Journal of Informatics and Mathematical Sciences
Vol. 9, No. 4, pp. 1125–1130, 2017
ISSN 0975-5748 (online); 0974-875X (print)
Published by RGN Publications
http://www.rgnpublications.com
DOI: 10.26713/jims.v9i4.1011

Research Article

Head Shape Variation in *Cnaphalocrocismedinalis* (Guenee) Larvae Associated with Different Rice Varieties

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Abstract. *Cnaphalocrosismedinalis* is considered a dominant insect pest of rice throughout the rice growing areas in the Philippines. Its head, a morphological trait, is specialized for food gathering and manipulation, including its relation to bite performance and ecology has been used for investigating the integration of different phenotypic components. Because of the role of this structure in the insect pest, we quantitatively describe the amount of morphometric variation between populations of the pest collected from different rice hosts. Landmark-based geometric morphometrics method was used to quantify and analyze head shape variation by the application of statistical methods of the relative warp scores. Based on the results of the assessment, significant variations in head shapes between populations of the insect were observed and argued to be due to the selection exerted by the host.

Keywords. Rice leaf; Cnaphalocrosismedinalis

MSC. 92C40

Received: June 8, 2016 **Accepted:** November 21, 2016

1. Introduction

Cnaphalocrocismedinalis (Guenee) is a pest in rice that causes severe yield losses [1, 2]. Resistance against this pest always fails because the pest was able to overcome the resistance factors in the rice plant. It is argued that the pest has developed resistance to the plant and is reflected in changes to its phenotype. Understanding variations in phenotypes can be best described with the use of geometric morphometric (GM) tools [3, 4]. GM provides precise quantitative information for the identification of species complexes and within and between population variations and offers a comprehensive use of information about the shape of a morphological structure [5]. In this study, landmark-based geometric morphometrics method was used to quantify and analyze head shape variation in *C. medinalis* collected from two different populations and different host varieties. This is to find out if the different populations from different geographical locations and rice plant are morphometrically differentiated. Its head, a morphological trait, is specialized for food gathering and manipulation, including its relation to bite performance and ecology and has been used for investigating the integration of different phenotypic components [6, 7].

2. Materials and Methods

Opportunistic sampling of rice leaf folder larvae was done from rice farms in Bukidnon and Lanao del Norte, Philippines. Rice leaves which have white mark feeding strips indicate the presence of a larva. Each collected larva was identified using a dissecting microscope. Larva of *C. medinalis* has two pairs of curve lines located at the lower part of the head.

By means of TPS utility software, meta files of the photographs of the head capsule were made. TPS or Thin Plate Splines Dig Ver. 2 was used to predict how points lie in those areas between landmarks in the initial form are arranged on the target form [8]. The raw coordinate data were then subjected to *Generalized Procrustes Analysis* (GPA) to superimpose the landmark configurations using least-squares estimates for translation and rotation parameters [9].

Landmark configuration of each organism was superimposed using the generalized Procrustes analysis in TpsRelw that standardize the size of the object and optimize their rotation and translation so that the distances between corresponding landmarks are minimized [5]. The relative warps were visualized with TPS transformation grid. Increasing or decreasing the amplitude factor away from zero, the original landmark configuration and grid would be progressively deformed according to the selected relative warp [10]. In TpsRelw, images were analyzed and variations were plotted in two-dimensional warp grid.

The relative warp scores were used in MANOVA and Kruskal-Wallis test using PAST software version 1.91 [11]. It was used to determine whether the head shape of the rice leaf folder differ significantly between different populations. The analysis was preceded with Hotelling's pairwise comparisons (post-hoc) test.

