RESEARCH ARTICLE

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Reproductive performance of selected Grasshopper species collected from Bihar under Field Conditions

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ABSTRACT

The reproductive ability of grasshopper is different in accordance with species due to body size, geographical distribution, host preference and forage activity during their life cycle. This study is aimed to assess reproductive behavior of local grasshopper species differed in terms of sexual maturity, copulation strategy, oviposition, hatching and duration of instar stages with adult morphology. There is variation observed in reproductive activity of various species and it may be concluded that grasshopper interacts in a community with both biotic and abiotic factors and their reproduction is consequence of various limiting factors in tropical environments. This research is perspective in terms of live feed for poultry farms.
Key words: *Grasshopper, oviposition, paurometabolous, hatching, nymph, cannibalism*

INTRODUCTION

Since Bihar is one of the hotspots for agricultural and horticultural practices, the insect pests affect these industries drastically causing great economic losses, therefore, an urgent need to study them. Among different insect groups, Orthoptera is one such order**/** group which attacks our crops.

Most grasshoppers lay their eggs in the ground or on vegetation. The eggs hatch and the young nymphs resemble adults but lack wings and at this stage are often called hoppers. They may often also have a radically different coloration from the adults. Through successive molts**,** the nymphs develop wings until their final molt into a mature adult with fully developed wings. The number of molts varies between species; growth is also very variable and may take a few weeks to some months depending on food availability and weather conditions. The time taken for laying a batch of eggs in *Acrotylus humberlianus* was reported to be half an hour (Fedrov, 1927), while it to be half an hour to one hour. In *Spathosternum prasiniferum,* it was reported to be from 2-4h (Iqbal and Aziz, 1974). Das and Haldar (2001) studied in detail the life cycle of *Oxya fuscovita* and discussed its habits. Chesler (1938) reported that male and female grasshoppers pass through 5 instars in *Oedaleus nigrofasciatus* De Geer. In *O. johnstoni* Uvarov, the number of hopper instars varies from 7 to 10 (Joyce, 1952). Chapman (1990) studied biology of grasshoppers and Riede (1987) described mating behavior. Sharma and Gupta (1996) studied the biology of *Atractomorpha crenulata* in tropical conditions.

The study of the life history of grasshopper pests is not only important from the academic point of view but it will also help in formulating the control measures of these insect pests. This study may be useful to both researchers and agriculture practitioners to formulate new approaches of control. The mass production of grasshoppers may be used as fish feed in underdeveloped regions of world.

RESULTS AND OBSERVATIONS

The occurrence of grasshopper species in different crops, vegetables, spices and sugarcane were showed in Table 1 and Table 2. Mean life cycle of studied grasshoppers were completed within 83.16 to 121 days in male and 89.06 to 136.8 days in female. The

mean incubation period of the studied grasshopper varied from 20 to 26.8 days and the total mean life span from hatching until death were 62.1 to 95 days in male and 68.0 to 110 days in female. Each nymph selects leaf blades and stem of grasses and then moved its abdomen rhythmically, as a result, the cuticle ruptured along the mid dorsal line of the head region and 15 to 30 minutes being taken by nymph in single molting.

Sexual Maturation and Pre-copulation Period, adults of all the grasshoppers attained sexual maturity without any change in their morphology. The time required from the final molting to the first copulation period was noted (Table 3-6).

The type of copulation appeared to be the 'riding type' in short horned grasshoppers in general. In this process the male ride on the back of female in an end to end position. Besides this, two other types are also found; dorso-lateral position, where the male and female remain side by side and the opposite position, keeping the head in opposite direction.

