Influence of host food plants on the post embryonic development of *Oxya japonica* (Orthoptera: Acrididae)

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Abstract: - Present study was conducted to investigate the influence of diet on the post embryonic development of *Oxya japonica* and its adaptability to its host plants with reference to life history statistics under laboratory conditions. The experiment involved rearing the nymphal instars and adults of *O. Japonica* on seven selected host plants viz. *Oryza sativa, Zea mays, Cyanodon dactylon, Trifolium berseem, Brassica compestris, Plantago sps, Andropogon sps* and mixed diet. It was found that mixed diet was mostly preferred with the average hopper development period of 56 ± 2.64, while *Brassica campestris* and *Plantago sps* prolonged the hopper development period, the average development time being 65.8 ± 1.08 and 66.6 ± 1.34, respectively. Experimental results showed that the acceptability percentages of various host plants seem to be correlated with their affects on the post embryonic stages of grasshoppers. It was concluded that *O. Sativa, , Andropogon sps* and mixed diet are most suitable hosts for *Oxya japonica* compared to other host plants tested as was indicated by the shortest hopper development period.

[S. Tariq Ahmad & Mir Tajamul. **Influence of host food plants on the post embryonic development of *Oxya japonica* (Orthoptera: Acrididae).** *Rep Opinion* 2014;6(6):44-48]. (ISSN: 1553-9873). http://www.sciencepub.net/report. 6

Keywords: Food plants, Post embryonic development, *Oxya japonica.*

1. Introduction

Most species of grasshoppers being polyphagous feed on a variety of unrelated plant families. However, some grasshopper species do restrict themselves to limited host ranges and a few of them even show relatively high fidelity to their host species (Sword and Chapman, 1994; Sword and Dopman, 1999). The rice grasshopper, *Oxya japonica*, is such an oligophagous insect, which feeds on a few graminaceous species. As the name suggests, rice grasshopper usually feeds on rice and is one of the most important agricultural pests causing reduced yield of rice (Hollis, 1971).

Although information on the host plants is available for many acrids (Gangwere 1965), but food preferences of *Oxya japonica* (Thunburg), found in the grass fields and Paddy fields of Kashmir region and elsewhere are only briefly reported in the literature. Food plants are known to affect the biology and behaviour of insects including growth rate, development, survival, fecundity and fertility (Pickford, 1962; Banjerjeet and Haque, 1985; Aslam and Whitworth, 1988). Gangwere (1961) studied the food selection, the role of food plants in grasshoppers and correlations between mandibular morphology and food specificity of American grasshoppers.

Extensive studies on the food selection in grasshoppers have been adequately carried by Uvarov (1977), Roffey (1979), and Chapman. The

feeding habits of the desert locust, *Schistocerca gregaria* (Forskal) were carried out by Husain *et al.* (1946). Mitchell (1975) studied the food preferences of three species of grasshoppers viz. *Melanoplus sanguinipes, M. Foedus* (Scudder) and *Aulocara elliotti* (Thomas). Roonwal experimented on the food preferences of the desert locust in its permanent breeding ground in Baluchisdtan. Williams (1975) reported on the food preferencs and the feeding habits of British grasshoppers and *Chortogonus trachypterus* (Blanchard), respectively.

It has been reported that plant availability in a habitat is very important in establishing the diet breadth of grasshopper species. However, diet breadth is determined not only by the relative abundance of individual plant species, but also by individual plant species nutritional and pathogical condition (Chapman, 1990). Bailey and Mukerji (1976) concluded that the ability of an insect to consume a variety of food plants indicates little with regard to the ability of plants to support growth. Low digestibility of a plant may result in most of the ingested materials being voided in faeces rather than being assimilated.

Therefore, the present study was designed to investigate the effect of various host plants on the post embryonic nymphal and adult stage of *Oxya japonica*. The results of such studies will be instrumental in formulating population management strategies, which could help avoiding any possible future outbreak.

2. Material and Methods

The present research investigations were conducted under laboratory conditions. The observations were taken to study the impact of various host plants on the post embryonic development of rice grasshopper, *Oxya japonica* during 2013 at the Entomology Research Division, Department of Zoology, University of Kashmir, Jammu and Kashmir India. The adult grasshoppers and various immature nymphal stages of *Oxya japonica* were mostly collected from cultivated rice fields and other surrounding vegetation of grasses from different climatic zones of Kashmir province during months of May-September in the year 2013. The collection of insects was made from 9:00 to 12:00 noon with the help of insect collecting net and kept in rearing cage measuring 112×82×82 cm. Green shoots of fresh leaves cuttings were clipped and placed into 50 ml conical flask filled with water. Two sides of the cage were made of wood, fitted with windows to clear the grasses and transferring the insects. The other two opposite sides were made of glass and wire mesh respectively. The floor of the cage was made of wire mesh provided with six holes each containing the metallic tube, each measuring 11cm in length and 3 cm in diameter, filled with moist sterilized sand which provided pseudo earth for oviposition. The cage was fitted with the temperature apparatus to maintain the constant temperature. Each cage was provided with a number of plant twigs for perching, moulting and for basking. The humidity of the cage was maintained by placing petridish containing moist cotton in the cage.

