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Comparative Study of Egg-pod Morphology in Two Genera of Oxyinae (Acrididae: Orthoptera)

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ABSTRACT

The egg-pods of 04 species viz: *Oxya hyla hyla* Serville, 1831, *O. velox* (Fabricius, 1787), *O. fuscovittata* (Marschall, 1836) of genus *Oxya* and *Oxyina bidentata* (Willemse, 1925) of *Oxyina* were examined under laboratory conditions. Significant differences were found in the sizes and shapes of the pods. Beside this, number of eggs in each egg pod, distribution pattern and weight, length and width of eggs in the pods were also noted. Eggs pods of *Oxya* species were cylindrically elongated, large, slightly bent in the middle and rounded at ends while egg pods of *Oxyina bidentata* are bean shaped. The weight, width and length of freshly laid egg pods of *Oxya* species was 46.82±5.28 mg, 15.56±9.56 mm, and 7.20±0.78 mm, 43.39±4.31 mg, 15.3±1.05 mm, 6.10±0.87mm, 33.73±7.28 mg, 13.4±1.1 mm, 6.73±0.56 mm for *Oxya velox, Oxya fuscovittata* and *Oxya hyla hyla* respectively while it was 37.59±6.28mg, 11.80±0.78 mm and 5.90±0.87 mm in *Oxyina bidentata*. Measurement and weight of these 4 species were also compared and it was noticed that the weight, length, and width of eggs of *Oxya velox* i-e 2.47±0.38 mg, 6.00±0.81 mm, and 3.31±0.30 mm respectively is significantly greater than that of *Oxya fuscovittata*, *Oxya hyla hyla* and *Oxya bidentata*. It was observed that the egg-pod is full of eggs without any empty space. There are more eggs at the base and their number decreased towards the top. The major hatching occur within few weeks i.e., 57.43 to 100% in *Oxya velox* from June to August but mostly in the month of June, 76.85% to 100% in *O. hyla hyla* from July to September but mostly in August, and 69.09% in *O. fuscovitatta* from July to August, mostly in mid-July then hatching stopped. Present study might be useful to forecast the exact hatching dates in near future.

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Authors' Contribution
RS designed the study. NS performed the experiments. SK collected the samples. AAS complied the data. SS collect the egg-pods.

Key words
Oxyinae, Egg-pods, Eggs-measurement, Distribution pattern, Hatching, Forecast

INTRODUCTION

Oxyinae species are the most important pests of cultivated crops of primarily Asian distribution e.g. Sindh (Janjua, 1957; Riffat *et al*., 2007; Riffat and Wagan, 2008, 2010), India (Uvarov, 1922; Roonwal, 1976), Thailand, Bangladesh, China, Afghanistan (Mason, 1973). Like many other grasshopper species, Oxyinae species are bivoltine in nature. Generally, their eggs are deposited from late July to mid November, but the hatching time of first instars nymphs are species specific from mid June to early August (Wagan and Riffat, 2006). Certain other aspects, including oviposition and mating, food selection, life-history, identification and pest status of Acrididae species has been studied by Srivastava (1956), Pradhan and Peswani (1961), Siddiqui (1986, 1989), Wagan and Riffat (2006), Riffat and Wagan (2007, 2008) and Shaikh and Riffat (2018). However, morphological characteristics of egg-pods in *Oxya only* given by Janjua (1957) from Pakistan and Roonwal (1976) from India seem to be inadequate. The only comprehensive treatment of egg-pods of acridoids is given by Zimin (1938) who reviewed the earlier data of Bezrukov (1923), Raranov (1935) described and illustrated in detail from field material egg-pods of 67 Russian species, Waloff's (1950) described the egg-pods of 10 species of British grasshoppers while Khdlifa's (1956) explained 7 Egyptian species, Chapman and Robertson (1958) gave an account of 48 East African species. Hilliard (1959) worked on 65 Texas species. Katiyar's (1960) worked out 14 Indian species, Chapman (1961) described egg-pods of 48 species from Ghana In addition to this Descamps and Wintrebert (1966) investigated egg-pods of 17 Madagascar species. More recently Shaikh and Riffat (2018) described the egg-pods of 9 species of grasshoppers from Sanghar Sindh. The present date adds to the known acridoid fauna of the world.

