# A MORPHOMETRIC STUDY OF THE VARIEGATED GRASSHOPPER *ZONOCERUS VARIEGATUS* (LINN.) (ORTHOPTERA: PYRGOMORPHIDAE) FROM PARTS OF SOUTHERN NIGERIA.

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## ABSTRACT

Morphometry of the dry-season population of adult *Zonocerus variegatus* L. from six different locations in southern Nigeria were investigated with a view to determining the similarity of the large populations of the pyrgomorphid grasshopper, arising from the recent large scale cultivation of cassava plants (*Manihot* spp.) in Nigeria. Measurements of body parts including forewing length, hindwing length, pronotum width, pronotum length, head width, body length, femur length, tibia length, tarsus length and antenna length of male and female specimens from each of the locations were made. The results showed that male and female *Z. variegatus* from different locations were statistically different from each other in morphological characters (Wilk's Lambda 0.41, $P < 0.001$), with the body length, pronotum length, pronotum width, and head width, being the best discriminatory characters. Canonical variate analysis (CVA) also showed that male specimens from all locations form clusters with overlapping ellipses with Port-Harcourt and Abakaliki populations being the most distinct. The CVA plot for the female specimens from the six locations studied also revealed overlapping ellipses with Port-Harcourt specimens being very distinct from the other populations. The discriminant function analysis showed that the male and female specimens from Port-Harcourt were the most correctly classified compared to specimens from other locations studied. The present study demonstrated the morphological similarities between the male and female *Z. variegatus* populations in southern Nigeria. However, the study confirmed the existence of some morphological differences within the male and female population from different locations.

**Key words**: Morphometry, *Zonocerusvariegatus*, Orthoptera, Pyrgomophidae, Southern Nigeria.

## INTRODUCTION

The variegated grasshopper *Zonocerus variegatus* L. (Acridoidea, Pyrgomorphidae) is a short-horned grasshopper with an aposematic colouration. It is widespread in West and Central Africa. In southern Nigeria, two distinct populations termed dry- and wet-season populations have been observed (Toye, 1971; Taylor, 1972). The dry-season population is the one constituting serious pest problem for farmers, damaging several crop plants growing during the dry-season especially cassava. The incidence and scale of outbreaks of *Z. Variegatus* have increased in the last 20years owing to increased growth of cassava and the spread of *Chromolaenaodorata(L.)*. Morphometric techniques have proven to be useful in separating morphologically similar groups in the absenceof any other diagnostic characters (Claridge*et al.,* 1983; 1985). Among Orthoptera, this technique has been widely used to differentiate new species and subspecies in groups of closely related species (Barrientos *et al.,* 1996). Barrientos (1988) used 37 morphometric characters and 5 characters of the acoustic signals to clarify the taxonomy of male *Pterophylla*. He separated the populations into two groups consisting of three populations for *P. Beltrani (Bolivar)* and four populations for *P. Roberts (Herbard)*. Owing to paucity of information on the morphometrics of *Z. variegatus*, the present study was carried out to determine the existence of morphological differences among *Z. variegatus populations* in southern Nigeria.

## MATERIALS AND METHODS

The dry season population of *Zonocerus variegatus* used for this experiment was collected from six sampling points located within the University campuses in Ile-Ife, Ado-Ekiti, Asaba, Abakaliki, Owerri and Port-Harcourt, representing six states in southern Nigeria. The insects were collected with a sweep net, kept in small cages (20x20x20cm) and brought to the laboratory.

Sixty male and sixty female individuals were selected at random from the populations of *Z. Variegatus* collected from each location and ten morphological characters were measured for each insect. The parts measured included the forewing length, hindwing length, pronotum length, pronotum width, head width, body length, antenna length, femur length, tibia length and tarsus length (of the hind leg). The measurements were obtained in millimeters using a meter rule

and vernier calliper. The data obtained were subjected to Analysis of Variance (ANOVA), regression and correlation, CANDISC and Linear DISCRIM to find the predicted differences between the populations (SAS Institute, 1988).

## RESULTS

The sexes formed two discernible clusters which also overlapped. Males separated more from the clusters than the females. The sexes were statistically different from each other in morphological characters (Wilk's Lambda 0.41, $p<0.001$; Fig.1). Body length, pronotum length, pronotum width and head width were the best discriminatory characters (Table 1).