The eggs laid were kept in petridishes lined with moist filter paper for hatching. Different host plants provided for the experiment were: *Oryza sativa* (Poaceae), *Cynodon dactylon* (Poaceae), *Zea mays* (Poaceae), *Andropogan sps, Trifolium berseem, Brassica campestris* (Brassicaceae), *Plantago sps*. and the mixed diet. Newly hatched nymphs were separated and shifted into glass jars 15×5 cm individually and fed twice per day as per experimentally designed conditions of food at a temperature of 30°C with 65±5 % RH. The open end of the jar was covered with muslin cloth held with a rubber band. Each experiment was replicated ten times with one pair of hoppers in each replicate and the data obtained was subjected to statistical analysis and significance was worked out to discriminate the deviation of treatment means. Newly emerged adults were paired in glass jars filled with moist sand at the bottom to serve as oviposition medium. Ten pairs were treated individually on single host plant and mixed diet. Adults were maintained till their death.

3. Statistical analysis

Data obtained from experimental groups were subjected to one-way analysis of variance (ANOVA), (MS Exel 2007, PRIMER software) with repeated measures and significant means were determined using Tukey's Multiple Comparison Test (TMCT).

4. Results

Post embryonic development rates:

As depicted in the Table 1, the plants were listed with respect to their effect on the duration of Nymphal development. The first instars of *O. japonica*, developed fastest while feeding on *O. sativa* and the mixed diet with the average development period of 8.4 ± 0.54 and 7.6 ± 0.54 days respectively. However, on *Brassica campestris* the first nymphal instar development was prolonged with the average development period of 11.8 ± 1.09 days. Development period of first instar nymphs was almost similar when feeding was on *Cyanodon dactylon* and *Andropogon species* with the average development period of 8.8 ± 0.70 and 8.6 ± 0.54 days respectively.

The second instar nymph development was fastest when fed on the mixed diet with the average development period of 9.4 ± 0.89 days but there was no significant difference in the nymphal duration of hoppers either reared on *O.sativa, Andropogon sps.* and *Cyanodon dactylon*. The development period was prolonged when the instars were reared on the *Plantago sps.*. In third nymphal instar, feeding on mixed diet led to a significantly shorter duration of 11.8 ± 0.83 days. No significant difference could be observer in the nymphal development of instars when feeding on *Andropogon sps., C. dactylon and Zea mays*. The development period of forth instar was minimum when nymphs were fed on *Z. mays* with the average development period of 12.6 ± 2.5 days, followed by *C. dactylon* with the average development period of 13.2 ± 1.48 days. The developmental period was maximum in case of instars fed on *O. sativa and Plantago sps.* with the duration of 14 ± 1.40 and14 ± 1.87 respectively.

While in the fifth instar, the development period did not differ significantly among the nymphs fed on the mixed diet, *Andropogon sps.* and *Z. mays* but it was significantly longer in the nymphs fed on *Plantago sps*. and B. *campestris* with the average development period of 15.4 ± 1.34 and 14.2 ± 0.83 days respectively. The development was most remarkable in the nymphs fed on *Z. mays, O. satova* and mixed diet with the development period of 13.2 ± 1.3, 13.6 ± 0.83 and 13.6 ± 0.54 respectively.

Overall, the one way repeated measures ANOVA for hopper instar development revealed the following differences:

(i) For first instar ($F = 25.38$; $df = 7/56$; $p < 0.05$) (ii) For second instar ($F = 5.73$; $df = 7/56$; $p < 0.05$) (iii) For third instar ($F = 3.14$; $df = 7/56$; $p < 0.05$) (iv) For fourth instar ($F = 1.12$; $df = 7/56$; $p > 0.05$) (v) For fifth instar ($F = 3.74$; $df = 7/56$; $p < .05$).

Summing up these readings, it was concluded that the mixed diet was the most preferred food of the various hopper instars of *Oxya japonica*, showing the minimum total development period of 56 ± 2.42 days. No significant difference was observed in the total development period of the nymphs that fed on *C. dactylon, Trifolium berseem, Z. mays, Andropogan sps,* and *Oryza sativa* but *Plantago species* and *Brassica campestris* led to the prolonged total development period of 66.6 ± 1.44 and 65.8 ± 1.08 days respectively.

Table 1: The effect of host plants on the post embryonic developmental stages of *Oxya japonica*.