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MATERIALS AND METHODS

Collection and rearing

Random sampling was done from different districts of Sindh i.e. Jamshoro Dadu, Larkana; Shikarpur, Thatta, Sukkur, Sujawal Badin and Karachi and weekly visits were carried out in 3 to 4 spots in each district. Different agriculture fields of rice, maize, sugarcane, millets, fodder crops and their surrounding vegetation of grasses were inspected time to time. Adults were collected with the help of traditional insect hand-net (8.89 cm in diameter and 50.8 cm in length) as well as by hand picking. The collection was done during 2014-2017 in the months of June to November from various districts of Sindh. Collected material was brought to the laboratory, pairing was made and then caged in rearing box (length 16.5 width 13.5 cms) as well as in separate ordinary jam bottles. Then these cages were placed under laboratory (25°-23/N 68°-24/ E) conditions where the temperature fluctuated between 28±2oC to 39±2oC with relative humidity of 26-61%. These temperature and relative humidity regimes were similar to the field conditions.

Collection of egg-pods and eggs

Each cage was provided with cup containing sieved garden sand for oviposition. Fresh drops of water were added daily to keep the sand moist. Green shoots of fresh maize leaves were clipped and placed in 50ml conical flask filled with water. Experimental cages and jars were thoroughly cleaned and placed in the sunlight for two to three hours after 10-12 days. The paper sheet placed on the bottom of the cage was changed daily. All egg cups were checked daily in the morning. Egg-pods were collected and opened carefully by following the method of Pradhan and Peswani (1961). The number of eggs, size and arrangement in each egg- pod was noted. Same method was adopted for all the studied species.

Statistical analysis

Data obtained from experimental groups were subjected to one-way analysis of variance (ANOVA) (SPSS 16.0 Soft-Ware) with repeated measures and significant means were determined using Least Significant Difference Test (LSD).

RESULTS

Morphology of egg-pods and eggs

Female usually deposit a heap of eggs in ground surface of cages, eggs were enclosed in a sac that consisting on the hardened secretions cemented with grains of earth, such mass of eggs is called egg pod. The pods are mostly sub- cylindrical and look slightly curved. The lower end is round in shaped and convex and the top slightly concave, the latter part is more fragile and partly composed of dried frothy material, the plug end has a tendency to break off. The variation in the size and weight of egg pods has been shown in the (Table I, Fig. 1). It was noticed that when female lay egg-pod it seems light whitish yellowish in color after expose to sunlight it becomes dark brown. In shape it was cylindrical towards its posterior end while the anterior end it was pointed usually in all cases the average number of each egg pod of Oxyinae species was calculated i.e. 3.15±0.54, 3.62±0.61, 2.46±0.40 and 2.32±0.53 for *Oxya hyla hyla*, *O. velox* and *O. bidentata* respectively. The total numbers of egg laid by female i-e 32.23±7.08, 29.0±6.09, 23.6±5.01 and 20.96±4.51 for *O. velox*, *O. hyla hyla, O. fuscovittata* and *O. bidentata* respectively. It was noticed that eggs was placed in two vertical rows (with exception of few cases of *O. bidentata*) (Table I, Fig. 1). Eggs cylindrical, elongated, large a little bent in the middle position and rounded at edges. The chorion covering the eggs is thin and almost colorless and has a weak hexagonal sculpturing exception of posterior end (lower end in the natural position) which is dark, brown and has a thick-walled hexagonal sculpturing. Above this band lies a ring funicular canals, the micropylar canals, as the embryo developed, it secretes on the inside a thick, elastic cuticle which protects the embryo until hatching. The size, length and weight of eggs in *O. velox* were significantly greater than that of *O. hyla hyla, O. fuscovittata* and *O. bidentata*. Similarly, there was significant difference between the weight of dry eggs and fresh laid eggs of Oxyinae species. It was noted that egg-pods are full of eggs without any empty space. There are more eggs at the base and their number become less towards the top and there were no any pour space between eggs they tightly joint with each other without showing any empty space. During this study it was notice that egg-pod of *O. bidentata* has very unique appearance it complete compact and there is minute pores on it, unlike that of other species.

