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Variation in Measurements of Some Body Parts of *Laodelphax striatella* (Fallén, 1826) (Hemiptera: Fulgoromorpha: Delphacidae) due to Altitude

Murat Karavin [1,a,*], Ünal Zeybekoğlu [2,b]

[1] *Vocational School, Amasya University, Suluova, Amasya, Türkiye.*
[2] *Biology Department, Arts and Science Faculty, Ondokuz Mayıs University, Samsun, Türkiye.*
**Corresponding author*

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ABSTRACT

The small brown planthopper *Laodelphax striatella* (Fallén, 1826), which belongs to Delphacidae family, is widespread in Palearctic. It is one of the important pests of agricultural crops such as rice, maize, oat, wheat etc. Because of its economic importance, identification of the factors that effective on *L. striatella* populations is required. Size of body parts closely related with vital processes such as metabolic performance, fecundity, and longevity. Several ecological factors such as light, temperature, water supply and moisture were effective on body size. The aim of the study was to determine the effect of altitude on some body measurements of *L. striatella*. Because light, temperature, precipitation and some of the other factors vary based on altitude, it is an important ecological factor for organisms. Understanding the effects of altitude on insect species may give useful information about them. The specimens were collected from three localities at different altitudes in Central Black Sea Region, Turkey. Except wing length, all the measurements of the body parts varied proportionally with increasing altitude. Statistically significant variations were determined in the measurements of head width, pronotum length, pronotum width, mesonotum width and forewing width. The maximum head, pronotum, mesonotum and forewing width (0.623, 0.686,0.707 and 0.730 mm, respectively) and pronotum length (0.172 mm) was measured at 50 m. The minimum measurements of these body parts were at 900 m. Additionally, relationships were determined between measured body parts and altitude.

Keywords: *Laodelphax striatella*, Altitude, Body parts, Insect, Variation.

[a] *murat.karavin@amasya.edu.tr* *https://orcid.org/0000-0003-0957-859X* [b] *unalz@omu.edu.tr* *https://orcid.org/0000-0001-7595-9572*

Introduction

Ecological factors play important roles in fitness of organisms. Topographic characteristics of an area are effective directly or indirectly on ecological factors. For example, altitude is the major determinant of light, temperature, precipitation. The variation in climatic factors and other characteristics due to altitude is related to species composition and fitness.

There are some key features which provide monitoring the ecological, biological, and physiological status of organisms and give information about their fitness. One of these key factors is the body size that give information about metabolic performance, fecundity, and longevity of organisms [1]. Body size is one of the most important characteristics of organisms. While it is associated with a variety of ecological and physiological characteristics, it also influences life histories [2-8].

Insects are important organisms of the world due to their ecological niches such as pollen transport, effects on plants as pests, and vector status. Because of their vital roles in ecosystems, understanding the ecological factors which are effective on insect body size and fitness is important.

There are several studies in the literature showing that the effect of elevation on insect body size [1,9-15]. While some of the studies reported increase in body size based on elevation, the others determined decrease. It was thought that these differences may be resulted from diversity of insect species and the multiple ecological factors in the area. However, there was no significant relationship between body size and elevation in some studies [16-17].

As the results vary widely according to the insect species, geographical region and ecological factors, no clear conclusion has yet been reached regarding the relationship between body size and height of insects. Therefore, new studies on various families and species are needed.

In the current study, it was aimed to determine the variation in the measurement of some body parts of *L. striatella* according to altitude. Delphacidae Leach, 1815 is a large family of the suborder Fulgoromorpha (Hemiptera), and it has approximately 2000 species placed in 300 genera and six subfamilies [18-19]. It is known that 250 species belonging to the Delphacidae family are distributed in the Europe, and about half of these species are from Central Europe [20]. Delphacids are easily distinguished from other members of Hemiptera by the presence of a posttibial spur on the tibia of their hind legs. With their piercing-sucking mouthparts, they generally feed by sucking the sap from plant species belonging to the Cyperaceae and Poaceae families. Most of the species are found on the plant parts which are close

to soil surface, such as roots and stems. For this reason, they do not attract much attention and can easily be overlooked. Delphacids damage plants directly by feeding and laying eggs, and indirectly by transmitting viruses, rickettsia, bacteria and mycoplasmas [21-22].

The small brown planthopper, *L. striatella*, is one of the harmful species for rice. It is widely distributed in Asia, Europe, and Northern Africa of Palearctic region. Both adults and nymphs feed directly on rice, and spread important viral diseases, such as rice black streaked dwarf disease [23-27]. The body size of specimens has less than 4 mm. Vertex is square in shape. The pronotum is straight anteriorly, concave posteriorly, and the lateral carinas do not extend to the posterior margin. The pronotum is about the length of the vertex. The mesonotum is approximately three times the length of the pronotum and its median carina extends to the mesoscutellum (Figure 1). There are more than 10 teeth of the same size on the ventral edge of the posttibial spur. The front wings are membranous.