Treatment	Mean post embryonic development period of instars in days ± SD					
I	II	III	IV	V	Total period	
Oryza sativa	8.4 ± 0.54^{a}	10.4 ± 1.40^{a}	13.2 ± 0.83^{a}	14 ± 1.40^{a}	13.6 ± 0.83^{a}	59.6 ± 2.42^{a}
Andropogon sps.	8.6 ± 0.54^{a}	10.6 ± 1.51^{a}	12.6 ± 1.41^{b}	13.8 ± 0.83^{a}	13.8 ± 0.83^{a}	59.4 ± 2.52^{a}
Cynodon dactylon	8.8 ± 0.70^{a}	10.8 ± 1.78^{a}	12.8 ± 1.09^{b}	13.2 ± 1.48^{b}	14.6 ± 1.41^{b}	60.2 ± 2.26^{a}
Trifolium berseem	9.0 ± 0.83^{b}	11.2 ± 1.09^{b}	13.2 ± 0.83^{c}	13.4 ± 1.08^{b}	14.4 ± 1.51^{b}	61.2 ± 2.15^{a}
Zea Mays	9.8 ± 0.54^{b}	11.2 ± 1.09^{b}	12.8 ± 0.83^{b}	12.6 ± 0.54^{c}	13.2 ± 1.3^{a}	59.6 ± 1.4^{a}
Brassica campestris	11.8 ± 1.09^{c}	12.2 ± 0.44^{c}	14.0 ± 0.70^{d}	13.6 ± 1.51^{b}	14.2 ± 0.83^{b}	65.8 ± 1.08^{b}
Plantago Sps.	11.6 ± 1.51^{c}	12.6 ± 0.83^{c}	13 ± 1.22^{c}	14 ± 1.87^{a}	15.4 ± 34^{c}	66.6 ± 1.34^{b}
Mixed Diet	7.6 ± 0.54^{d}	9.4 ± 0.89^{d}	11.8 ± 0.83^{e}	13.6 ± 0.54^{b}	13.6 ± 0.52^{a}	56 ± 2.64^{c}
F	25.38*	5.73*	3.14*	1.12^{ns}	3.74*	23.39*

Note: Mean in the same column followed by the same letter(s) are not significantly different from one another at 5% level of probability (TMCT), ns-not significant, $p \geq 0.05$.

4. Discussions

The experiment clearly reveals that the post embryonic development of the *O. japonica* is significantly affected by the type of food i.e. host plants. Among the food plants observed in the experiment, *Z.mays* resulted in the shortest nymphal development for the 5th nymphal instar. Likewise, feeding on the mixed diet caused rapid development in 1st, 2nd and 3rd nymphal instar. In contrast, *Plantago sps*. led to the prolonged nymphal development for 2nd, 4th and 5th nymphal instar.

The present studies showed that the mixed diet was mostly preferred with the shortest hopper development period while the *Plantago sps.* was the least preffered food with the longest hopper development period. The rest of the plants ranged in between these two. Thus, in nature the insects are subjected to the variable developments depending on the preponderance of particular food plants in various localities (Nzekwu and Akingbohungbe 2002; Smith and Capinera 2005). However the efficiency of conversion of the ingested and digested food is higher in the less preferred host thereby enabling the insect to complete its development and reproduce when fed on the lesser preferred hosts (Syed; lal; Abro and Siddiqui, 2011).

The choice of plants by the Acrid grasshopper under study seems to reveal that it may be based on the absence of feeding detergents or their presence in small amounts in the host plants. As reported by Bemays and Chapman, 1977, *O. nitidula* totally rejected all forbes, perhaps due to the presence of one or more compound deterrents to the graminivore. Adams and Bernays (1978) had earlier shown that a range of chemicals having antifeedent properties of nymphs of *Locusta migratoria* (L) is additive in its effect. However, Bernays and Bright (1991) provide evidence that individual polyphagous grasshoppers do switch more between dietry items and mix intake of different complementary foods, than when the two foods are nutritionally adequate and identical.

Experimental results showed that the acceptability percentages of various host plants (Haldar; Bhandar and Nath, 1995) seem to be correlated with their affects on the post embryonic stages of grasshoppers. Besides, it was concluded that

mixed plant diets are superior for *Oxya japonica* as is indicated by the shortest hopper development period. The result is in correlation with the studies of McFarlane and Thorsteinson (1980) on *Melanoplus bivittatus* who proposed that mixed plant diets are thought to promote higher survival and higher growth indices than any single plant diet. Fanny *et al*. (1999) found that in *Oxya nitidula*, the shortest nymphal period was obtained when rearing was on *Panicum maximum* . Adequate diet is expected to reduce nymphal developmental period, which is very important for the fitness and survival of insects.

Balanced and optimum nutritional levels play a vital role in the insect development by influencing the activity of endocrine system. It is generally supposed that the activity within the endocrine system is generated by the stimulation of foregut stretch receptors during increased feeding (Hill *et al*., 1966). Therefore, the optimal amount and quality of food are necessary pre-requisites for the development and growth of different instar larvae and the adults.

It was observed that plants of the Poaceae were preferred to a higher degree by the Acrid grasshopper under study. These findings bring to light some observations which may have major importance agro-economically. The present study suggests that this insect species may act as a potent pest of these plant species some of which are of considerable economic importance. Future studies including field studies are expected to provide other essential data to tackle this complex agro-economically important insect species.

Acknowledgements:

The authors are grateful to Head, Department of Zoology, University of Kashmir, Srinagar for providing necessary research facilities

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6/13/2014