Eggs are banana shaped measuring about 5.00±0.81mm, 6.00±0.81mm, 5.82±0.31mm for *O. hyla hyla, O. velox,* for *O. fuscovittata* respectively and 4.50±1.08mm for *O. bidentata* (Table I, Fig. 2). Eggs were maximum numbers at the posterior side of the pods, while they become gradually reduced in the anterior side. Our field study showed that its average incubation period is about 46.32±0.98 days in summer while it was 53.25±0.67 days in autumn season. On very rare occasion we have observed direct hatching of nymphs from a pod in field. We have seen that within 13–15 minutes most of hopper comes from pod all were vermiform larva. On the emergence all were light pale to greenish in color look about

Table I. Measurement (Mean ± SD) of egg pods and eggs of *Oxya* and *Oxyina* species.

Species	Freshly laid egg pods			Dry egg pods		
	Weight (mg)	Length (mm)	Width (mm)	Weight (mg)	Length (mm)	Width (mm)
Egg pods						
Oxya hyla hyla	33.73±7.28^{d}	13.4±1.1^{c}	6.73±0.56^{b}	26.72±5.40^{d}	12.5±1.0^{c}	5.4±0.86^{c}
O. velox	46.82±5.28^{a}	15.56±9.56^{a}	7.20±0.78^{a}	42.17±4.81^{a}	14.5±1.35^{a}	5.40±1.07^{a}
O. fuscovittata	43.39±4.31^{b}	15.3±1.05^{b}	6.10±0.87^{c}	32.92±9.47^{b}	13.6±1.26^{b}	5.10±0.87^{b}
Oxyina bidentata	37.59±6.28^{c}	11.80±0.78^{d}	5.90±0.87^{d}	30.57±4.97^{c}	11.6±1.14^{d}	4.90±0.87^{d}
F. $_{(0.05)}$	$_{(40.38)}$ 70.69	$_{(14.01)}$ 25.31	$_{(6.48)}$ 13.09	$_{(33.09)}$ 58.47	$_{(13.05)}$ 23.56	$_{(5.20)}$ 09.60
Eggs						
Oxya hyla hyla	2.00±0.46^{c}	5.00±0.81^{c}	2.97±0.44^{b}	1.36±0.35^{b}	4.51±0.08^{c}	2.28±0.41^{b}
O. velox	2.47±0.38^{a}	6.00±0.81^{a}	3.31±0.30^{a}	2.01±0.48^{a}	6.00±0.81^{a}	2.62±0.53^{a}
O. fuscovittata	2.03±0.24^{b}	5.82±0.31^{b}	2.98±0.28^{b}	1.46±0.47^{b}	4.86±0.57^{b}	2.55±0.43^{a}
Oxyina bidentata	1.97±0.32^{d}	4.50±1.08^{d}	2.93±0.63^{b}	1.34±0.02^{b}	4.20±1.03^{d}	2.25±0.53^{b}
F. $_{(0.05)}$	$_{(2.11)}$ 04.36	$_{(5.33)}$ 09.60	$_{(3.04)}$ 06.11	$_{(1.54)}$ 04.36	$_{(4.89)}$ 09.60	$_{(2.42)}$ 04.36

Table II. Life span of Oxyinae species on different diet under laboratory conditions (After emergence from 6th nymphal instar).