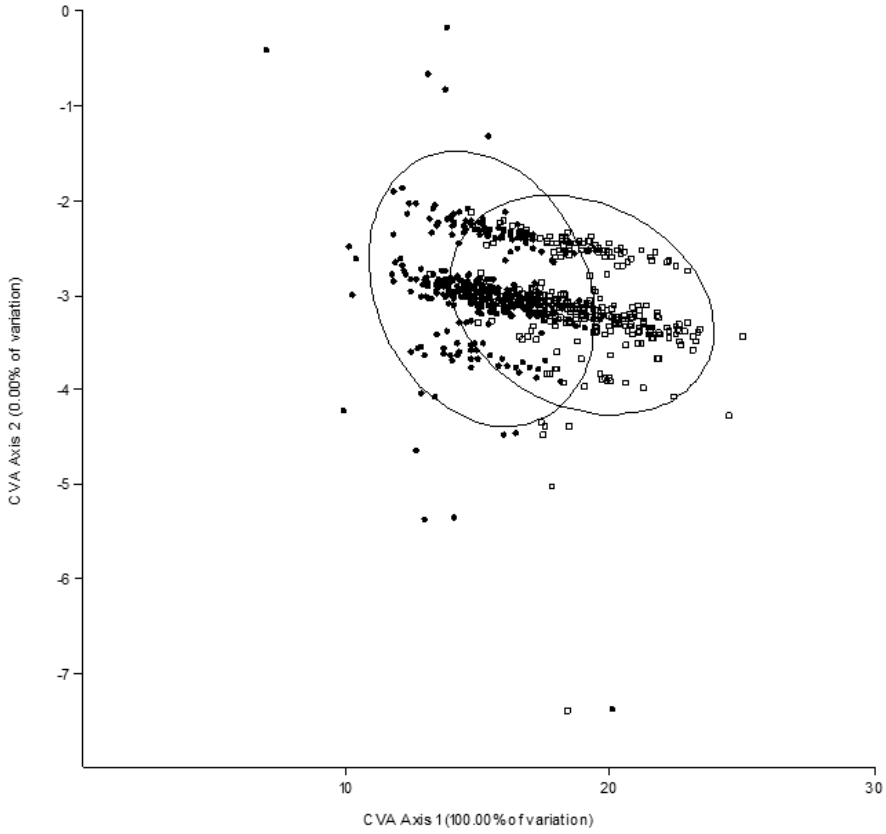


Fig. 1: Canonical Variate Analysis (cva) Between Male (dots) and Female (squares) *Zonocerus variegatus* Collected from Six Locations in Southern Nigeria.

Table 1: Canonical Variate Analysis (cva) Discriminatory Loadings Between Male and Female *Zonocerus variegatus* Collected from Six Locations in Southern Nigeria. (n=60 for each location)

| **Attributes** | **Axis 1 (100.00% of variation)** |
|---|---|
| Forewing length | -0.1164 |
| Hindwing length | -0.0665 |
| Pronotum length | 0.45398* |
| Pronotum width | 0.34917* |
| Head width | 0.1269* |
| Body length | 0.66409* |
| Femur length | -0.1861 |
| Tibia length | 0.0329 |
| Tarsus length | -0.1676 |
| Antenna length | -0.3648 |

*: most discriminatory characters.

The canonical variate analysis of male specimens from six locations (Fig. 2) showed that the ellipses for each locality overlapped, with Port-Harcourt and Abakaliki specimens most separated and appearing on opposite extremes of axis 1 of the canonical variate analysis.

Axis 1accounts for a greater amount of the variation among specimens, and the localities are better separated along this axis than axis 2; hencethe best discriminatory characters on axis 1 are pronotum width,head width,body length andtarsus length(Table 2).

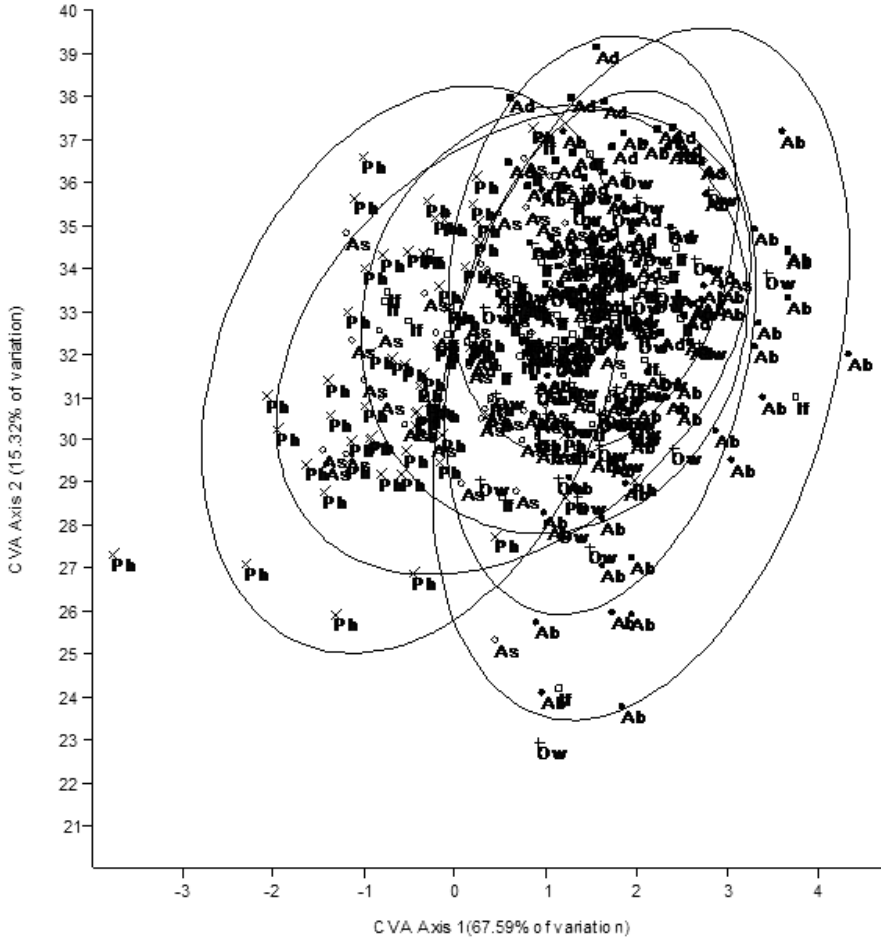


**Fig. 2:** Canonical Variate Analysis Plot of Male *Zonocerus variegatus* from Six Locations.

**Table 2:** Canonical Variate Analysis (cva) Discriminatory Loadings Among Male *Zonocerus variegatus* Collected from Six Locations in Southern Nigeria. (n=60 for each location)

| **Attributes** | **Axis 1 (67.59% of variation)** | **Axis 2 (15.32% of variation)** |
|---|---|---|
| Forewing length | -0.04211 | -0.10233 |
| Hindwing length | -0.11864 | 0.60479 |
| Pronotum length | -0.20232 | -0.07371 |
| Pronotum width | 0.15809* | 0.39316 |
| Head width | 0.15715* | 0.19285 |
| Body length | 0.26481* | 0.52797 |
| Femur length | -0.3205 | 0.05089 |
| Tibia length | -0.06864 | 0.2915 |
| Tarsus length | 0.82278* | -0.20625 |
| Antenna length | -0.19748 | -0.13307 |

*: most discriminatory characters.