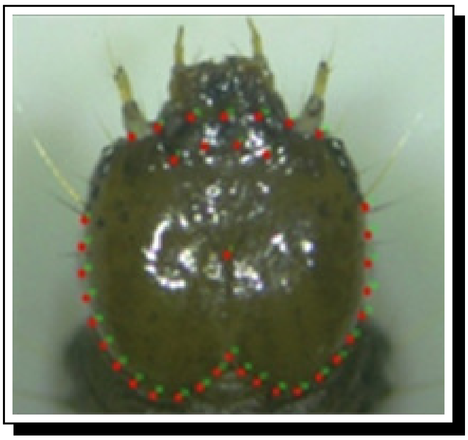

Figure 1. Rice Leaf Folder's Head showing the 37 landmarks

3. Results and Discussion

The *Canonical Variate Analysis* (CVA) of the relative warp scores show the variations observed in head shapes was significant [Wilk's lambda: 0.06477, F: 5.706; *p*(same): 6.94E-77]. The distribution of individuals were shown in a scatter plot (Figure 2) and comparison between populations (Tables 1 and 2) revealed significant variations in head shapes between *C. medinalis* feeding on different rice varieties. The variations in the head shapes were described based on the results of the relative warp analysis (Table 3).

Table 1. Comparison of head shapes between populations of *C. medinalis* feeding on different rice varieties

	Redrice	Rc128	Rc226
Masipag	**1.17E-07**	**1.57E-15**	**3.28E-21**
Redrice	-	**5.77E-10**	**4.80E-15**
Rc128		-	**1.08E-07**
Rc226			**1.05E-10**

Table 2. Confusion matrix showing the degree of similarities in head shapes of *C. medinalis* feeding on different rice varieties

	Masipag	Redrice	Rc128	Rc226
Masipag	**84 (93.33%)**	4 (4.44%)	2 (2.22%)	0
Redrice	9 (10.00%)	**77 (85.55%)**	4 (4.44%)	0
Rc128	1 (1.11%)	6 (6.66%)	**79 (87.77%)**	4(4.44%)
Rc226	0	1(1.11%)	5 (5.55%)	**84 (93.33%)**

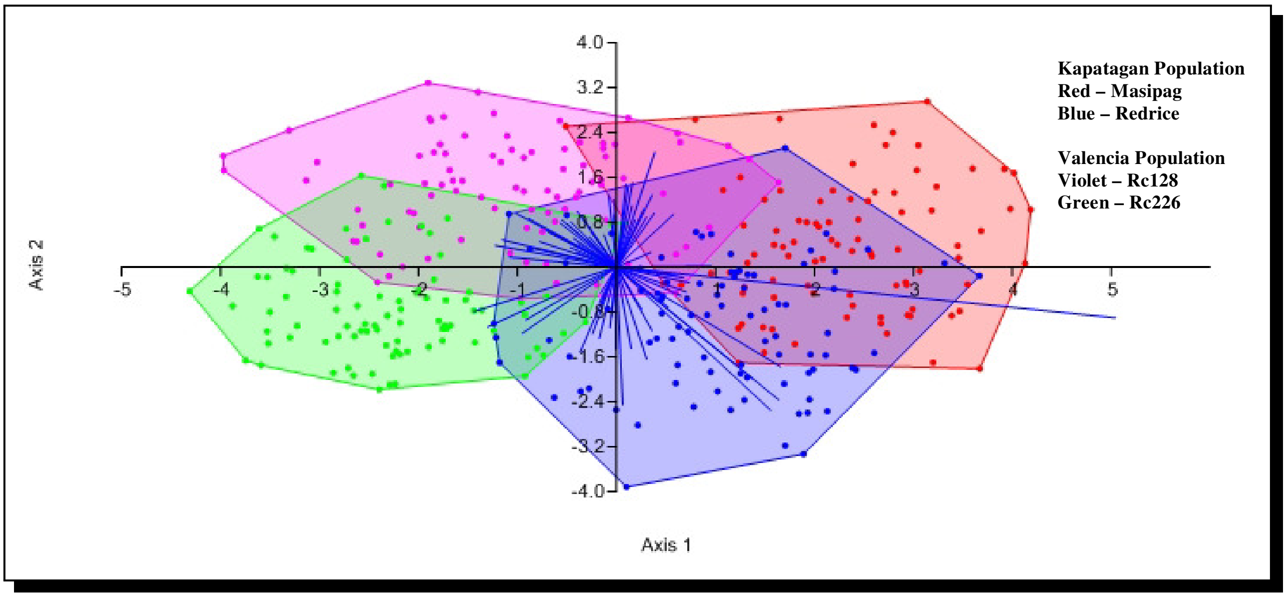

Figure 2. Scatterplot showing the distribution of individuals with different head shapes