Species	*Oryza sativa*		*Zea mays*		*Triticum aestivum*		Mixed diet		Mean ±S.D	Mean ±S.D
	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀
Oxya hyla hyla	28	37	25	33	21	29	24	32	24.5±2.88	32.75±3.30
O. velox	29	39	24	34	22	32	25	36	25.00±2.94	35.25±2.98
O. fuscovittata	26	35	23	32	21	31	25	33	23.75±2.21	32.75±1.70
Oxyina bidentata	26	35	25	31	22	29	23	31	24.00±1.82	31.50±2.51
									$_{(24.31)}$ 42.76	$_{(32.50)}$ 56.72

Table III. Season wise collection of different stages of *Oxya hyla hyla* from field during various months of year.

Months	1st Instar	2nd Instar	3rd Instar	4th Instar	5th Instar	6th Instar	Adult Male	Adult female	Total No.	Total %
Summer season (First generation)										
April	19	21	22	36	-----	-------	-----	-----	98	3.16%
May	27	33	35	43	53	58	54	71	374	12.08%
June	24	29	32	41	98	132	32	26	414	13.37%
July	37	42	56	62	88	129	50	57	521	16.82%
August	32	37	49	58	66	94	102	98	536	17.31
Autumn season (Second generation)										
September	17	21	25	29	56	96	54	61	359	11.59%
October	15	19	22	32	38	50	122	85	383	12.37%
November	11	16	18	24	28	44	43	31	215	6.94%
December	9	13	16	21	28	40	30	39	196	6.33%
Total	191	231	275	346	455	643	487	468	3096	37.23%

(7.66±0.18 mm) long. Antennal segments were 1.35 ±0.03 mm long. During field survey it was noted that maximum hatching was about 91.20±1.01 days was obtained on 35^{o}C with contact moisture. However, hatching was significantly affected when temperature in low range i-e (25^{o}C) or too high i-e 40^{o}C to onwards.

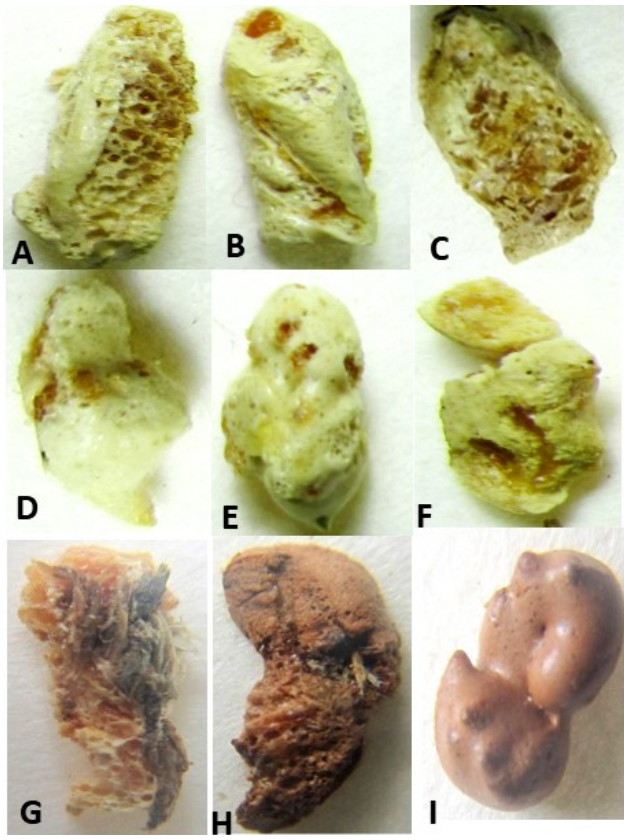

Fig. 1. Egg pods of *Oxyinae* spp. (A-C), *O. hyla hyla*; (D-F), *O. fuscovittata*; (G-H), *O. velox*; I, *Oxyina bidentata* (arrow indicate minute pores).