The ellipses for all the localities from the plot of female specimens also overlapped (Fig. 3) and Port-Harcourt specimens stood out most from the others. The best discriminatory characters, similar to what was obtained in the male specimens, were pronotum width, head width,body length and tarsus length, along axis 1 (Table 3).

The male and female specimens from Port-Harcourt were the most correctly classified against other locations as presented in Tables 4 and 5. For male and female specimens from Port-Harcourt, 95.83% and 92.50% of individuals, respectively were correctly classified against Owerri specimens.

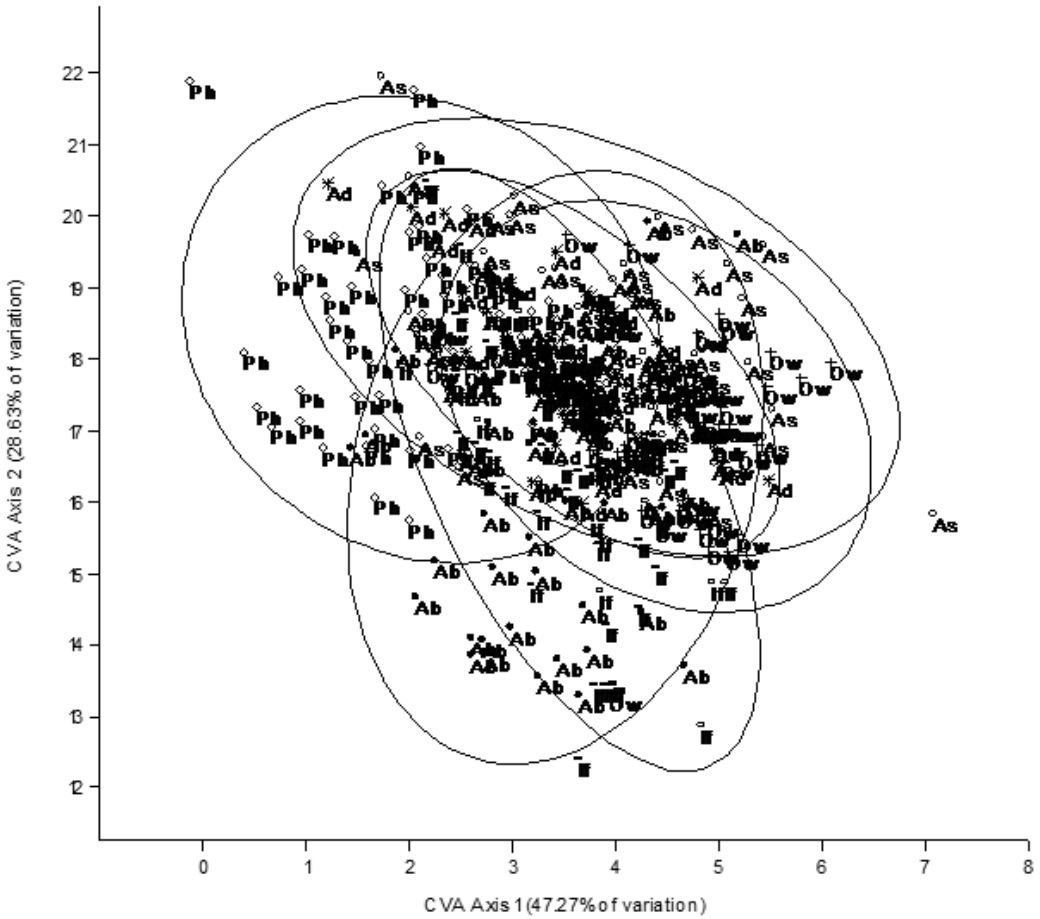


**Fig. 3:** Canonical Variate Analysis Plot of Female *Zonocerusvariegatus* from Six Locations.

**Table 3:** Canonical Variate Analysis (cva) Discriminatory Loadings Among Female *Zonocerus Variegatus* Collected from Six Locations in Southern Nigeria. (N=60 for each location)

| | **Axis 1 (42.27% of variation)** | **Axis 2 (28.63% of variation)** |
|---|---|---|
| Forewing length | -0.07015 | 0.24629 |
| Hindwing length | 0.038299 | -0.00088 |
| Pronotum length | -0.13606 | -0.16002 |
| Pronotum width | 0.30822* | 0.42632 |
| Head width | 0.12318* | 0.4555 |
| Body length | 0.14779* | -0.26084 |
| Femur length | -0.05019 | 0.30187 |
| Tibia length | -0.0441 | 0.24502 |
| Tarsus length | 0.80994* | 0.12642 |
| Antenna length | -0.42734 | 0.53789 |

*: most discriminatory characters.

