies on the Ovipositional behaviour of *Hieroglyphus* species (Hemiacridinae: Acrididae: Orthoptera) from Pakistan. *Pakistan J. Zool.*, **39**: 321-325.

- REINHARDT, K., SAMIETZ, J., WAGNER, G., OPITZ, S. AND KOHLER, G., 2001. Diel and seasonal mating peaks in grasshopper populations (Caelifera: Acrididae). *J. Orth. Res.*, **10**: 263-269.
- ROONWAL, M.L., 1945. Notes on the bionomics of *Hieroglyphus nigrorepletus* Bolivar (Orthoptera: Acrididae) at Banaras, United Province, India. *Ent. Res.*, **36**: 339-341.
- ROONWAL, M.L., 1976a. Ecology and biology of the grasshoppers *Hieroglyphus nigroreplet* Bolivar (Orthoptera: Acrididae)1. Eggs pods, diapause, prolonged viability and annual hatching rythum. *Zool. angew. Berlin.*, **63**: 171-185.
- ROONWAL, M.L., 1976b. Ecology and biology of the grasshoppers *Hieroglyphus nigrorepletus* Bolivar (Orthoptera: Acrididae) Distribution, economic importance, life history, color forms and problems of control. *Zool. angew. Berlin*, **63**: 307- 323.
- ROONWAL, M.L., 1978. The phadka grasshopper and its control. *Indian Farm.*, **27**: 3-6.
- RIZVI, S.S.A. AND KHAN, M.A., 1970. Egg diapause of *Hieroglyphus nigrorepletus* Bolivar (Orthoptera: Acrididae). *J. Bombay nat. Hist. Soc.*, **66**: 646-648
- SIDDIQUI, J.I., 1986. Studies on reproduction IV. Oviposition in *Hieroglyphus nigrorepletus* Bolivar (Orthoptera: Acrididae). *Indian J. Ent.*, **48**: 169-182.
- SIDDIQUI, J.I., 1989. Studies on reproduction I. Mating in *Hieroglyphus nigrorepletus* Bolivar (Orthoptera: Acrididae). *Indian J. Ent.*, **51**: 125-130
- SRIVASTAVA, P.D., 1956. Studies on the copulatory and egg-laying habits of *Hieroglyphus nigrorepletus* Bol. (Orthoptera: Acrididae). *Ann. ent. Soc. Am.*, **49**: 167-170.
- UVAROV, B.P., 1966. *Grasshoppers and Locust: A hand book of general acridology*, vol. 1, pp. 1-481, Cambridge University Press.
- WAGAN, M.S. AND RIFFAT, S., 2006. *Taxonomy and biology of Hieroglyphus spp.* Final Tech. Rep(PSF) Res.No S-SU/Bio (338), Islamabad, pp. 1-158.
- ZHU, H. AND TANAKA, S., 2002. Prolonged precopulatory mounting increases the length of copulation and sperm precedence in *Locusta migratoria* (Orthoptera: Acrididae). *Ann. entomol. Soc. Am.*, **95**: 370-373.

(Received 30 October 2006; revised 3 September 2007)