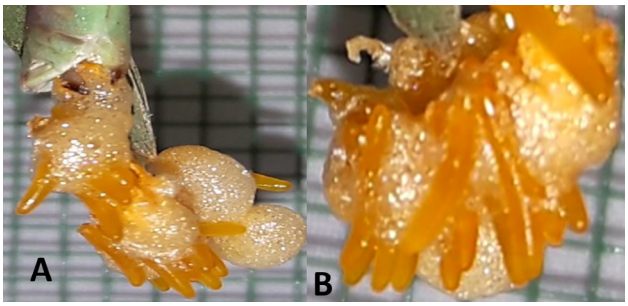

Fig. 2. (A), Egg laying of *Oxyinae* species along with foamy mass secretion; (B), enlarged view of eggs.

DISCUSSION

The information on the fertility, fecundity and longevity of four Oxyinae species was figure out for the first time. It was noticed that female of *O. hyla hyla*, *O. velox*, *O. fuscovittata* and *O. bidentata* deposit an average of 3.15±0.54, 3.62±0.61, 2.46±0.40 and 2.32±0.53 egg pods respectively. While Aziz (1981) carried work on the bionomics and life history of *O. velox* and reported that *O. velox* lays about 6 to 14 egg pods during entire period, during this study we have not observed the maximum ratio of egg pods. However, it was noted that the number of eggs remain almost the same in first two oviposition but decline afterwards. Its possible reason might be (I) not energetic feeding of insect (II) female become weak with the passage of time. He also claimed that female survive lesser i.e. (29.90±1.68) days than that of male but wontedly, during this study we noticed longer survival of female i.e. (32.75±3.30), (35.25±2.98), (32.75±1.70) and (31.50±2.51) for *O. hla hyla, O. velox*, *O. fuscovittata* and *Oxyina bidentata* respectively.

According to Uvarov (1966) in Acrididae the total number of layings by a female primarily depends on the length of period during which the female continued its reproductive activities and duration of survival period definitely affect the rate of fecundity in females. The results of present study are close to the above account. At present it was also noted that fecundity reduced with increased rate of oviposition. The chances of repeated mating were found to be decrease. Present study suggests that when female progressively grew she became less energetic and it might be one of the reasons to reduce the production of eggs in respective batches. A significant difference between the life-span of male and female was observed female live longer than male (Table II). He further pointed out that mostly in Acrididae towards the end of oviposition period females die off before males (with the exception of few cases) when females die during the act of prolong copulation it might be one of the reasons for the longer survival of males.

Life history of different species of Orthoptera was studied in the laboratory and field by Roffey (1979), Sharma and Gupta (1996), Riffat and Wagan (2007, 2008, 2010) and Samejo and Riffat (2019) but information on the biology of Oxyinae species was noted listed thoroughly in literature (with exception of *Oxya japonica)* from Kashmir region by Tajmul and Ahmed (2016). They reported that *O. japonica* undergoes three generations each year. Eggs are laid in the soil during August to September and hatching takes place during the following June or July soon after the first showers of monsoon. The adults begin to appear in late July and mature by the month of August when the copulation and oviposition occur. The adults die off towards the end of September. Similarly, Khan *et al.* (1963) from Rajasthan, India stated that the adults persist from July to October. Moizuddin (2001) from Balochistan Pakistan reported that hoppers emerge after a week or two after the monsoon rains in July or August. The duration of the hoppers stage is four to five weeks. The adults begin to appear in August depending on early or late summer

rains. During the present study we have reported 02 generations of *Oxya hyla hyla* per year first generation appears in autumn and second in summer season (Table III). The present finding correlates with above account but, it is slightly differ particularly with Indian authors for the reason that the monsoon rains occur in early summer in June and July in India in late summer in July and August in Pakistan. The difference between the emergences and duration of hoppers might be because of that insect's habitats, seasonal fluctuation and egg diapause vary from place to place depending on climatic and ecological conditions of the region. Furthermore, present study also revealed that rains in June and July are therefore important, because, if these two months were dry, a large percentage of the eggs would fail to hatch. On the whole, early and uniformly distributed summer rains create favorable conditions for hatching. Present study might be useful to forecast the exact hatching date and should be of benefit in avoiding or preventing any possible future outbreak.

Statement of conflict of interest

The authors declare there is no conflict of interest.

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