**Table 4:** Percentage of Male *Zonocerus variegatus* Correctly Classified in Discriminant Function Analysis Among the Various Locations

| | **Abakaliki** | **Owerri** | **Ile-Ife** | **Ado-Ekiti** | **Port-Harcourt** | **Asaba** |
|---|---|---|---|---|---|---|
| Abakaliki | - | | | | | |
| Owerri | 83.33% | - | | | | |
| Ile-Ife | 77.5% | 80.83% | - | | | |
| Ado-Ekiti | 91.67% | 85.83% | 81.67% | - | | |
| Port-Harcourt | 94.17% | 95.83% | 83.33% | 90.83% | - | |
| Asaba | 85.00% | 85.83% | 72.5% | 85.00% | 81.67% | - |

**Table 5:** Percentage of Female *Zonocerus Variegatus* Correctly Classified in Discriminant Function Analysis Among the Various Locations

| | **Abakaliki** | **Owerri** | **Ile-Ife** | **Ado-Ekiti** | **Port-Harcourt** | **Asaba** |
|---|---|---|---|---|---|---|
| Abakaliki | - | | | | | |
| Owerri | 81.67% | - | | | | |
| Ile-Ife | 67.50% | 80.00% | - | | | |
| Ado-Ekiti | 77.50% | 80.00% | 82.50% | - | | |
| Port-Harcourt | 91.67% | 92.50% | 89.17% | 89.17% | - | |
| Asaba | 81.67% | 80.00% | 85.83% | 83.33% | 86.67% | - |

The correlation coefficients of hindwing length on body length for male *Z. variegatus* from all the locations were significant in the sequence Owerri> Port-Harcourt >Asaba>Ado-Ekiti>Abakaliki> Ile-Ife. There was significant relationship between the forewing length and body length of male *Z. variegatus* from all locations with the Owerri population being the most significant (Figs. 4&5). There was a positive correlation between the forewing length and body length; and between hindwing length and body length for female *Z. variegatus* from Ado-Ekiti, Abakaliki, Asaba, and Owerri,but there was no significant relationship in the forewing length and body length; and also in the hindwing length and body length for Ile-Ife and Port-Harcourt populations (Figs. 6 & 7).

Figs.8 & 9 showed the frequency distribution of relative forewing length (RFL) and relative hindwing length (RHL) in male and female *Z. Variegatus* collected from the six locations. RFL was normally distributed in both sexes with maximum values between 0.3 to 0.8 for females and 0.5 to 0.9 for males. Distribution of RFL was wider in females than in males. Frequency distribution of RHL was unimodal, with maximum value between 0.3 and 0.7 for females, and 0.3 and 0.9 for males. Distribution was wider in males than in females.

