Morphometric studies of the post embryonic developmental stages of Rice Grasshopper, *Oxya japonica* (Orthoptera: Acrididae)

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Abstract: Morphometric analysis of the external body parts of each post embryonic development stage of rice grasshopper, *Oxya japonica* was carried out under laboratory conditions. Data collected included total body length, head length, antennal length, pronotum length, femur length, length of abdomen, prothoracic leg, mesothoracic leg, metathoracic leg, antenna and abdominal width,. The result of the study showed that the size of the measured body parts increased progressively during the post embryonic development. There was a strong positive relationship between the body length, femur length, antennal length and pronotum length. The life cycle of the insect included 5 instar stages. The study revealed that the total body length, head length, antennal length, abdominal length, hind femur length and length of metathoracic leg could be taken as indicators for the recognition of various instar stages.

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1. Introduction

The rice grasshopper, *Oxya japonica* is widely distributed throughout – Asia/temperate (china), Africa, Northern Africa, Algeria (Global biodiversity information facility network, 2011). It is 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).

Life history and life cycle were studied in the laboratory as well as field conditions for different species of Orthoptera by various workers (Roffey, 1979; Sharma & Gupta, 1996). The micro distribution and fidelitic status of Orthopteran populations in grasslands of Dachigam National Park of Kashmir region was studied by Bhat and Qadri (1999). Biology and taxonomic parameters of some short horned grasshoppers from sub-shivalik plains of Jammu region were studied by Sharma & Gupta (1996). Further, significant contribution to grasshopper fauna of Kashmir was made by Bei-Beinko & Mishchenko (1951). Mehmood & Yousuf (1999) recorded Oedipodinae (Acrididae: Orthoptera) from Azad Jammu and Kashmir with the description of a new species *J. Orth.*

Recently, morphometric studies of Variegated Grasshopper, *Zonocerus variegates* (Linnaeus, 1758) were carried on by Ademolu, Idowu & Oke (2013). Some studies were carried-out on incubation period, hatching of eggs, duration of hoppers, food preferences, Dyar's law and cannibalistic behavior of some acridid species (Ahmad *et al*.,2007; Ahmad, 2008; Ahmad & Nabi, 2009, 2010, 2012). Effect on morphometry and fecundity of *Z. variegates* was studied by Chikwuma Simon (2010).

Grasshopper species compete with humans for plant resources all over the world (Dempster, 1963). In Africa, Australia and Asia, the grasshoppers are generally termed as 'locusts' for their aggressiveness, gregariousness and swarm forming behavior. They often cause extensive and serious damage with their potential of invading cropping areas in swarms of millions of individuals leaving behind devasted fields and plantations.

It is obvious from literature that it would be more convenient to direct control operations to the 1st-3rd instars of *O. japonica*. However, in order to do this effectively, the stadial time of each instar stage should be known which is not available in literature. Also, the control strategies would be ineffective without a comprehensive knowledge of the biology of the insect which morphometrics are part of. The aim of this work is to carry out morphometric analysis of each instar stage of *O. japonica* body parts during post embryonic development of the insect.

2. Material and Methods

The present research investigations were conducted under laboratory conditions. 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. Host plant provided for the experiment was *Andropogan sps.* because of its easy availability in the campus. 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 25°C with 65±5 % RH. The open end of the jar was covered with muslin cloth held with a rubber band.

In the morphometric studies, as each developmental stage emerged, the measurements of various body parts were taken out with the help of Vernier digital caliper. A comparison of mean of all the data was subjected to ANOVA and and significant means were determined using Tukey's Multiple Comparison Test (TMCT).

3. Results

The measurements of the body parts examined are shown in table below. The size of the various body parts showed a progressive increase in size. Total body length showed a progressive increase in size in the successive instar stages from 6.41 ± 0.12 in the first instar to 33.23 ± 0.92 in the adult insect. Regression analysis showed a strong positive relationship between the total body length and the length of antenna (0.979) as well as between the total body length and the femur length (0.9869). There was a significant difference ($P \leq 0.05$) in the size of body length, size of antennae, head length, pronotum length, pronotum width, abdominal length, abdominal width, hind femur length, prothoracic legs, mesothoracic legs and metathoracic legs during post embryonic development.

Antennal length varied significantly between second (1.12 ± 0.57), third (2.20± 0.21) and fifth (4.97 ± 0.95) instars ($P \leq 0.05$), however, the antennal length of the first and second instar, third and fourth instar showed insignificant differences ($P \geq 0.05$). Head length showed a significant difference between first (1.06 ± 0.02), second (1.95 ± 0.15), third-fourth (3.01 ± 0.42, 3.25 ± 0.36) and fifth instar (4.26± 0.91), but the difference was insignificant between third and fourth, fifth and adult stage ($P \geq 0.05$). The pronotum length varied significantly between first, second, third-fourth fifth and adult stages ($P \leq 0.05$) but the difference was insignificant between third and fourth instar ($P \geq 0.05$). Pronotum width also varied significantly among various stages ($P \leq 0.05$) except between first and second instar, fifth instar and the adult stage ($P \geq 0.05$)

Abdomen showed a progressive increase in length measuring 3.44 ± 0.66 in the first instar and 12.91 ± 1.54 in the adult. It varied significantly between first, second, third, fourth-fifth and adult stage ($P \leq 0.05$), however the difference was insignificant between fourth and fifth instar. Abdominal width also varied significantly between first-second, third, fourth- fifth and adult stage but the difference was insignificant between first and second instar, fourth and fifth instar ($P \geq 0.05$).