Table 1: Grasshopper occurrence on some major crops

Species	Paddy	Wheat	Maize	Pea	Gram
A.acrenulata	+	+	+	+	+
Oxya hyla hyla	+	+	-	-	-
Aiolopus th.tamulus	+	+	+	+	+
Acrida exaltata	+	+	-	+	+
Phlaeoba infumata	+	+	+	-	-

Table 2: Grasshopper occurrence on major vegetables, spices and sugarcane

Species	Colosium sp.	Cauli flower	Sugar cane	Ladies finger	Chilli	Brinjal	Cucumber
A.acrenulata	+	-	-	-	+	-	-
Oxya hyla hyla	+	+	+	+	+	+	-
Aiolopus th.tamulus	-	+	-	+	+	-	-
Acrida exaltata	-	-	+	+	+	+	-
Phlaeoba infumata	-	-	-	-	-	-	-

Table3: Oviposition of Phlaeoba infumata in the laboratory

Final moult date	Ist ovi Position (day)	Time of oviposition (min)	Pre-oviposition (day)	Time in Ist copulation &oviposition	Time in 2nd oviposition (min)	No. egg Pod	Time in 1st &2nd oviposition
26.4.13	7	20	19	12	20.5.13 (30 min)	2	5
6.7.13	7	30	13	13	30.7.13 (40 min)	3	4
26.7.14	8	45	10	10	19.8.14 (25 min)	3	6
4.7.15	8	50	15	15	1.8.15 (35 min)	3	3

Table 4: Oviposition in *Aiolopus* th. *tamulus* recorded in the laboratory

Final moult date	Ist ovi Position (day)	Time of oviposition (min)	Pre-oviposition (day)	Time in Ist copulation &oviposition	Time in 2nd oviposition (min)	No. egg Pod	Time in 1st & 2nd oviposition
17.4.13	4	18	14	10	6.5.13 (30 min)	4	5
27.7.13	5	30	16	12	13.8.13 (20 min)	3	1
4.7.14	3	28	15	12	26.7.14 (28.3 min)	27	-
20.8.15	6	20	19	13	10.9.15 (30 min)	3	2

The copulation in grasshoppers takes place more actively during daytime. There mode of copulation and its duration vary little from species to species and mating lasted in 5 to 50 minutes. The number of copulation observed was 4 to 7 times in the laboratory. The females were seen to be copulated by the male even after the first or second oviposition. The interval between copulation and the first egg laying was varied from individual to individual and even from species to species depending upon the factors like temperature, humidity and availability of food (Table 3-6).

Table 5: Oviposition in *Acrida exaltata* recorded in the laboratory

Final moult date	Ist ovi position (day)	Time of oviposition (min)	Pre-oviposition (day)	Time in Ist copulation &oviposition	Time in 2nd oviposition (min)	No. egg Pod	Time in 1st & 2nd oviposition
24.5.13	12	50	26	14	23.1.13 (40 min)	5	4
23.8.13	10	45	28	18	28.9.13 (65 min)	6	8
27.6.14	11	30	27	16	28.7.14 (45 min)	4	4
6.4.15	10	60	22	12	3.5.15 (35 min)	7	5

Table 6: Oviposition of *Atractomorpha crenulata* recorded in the laboratory.

Final moult date	Ist ovi Position (day)	Time of oviposition (min)	Pre-oviposition (day)	Time in Ist copulation &oviposition	Time in 2nd oviposition (min)	No. egg Pod	Time in 1st & 2nd oviposition
25.4.13	2	40	13	10	20.5.13 (105 min)	2	10
8.6.13	3	90	17	14	28.6.13 (45 min)	4	3
25.4.14	3	35	19	17	21.5.14 (45 min)	4	6
23.7.15	5	45	20	18	17.8.15 (30 min)	4	3

OVIPOSITION

The gravid female of these species of grasshoppers after selection of sites, put the tip to the abdomen to the desired depth in the hole make by her and retractors its abdomen slightly. Before laying of eggs a spongy silvery white secretion stopped for a while and light yellow eggs with foamy substances were laid. During the deposition of eggs, the abdomen contracted a little but never rotated. When the egg laying was complete some more substances came out and after that the female lifted its abdomen and sealed the hole with a plug made up of soil and forthy materials. The time required for deposition of eggs and the release of forthy secretion of different species are given in (Table 7-10). The abdomen tip of each of these species when reached upto their desired depth for deposition of egg in the soil, the abdomen contracted a little before deposition. The contraction varies from species to species to species ranging approximately from 0.15 to 0.50 cm.