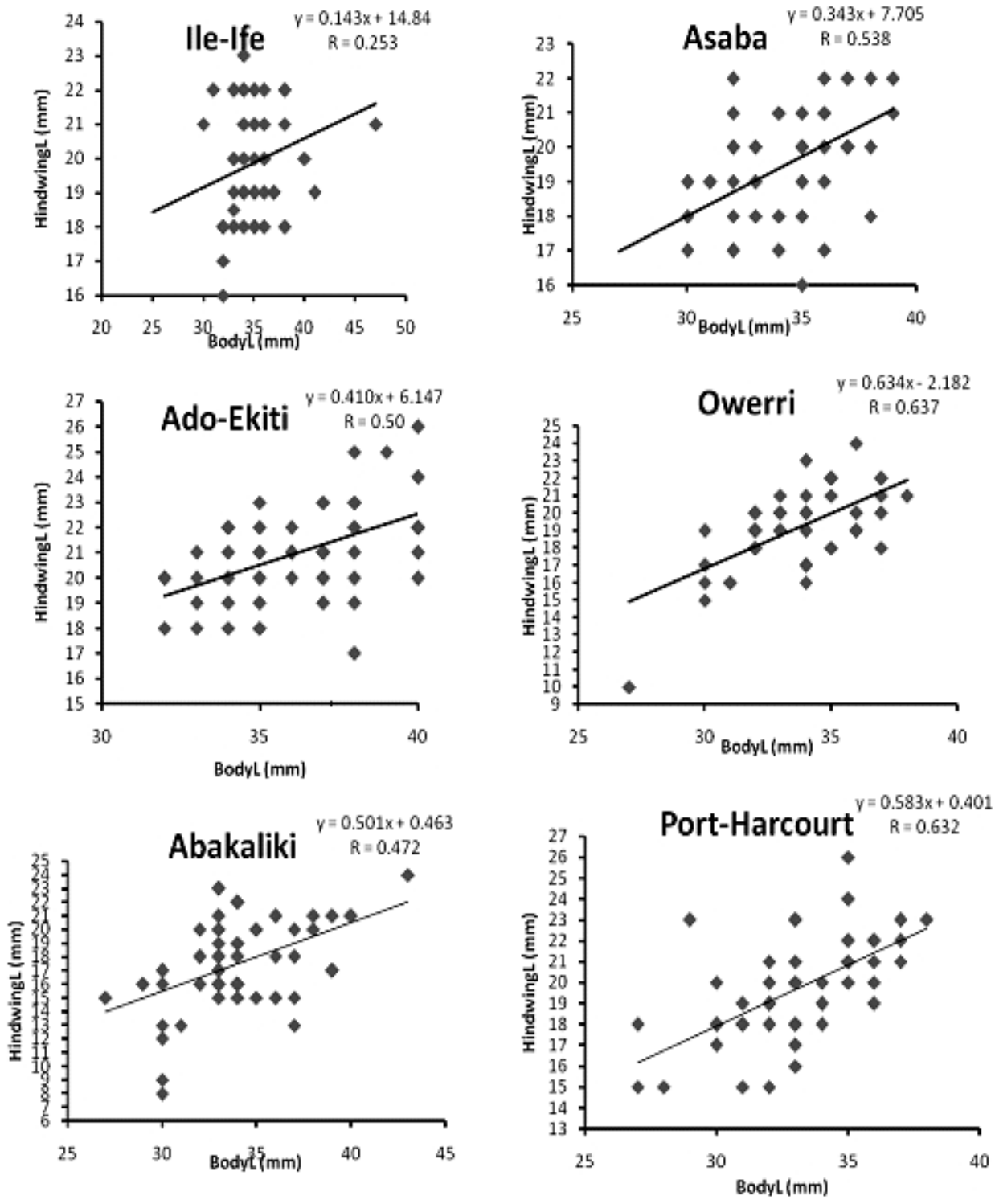


**Fig. 4:** Relationship Between Hindwinglength and Body Length in Male*zonocerus Variegatus*

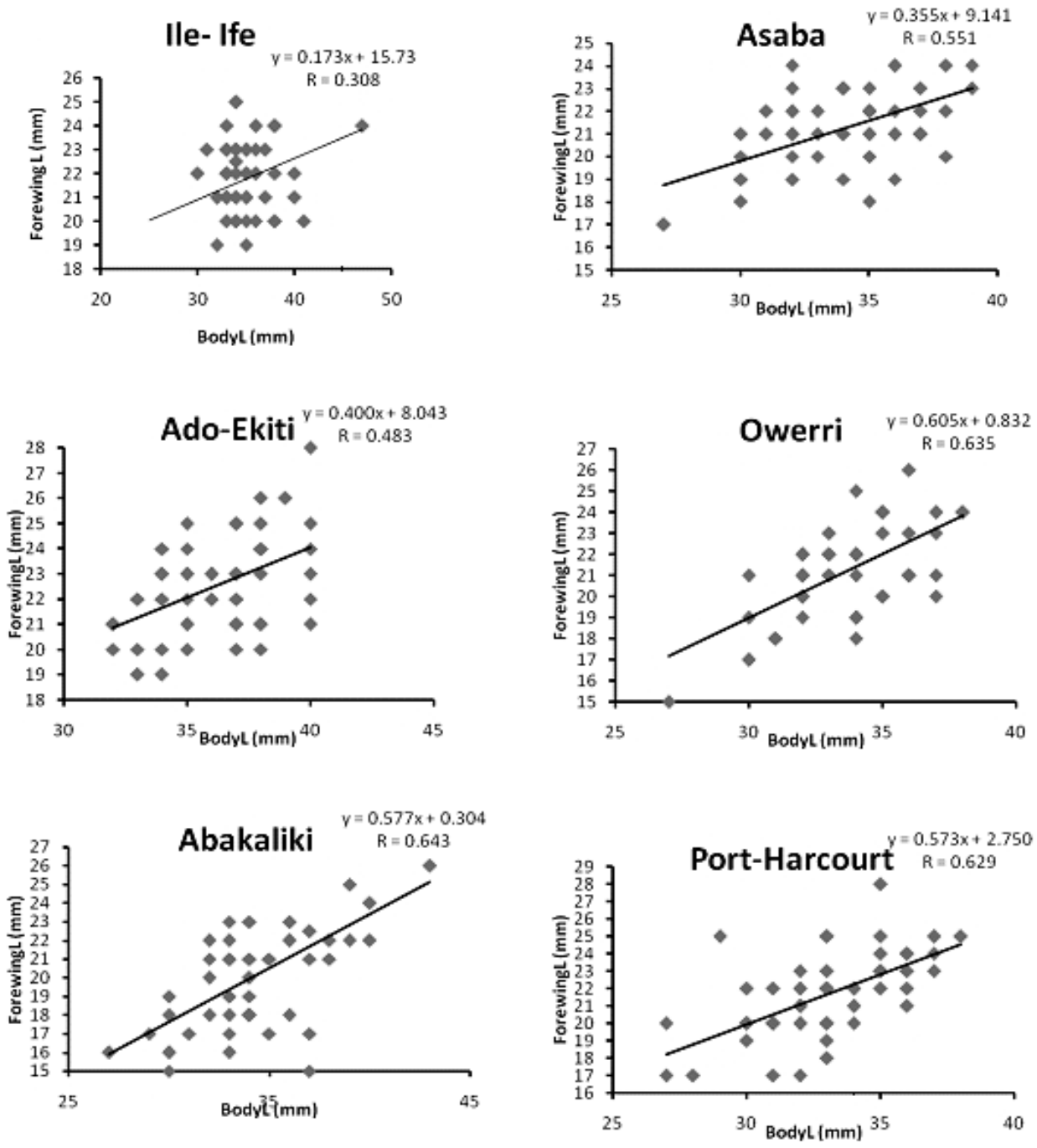


**Fig.5:** Relationship between Forewing length and Body length in Male *Zonocerusvariegatus*

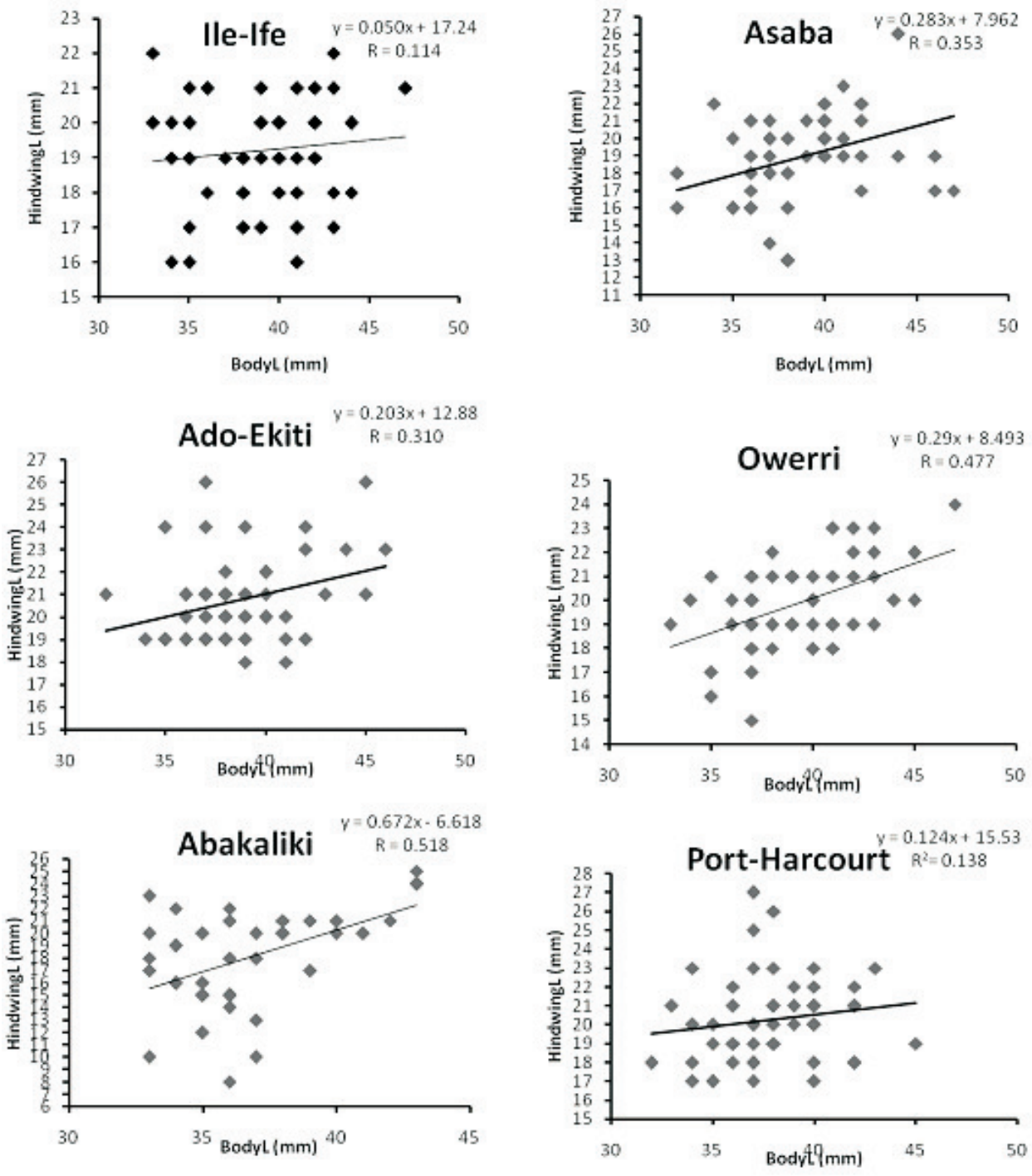


**Fig.6:** Relationship between Hindwing length and Body length in female *Zonocerusvariegatus*

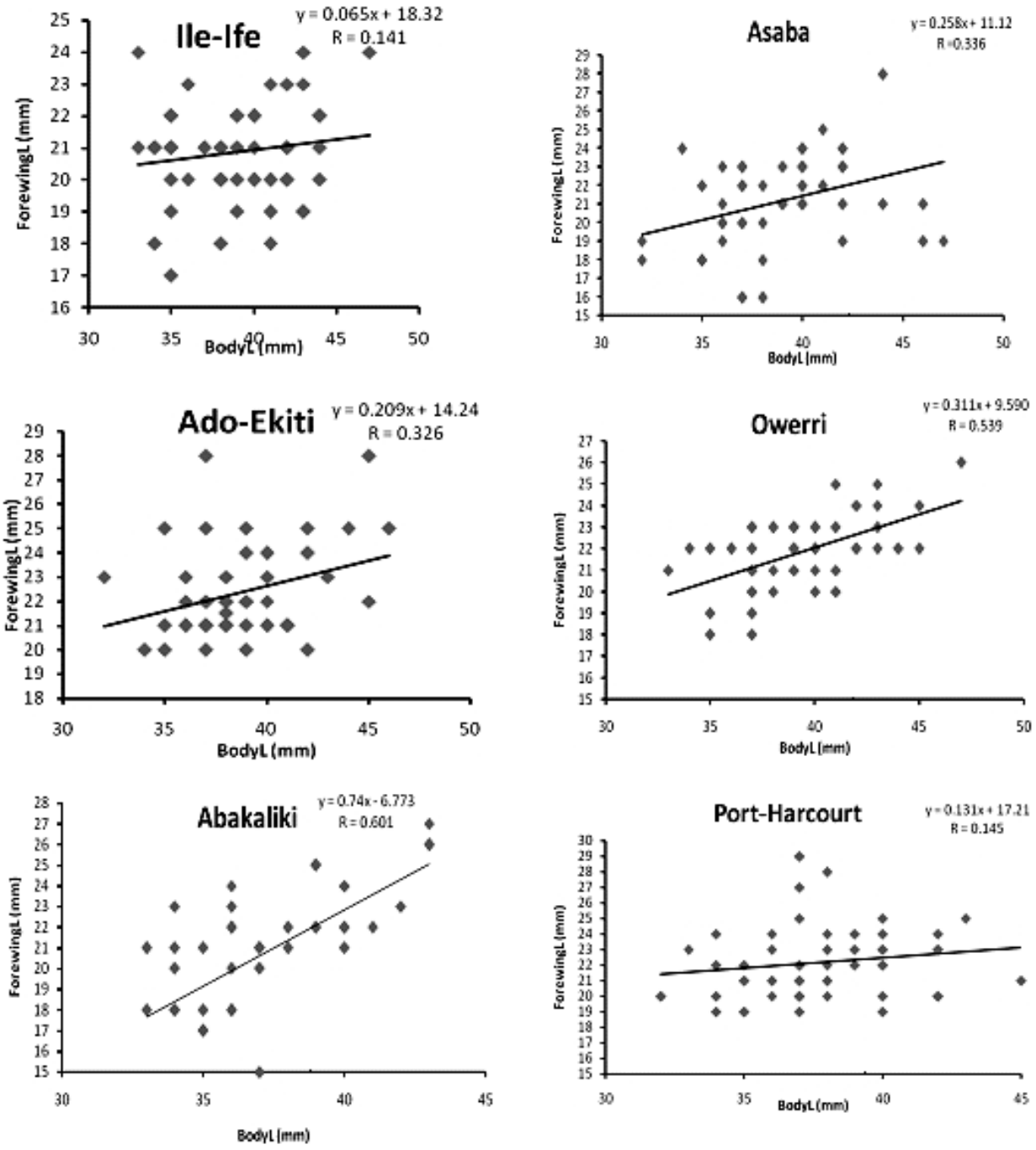


**Fig.7:** Relationship between Forewing