Table 3. Descriptions of variation in the head of *C. medinalis* feeding from the 2 rice types in Kapatagan, Lanao del Norte, Philippines

RW	% Variance	Masipag vs Redrice (Kapatagan)
1	23.59%	Variation in the base of the vertex and anterior portion of the head. Masipag has the most varied vertex and frons. Redrice variety has head characterized with define curvature in the base of the vertex.
2	16.93%	Variation in the shape of anterior region, width and base of the vertex of the head. Masipag and Redrice have both a wide head and an anterior region of the head that ranges from having a dull to pointed shape. Redrice has less defined curvature in the base of the vertex.
3	12.59%	Variation in the width of the head. Masipag and Redrice possess head widths that are highly distributed and variable.
4	11.49%	Variation in the dimension of the frons, width and shape of anterior region of the head. Masipag has a rounded anterior region and redrice has a blunt anterior region. Both frons shifted towards the anterior region. Redrice has slightly average bended head.
5	7.66%	Variation in the shape of the curvature at the anterior portion, width and base of the vertex of the head. Masipag has a blunt anterior margin compared to redrice that has rounded blunt anterior region and both have less defined curvature in the base of the vertex.
6	5.14%	Variation in the shape of the curvature at the anterior portion and dimension of frons. Masipag has an anterior region of the head that ranges from having dull to side pointed shape. Both have frons shifted towards the anterior region. Redrice has an average head shape with rounded anterior region.

Table 4. Descriptions of variation in the head of *C. medinalis* feeding from the 2 rice types in Valencia, Bukidnon, Philippines

RW	% Variance	Rc128 vs Rc226(Valencia)
1	30.85%	Variation in the shape of the anterior region and base of the vertex. Rc128 head is characterized with blunt anterior region and less defined curvature in the base of the vertex. Rc226 has a head shape characterized with rounded anterior region and more defined curvature in the base of the vertex. The Rc226 population showed a highly variable head shape in this relative warp.
2	22.99%	Variation in the frons, width and base of the vertex. Both frons from Rc128 and Rc226 are shifted outward and inward towards the anterior with less defined curvature in the base of the vertex and are wide.
3	11.58%	Variation in the anterior region, frons and width of the head. Rc128 population has rounded anterior, frons shifted towards the anterior region and slender head compared to the Rc226 that is wider with a slightly rounded bended anterior region.
4	9.61%	Variation in the anterior region and base of the vertex. Rc128 has more defined curvature in the base of the vertex compared to Rc226. Rc128 and Rc226 has blunt anterior region.
5	6.53%	Variation in the width of the head. The width of the head in Rc128 population is highly distributed and variable. Rc226 population has samples with wider head compared to Rc128 population.

Relative warp analysis revealed that the variation in the head shape was mainly due to the variation in the anterior region, base of the vertex and over-all width of the head. The result of the landmark based geometric morphometrics in the head shape of *C. medinalis* depicts a statistically significant variation between different populations of *C. medinalis* on different rice types. Alicea (2002) published that morphological traits grow and progress in similar ways between populations over the course of evolution and can differ extensively in terms of size and shape [12]. So, observations on the head shape of the larvae were very useful in understanding the extent to which the morphometric character varies being affected by the host rice. The variation in this morphometric trait can be argued to be also caused by underlying intra specific genetic variation and not only due to plastic changes in response to environmental changes [13]. Furthermore, when a pest population has two or more host species, like the *C. medinalis*, the possibility arises that gene flow is restricted between groups on different hosts that are subjected to divergent natural selection for host adaptations [14].

4. Conclusion

Results show that variations in the head of the larva of *C. medinalis* which vary between geographical distances were attributed to variations within the populations of the larvae feeding on different rice types. This indicates that the host plant play an important role in the differentiation of the insect pest as reflected in their head shapes.

Competing Interests

The authors declare that they have no competing interests.

Authors' Contributions

All the authors contributed significantly in writing this article. The authors read and approved the final manuscript.

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