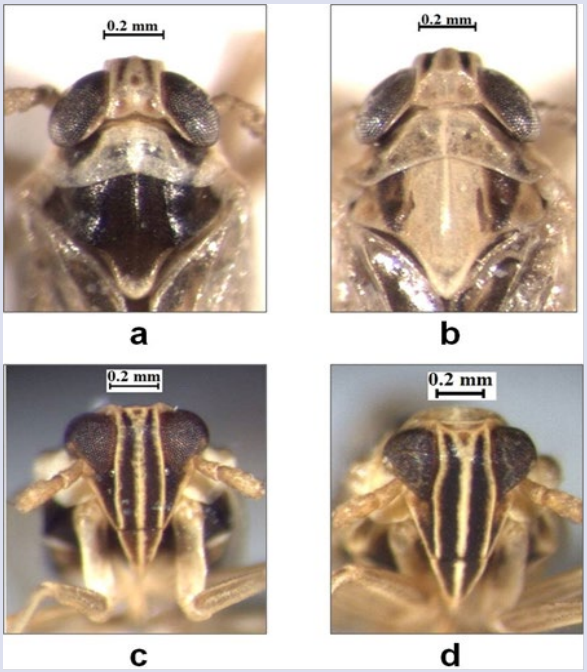


Figure 1. *L. striatella*, a, b) head, pronotum and mesonotum from dorsal (a: male, b: female), c, d) head from anterior (c: male, d: female).

According to the literature survey, no study was found on the variation in body size of Delphacidae family members based on elevation. For this reason, the study is original and may give useful information about both entomology and agriculture.

Materials and Methods

The *L. striatella* specimens were collected from three different localities with 50, 550 and 900 m. above sea level in the Central Black Sea Region, Turkey. Specimens were collected by sweep net in the daytime. Specimens were prepared according to standard methods and identified by comparing with the descriptions and figures given in Holzinger et al. [20]. Measurements of body length, body width, forewing length, forewing width (Figure 2a), head width, pronotum length, pronotum width, mesonotum length, mesonotum width, vertex length and vertex width (Figure 2b) were measured by Leica IM-50 module in Leica MZ 12.5 stereomicroscope. Statistical analyses were performed with SPSS 20.0 statistical software. Differences between measurements were determined by one-way ANOVA and Tukey post-hoc test. Relationships between measurements and altitude were examined by Pearson correlation. Materials were deposited in the collection of Suluova Vocational School, Amasya University, Turkey.

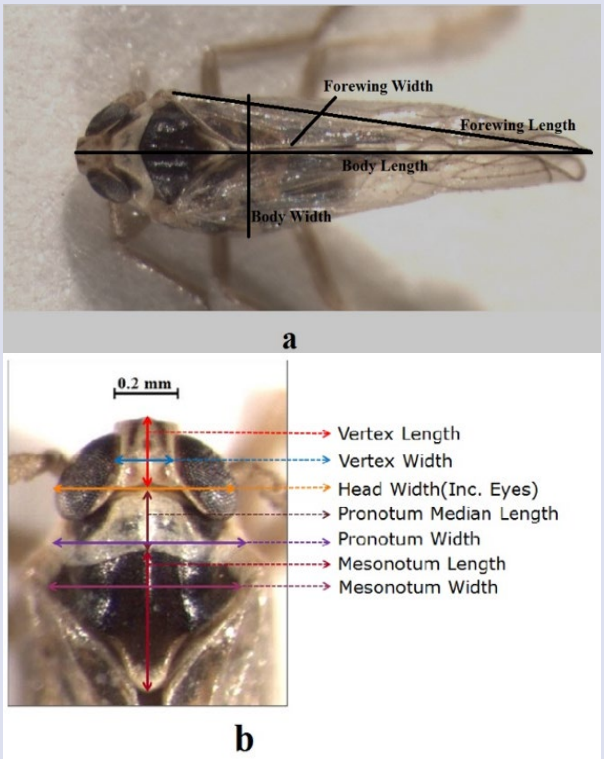


Figure 2. The measured body parts.

Results and Discussion

Results showed that, head width, pronotum length, pronotum width, mesonotum width and forewing width were significantly varied according to elevation (Table 1). There were not statistically significant differences in body, mesonotum, forewing, vertex length, and body and vertex width due to elevation. Measurements of these characters tended to decrease with increasing altitude (Figure 3). While the maximum values of body measurements were determined at 50 m, the minimum values are obtained at 900 m. Results showed that measurements of head width, pronotum length, pronotum width, mesonotum width and forewing width were obviously affected by elevation.