length and Body length in female *Zonocerusvariegatus*

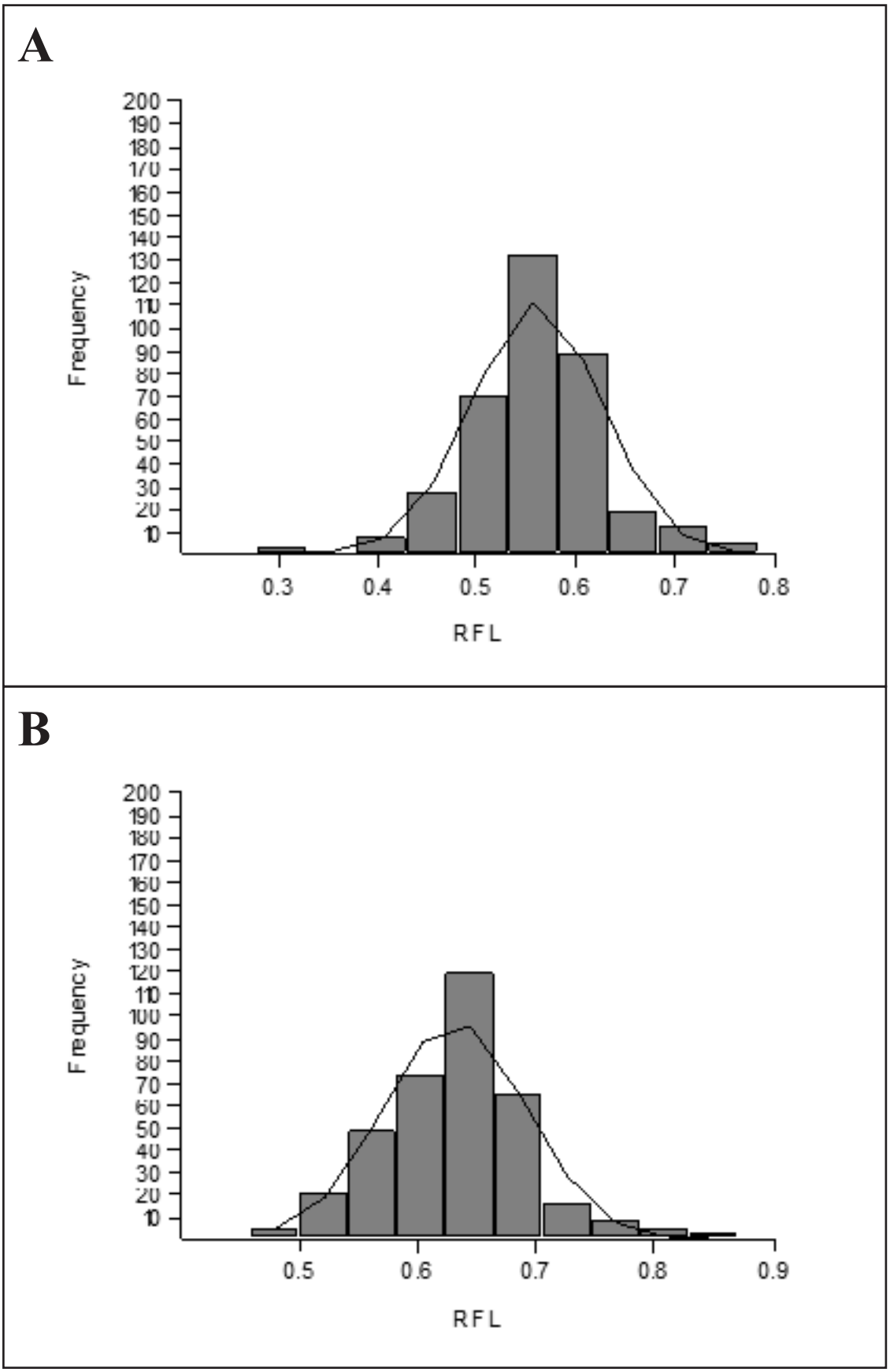


**Fig. 8:** Frequency distributions of Relative Forewing length (RFL: Ratio of Forewing Length to body length) in female (A) and male (B) *Z. Variegatus*.