POST OVIPOSITION PERIOD

The longevity of the females after deposition of eggs varied from species to species. In the present observation the following longevity has been recorded.

After ovipostion, the female of all the species become sluggish, less active lose weights and ultimately die as *Phlaeoba infumata* died within 10 to 14 hours. The longevity of an adult *Phlaeoba infumata* female varies from 25 to 40 days (M 34.4 days). In case of *Aiolopus th. tumulus*, the female required 31 to 43 days (M 33.5 days); In *Acrida exaltata*

the longevity was 53 to 73 days (M 62.5 days) in female; Similarly the female *Altractomoroha crenulata* required 26 to 41 days (M 35 days).

INCUBATION PERIOD

The period from the deposition of egg into soil upto the period of hatching is known as incubation period o the egg and variation in time is given in (Tab. 10). The hatching period is different in various species**.**

Egg-Pods and Eggs:

In grasshopper the number of egg-pods laid by a female was directly proportional to the frequency of mating. The fertility was observed after counting the total hatched nymphs of an egg pod and the remaining un-hatched eggs were considered as the unfertilized eggs. The mortality of the egg was estimated by counting the number of unfertilized eggs present in the pod.

Number of molting and duration of nymphal stages:

From table 11 to 14, it may be observed that the number of molts and their duration appeared to vary from species to species. The duration of stages are presented in Table.

Table 7: Records of egg-laying, incubation period and egg hatching of *Phlaeoba infumata* in the laboratory

Date on egg-pod laying	Incubation period	Date of hatching	Number of Egg-pod	Number of hatched egg per pod	Male %	Female %
20.5.13	21	11.6.13	22	20	60	40
19.3.14	20	9.4.14	13	11	54.55	45.45
17.4.14	21	8.5.14	25	25	44	56
29.7.15	19	17.8.15	25	25	56	44

Table 8: Records of egg-laying, incubation period and egg hatching of Phlaeoba infumata in the laboratory

Date on egg-pod laying	Incubation period	Date of hatching	Number of Egg-pod	Number of hatched egg per pod	Male %	Female %
6.5.13	19	25.5.13	14	9	66.67	33.33
13.8.14	18	31.8.14	17	14	57.14	42.86
26.7.14	21	16.8.14	47	47	44.68	55.52
5.7.15	21	27.7.15	14	11	36.36	63.45

Table 9: Records of egg-laying, incubation period and egg hatching of *Aiolopus th. tamulus* in the laboratory.

Date on egg-pod laying	Incubation period	Date of hatching	Number of Egg-pod	Number of hatched egg per pod	Male %	Female %
23.6.13	20	13.7.13	37	33	57.60	42.40
20.9.13	23	14.10.13	51	48	43.75	56.25
28.7.14	23	20.8.14	55	51	53	47
7.5.15	24	31.5.15	35	30	50	50

Table 10: Records of egg-laying, incubation period and egg hatching of *Aiolopus th. tamulus* in the laboratory

Date on egg-pod laying	Incubation period	Date of hatching	Number of Egg-pod	Number of hatched egg per pod	Male %	Female %
25.4.13	20	3.5.13	12	08	62.50	37.50
7.7.13	21	29.7.13	46	43	46.51	53.49
25.4.14	17	9.5.14	66	66	45.45	54.55
15.5.15	19	2.6.15	66	60	43.33	56.67

Table 11: Duration of nymphal life (days) of Phlaeoba infumata reared for development in BOD incubator (33±2⁰C)

Number of instars	1	2	3	4	5	6	7	Mean total days
Male mean (days)		6.5	7.0	7.6	7.0	9.4		36.20
Male range (days)		5-8	5-8	6-9	7-9	8-12		32-44
Female mean (days)	6.0	6.5	7.3	8.4	8.6	10.5		41.5
Female range (days)	5-8	5-8	6-9	7-11	7-10	10-14		38-45

Table 12: Duration of nymphal life (days) of *Aiolopus* th. tamulus reared for development in BOD incubator (33±2⁰C)