The length of prothoracic leg varied significantly between first, second, third-fourth, fifth and adult stage ($P \leq 0.05$). Similarly the length of mesothoracic leg varied significantly between various stages except fifth and adult stage ($P \geq 0.05$). There was insignificant difference between the length of metathoracic leg of first and second instar ($P \geq 0.05$), fifth and adult stage ($P \geq 0.05$). Hind femur length varied significantly between second, third, fourth, fifth and adult stages ($P \leq 0.05$).

The size of various body parameters helps in identification of various instar stages. In general total body length of above 30 mm with abdominal length of more than 12 mm and hind femur length of more than 13 can be taken as representatives of the adult stage. Similarly, the antennal length of less than 2 mm with metathoracic leg length of less than 10 mm can be taken as the indicators of First or second instar stage. However no significant difference could be seen between the two.

Third instar stage could be identified on the basis of total body length of 10-18mm with metathoracic leg of 10-20 mm. Fourth instar can be identified on the basis of total body length of 18-24 mm with hind femur length of 8-10 mm. Fifth instar stage can be recognized by total body length between 24-30 mm with hind femur length of 11-14mm.

Table 01. Mean length (± SD) of nymphs and adults of Oxya *japonica* during post embryonic development (in mm) (n=25)

Parameter	1st instar	2nd instar	3rd instar	4th instar	5th instar	Adult
TBL	6.41±0.12a	7.25±0.84a	13.36±1.01b	21.66±2.21c	27.57±1.04d	33.23±0.92e
ANT.L	0.97±0.01a	1.12±0.57a	2.20±0.21b	4.62±0.32c	4.97±0.95c	7.95±0.87d
HL	1.06±0.02a	1.95±0.15b	3.01±0.42c	3.25±0.36c	3.99±0.41d	4.26±0.91d
PL	1.11±0.21a	2.32±0.85b	3.98±1.02c	3.67±0.84c	5.16±1.02d	6.72±1.17e
PW	0.95±0.03a	1.25±0.54a	2.57±0.42b	3.56±0.64c	4.23±1.2d	4.87±0.99d
ABD.L	3.44±0.66a	5.20±0.74b	7.42±0.62c	9.75±1.21d	10.77±1.02d	12.91±1.54e
ABD.W	1.07±1.01a	1.45±0.23a	1.95±1.48b	2.32±0.39c	2.45±0.84c	2.97±0.77d
PTL	2.05±0.31a	5.62±0.89b	7.45±0.71c	8.12±1.03c	13.15±1.57d	15.75±1.46e
MSL	2.76±0.01a	5.79±0.36b	6.85±0.97c	9.61±0.88d	16.21±1.32e	17.02±1.25e
MTL	7.2±0.35a	8.3±0.85a	14.13±1.05b	22.23±1.42c	29.94±1.29d	30.33±2.06d
HFL	2.9±0.6a	3.1±0.71a	6.45±0.79b	10.98±1.05c	13.56±1.39d	15.07±1.92e

Mean values in the same row having different subscript are significantly different ($P \leq 0.05$).

TBL-Total Body Length, ANT.L – Antennal Length, HL – Head Length, PL-Pronotum Length, PW – Pronotum Width, ABD.L – Abdominal Length, ABD.W – Abdominal Width, PTL – Prothoracic Leg, MSL – Mesothoracic Leg, MTL – Metathoracic Leg, HFL – Hind Femur Length.

Table 02. Measurements of various body parameters (in mm) for identification of *O. japonica* instars.

Body Part / Instar	TBL	HL	ANT. L	ABD. L	MTL	HFL
1st-2nd	…….	1-2	< 2	…...	< 10	……
3rd	10-18	...….	…….	……	10-20	……
4th	18-24	…….	….....	……	……	8-10
5th	24-30	…….	…….	…….	……	11-14
Adult	>30	…….	…….	>12	……	> 13

TBL-Total Body Length, HL-Head Length, ANT.L-Antenna Length, ABD.L-Abdominal Length, MTL-Metathoracic Leg, HFL-Hind Femur Length.

4. Discussions

There was a progressive increase in the size of various body parts of the post embryonic developmental stages of *O. japonica.* Similar results were obtained by Chapman et al. (1977) that the size of the appendages of *Zonocerus variegates* (L.) increased during the post embryonic development and by K. O. Ademolu and A.B. Idowu by their studies on *Z. variegatus*. Clarke and Richards (1976) likewise reported that the growth in locust is rapid as the insect undergoes moulting.

The gradual increase in the abdominal length corroborates Ademolu & Idowu (2011) observation that there is increase in the microbial load of grasshopper gut as it moults from first instar to the adult stage. The increase in the length is necessary probably in order to accommodate the increase in food consumption during the post embryonic development. It can be observed from this study that body parts and gut length of *O.japonica* increase as the insect advanced in age which becomes more pronounced in 5th to adult stage, thus increasing in complexity.

The length of antenna showed a progressive increase from first instar to adult stage. This explains the gregarious behaviour of the lower instars (1st – 3rd) and the dispersing character of the fifth instar to adult as reported by Toye (1982). The difference between prothoracic leg and mesothoracic leg means of instar stages and adult was not significantly different ($P \geq 0.05$), however, there was a significant difference between mesothoracic and metathoracic leg means ($P \leq 0.05$). This might likely be explained in terms of their function. Both prothoracic and mesothoracic legs are sets of walking legs where as metathoracic legs are for hopping.

The analysis of various measurements of morphological characters has distinctly separated various instar stages of *O. japonica.* The present study has demonstrated that the total body length , head length, antennal length, metathoracic leg length and femur length can be used to separate various post embryonic life stages.

This information will be of particular interest to crop protection agents and in the administration of various control strategies. It is noteworthy that the lower instars ($1^{st-}3^{rd}$) are easier to control because of their simplicity (Ademolu & Idowu, 2006). It is thus advisable to launch control attacks on the early instars that are physiologically less complicated.

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