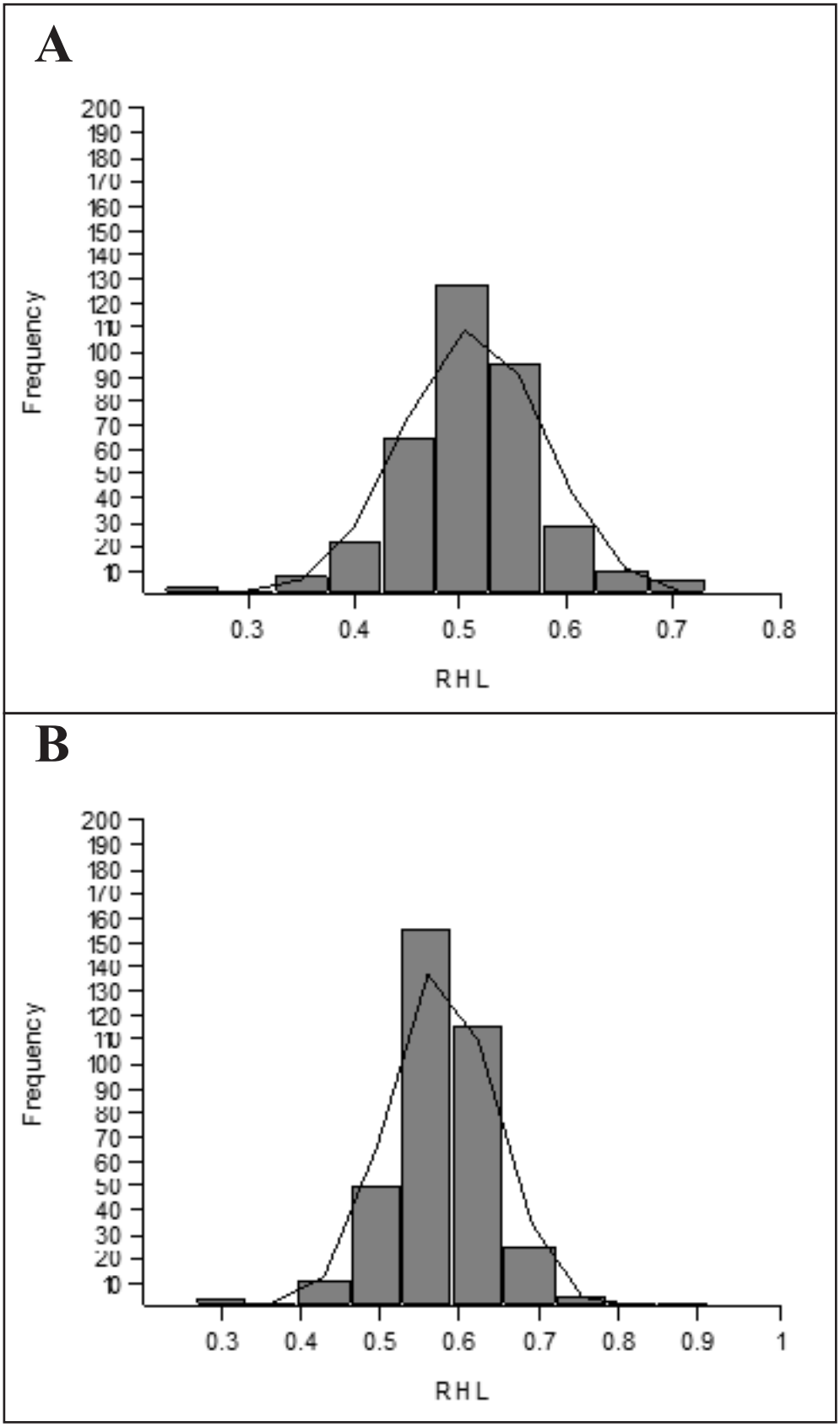


**Fig.9:** Frequency distributions of relative Hindwing length (RHL: ratio of hindwing length to body length) in female (A) and male (B) *Z. variegatus.*

## DISCUSSION

The analyses of various measurements of morphological characters have distinctly separated male from female *Zonocerusvariegatus* irrespective of area of collection. Ajayi (1997) used the forewing and hindwing to separate male and female *Z. variegatus* collected from Ile-Ife. Male and female insects are obviously separated by their reproductive organs but the present results have demonstrated that external features, apart from external structure of male and female reproductive system, can be used to separate the sexes. The study, therefore, provides an alternative to internal dissection in the determination of sexes. Dike (1996) used Wilks Lambda stepwise discriminant analysis to separate the IkotEkpene population of *Atherigonatormentigera(Emden)* from the Samaru population using 19 characters. The best discriminating characters for separation of male and female were the body length, pronotum length and pronotum width. Chemengich (1998) separated males and females of seven Agromyzids using morphometric measurements of the leg, wing and genital apparatus.

Males and females from all locations form two overlapping clusters, a major and minor one demonstrating the closeness of the distinct populations, with males being more independent than females. Discriminant analysis which is used extensively in this study has been able to deal with taxonomic problems of interpopulations of *Z. variegatus*. In the scattered plots for the populations of males and females and the individual plots for males and females from different locations, the ellipses of the males and females and individual males and females are very close to one another which confirm the close morphological relationship between the populations. Dike (1996) reported that the closer the group centroids of *A.tormentigera* are, the more closely the related groups. This suggests a morphological closeness in the population of *Z. variegatus* from the six different locations in southern Nigeria. The strong overlap in the ellipses is an indication of some strong similarities in males and femalesfrom the various locations. Some distinctiveness seems to exist for a part of male and female *Z. variegatus* from Port- Harcourt population which was incidentally the most correctly classified population among all the locations.

There was a strong positive relationship between the forewing length and body length; and hindwinglength and body length of male and female *Z. variegatus* indicating that either forewing length or hindwing length can be used for the determination of body length of *Z. variegatus*. Body length is constant as best discriminatory character for male and female *Z. variegatus*. Body size play a significant role in the reproduction of *Z. variegatus* since large male sought out large female and vice versa, rather than small male or small female (Muse, 2003). Body length is, therefore, a predictive tool owing to its strong correlation with performance. The normal distribution of relative wing length of *Z. variegatus* collected from different locations suggests the existence of wing polymorphism rather than distinct macropters and brachypters (Sakashita*et al.*, 1996 and Chapman *et al.*, 1978).

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