Number of instars	1	2	3	4	5	6	7	Mean total days
Male mean (days)	4.5	4.8	5.8	7.5	8.5	9.4		31
Male range (days)	4-6	4-6	5-8	6-10	7-13	8-12		26-34
Female mean (days)	4.6	4.9	5.5	7.0	8.0	10.0		37
Female range (days)	4-6	4-6	5-8	6-10	7-12	8-14		34-44

Table 13: Duration of nymphal life (days) of Acrida exaltata reared for development in BOD incubator (33±2⁰C)

Number of instars	1	2	3	4	5	6	7	Mean total days
Male mean (days)	5.4	6.0	6.7	9.2	10.7			40.0
Male range (days)	5-6	6-7	7-9	8-11	9-13			34-48

Table 14: Duration of nymphal life (days) of *Atractomorpha crenulata* reared for development in BOD incubator (33±2⁰C)

Number of instars	1	2	3	4	5	6	7	Mean total days
Male mean (days)	5.3	5.6	6.2	7.6	8.5			31.5
Male range (days)	5-6	5-6	5-7	5-9	7-10			29-35
Female mean (days)	5.2	5.5	6.5	7.0	8.3	9.8		36.8
Female range (days)	5-6	5-7	5-8	6-9	7-10	8-12		35-40

DISCUSSIONS

The biology of the studied species showed that sexual maturity was variable in different sexes and species. There was a tendency of earlier sexual maturity than females as also confirmed by Kevan, *et al*., (1974) and Bhowmik (1986). However, both male and female has longer time for their sexual maturity in the case of larger species (Iqbal, *et al.*, 1974). The variations in the time of maturity within individuals of the same species might be due to the absence of a specific food plants. Parihar (1974) noted *Poeceilocerus pictus* failing to mature unless availability of *Calotropis* as food plant. The oviposition time of a female ranging from 11.75 (*Spathasternum* pr. Prasiniferum) to 15.8 days (*Acrida exaltata*) even after receiving the same favorable condition. The reason for such behavior could not be explained (John, *et al.,* 1981).

The soil conditions appeared to play an important role for the oviposition. It was observed in the present study that the species like *Phlaeoba infumata* and *Acrida exaltata* preferred loose sandy soil. When soil was hard and disturbed, *Phlaeoba infumata* was seen to deposit their eggs on the upper layer while in the undisturbed field, the eggs were laid in the lower depth. Similar observation in *Atractomorpha crenulata* was observed by Srivastava (1957). The longevity of the adult species after egg laying varied from one species to another, depending mainly on the temperature, humidity and palatability of food Keven and Lee 1974).

It is evident from tables 6-10 that the mean incubation period of egg of *Acrida exaltata* was maximum (22.8 days) and minimum in *Atractomorpha crenulata* (20 days). The little

variation in the incubation of different species might be due to the availability of moisture and the presence of favorable temperature in soil (Keven, *et al.,* 1981). The hatchability of grasshopper eggs might depend mainly upon the soil temperature, moisture and also the fertility of the eggs (Khan and Aziz, 1974).

The duration of nymphal life was maximum in the *Acrida exaltata* (47.5 days) female and minimum in *Atolopus tumulus* (31.0 days). The prolonged nymphal period of the grasshopper seemed to be due to inadequate nutrition as well as some physical parameters (Wigglesworth 1953). The result exhibited as highest peak in November and two other showed comparatively lower peaks in the month of October and July agreed with the observations of Dwivedi (1977) and Hazra (1984). The population of nymphs out numbering the adults of both the sexes, conformed with the works of Hazra, *et al*., (1984). It could be concluded from the present study that the temperature and humidity exerted influence on the size, quality and the distribution of grasshopper population as indicated by Chapman (1962). Uvarov, Hazra, *et al.,* (1984) and Tandon, *et al.,* (1988) it is interesting to note that the two species namely the *Atractomorpha crenulata* and *Phlaeoba infumata* seemed different nymphal instars throughout the year or this might be due to the prevalence of similar food plants and other ecological conditions throughout the year in the present field of study (Uvarov, 1977).

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