Declines in body measurements of L. striatella based on elevation may be caused by the influence of different

multiple ecological factors due to altitude. It is known that ecological factors such as temperature, wind speed, precipitation, vegetation composition and food quality differ by altitude. Environmental conditions in exposed habitat factors are important determinants for characteristics of organisms and may cause differences in features. It is known that temperature gradually decreases with increasing elevation. According to the temperature-size rule hypothesis, high temperature may promote growth rate and this result in smaller body size for adults. But findings of both our study and the some of the previous studies did not verify this rule. For example, in the studies on *Dichroplus pratensis* (Acrididae) [28], *Onthophagus* spp. (Scarabaeidae) [29] and *Paropsis atomaria* (Chrysomelidae) [30], decrease in body size were reported [1]. It was thought that this may be caused by combined effect of the exposed ecological factors and insect species. When we thought diversity of insects, the physiological differences among the insect species may be an important factor in this context. In addition, it should be explained that the results obtained from laboratory and natural areas also differed.

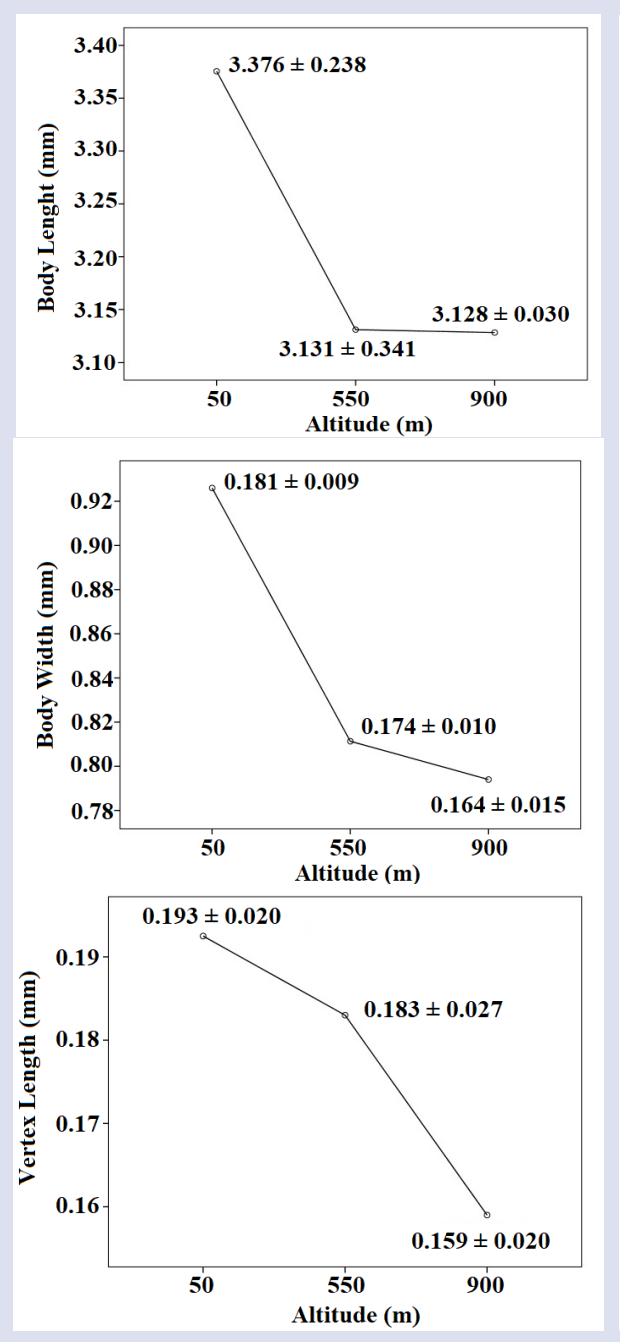
Table 1. ANOVA table of differences in measurements of body parts according to altitude (df: Degrees of freedom; F: F value; P: Significance)

Body Part	Sum of Squares	df	Mean Square	F	P
Body Length	0.196	2	0.098	1.887	0.202
Body Width	0.001	2	0.000	2.914	0.101
Head Width	0.020	2	0.010	10.505	**0.003**
Pronotum Length	0.003	2	0.002	6.005	**0.019**
Pronotum Width	0.056	2	0.028	30.341	**0.000**
Mesonotum Length	0.002	2	0.001	0.596	0.570
Mesonotum Width	0.049	2	0.025	17.874	**0.000**
Forewing Length	0.049	2	0.025	0.757	0.494
Forewing Width	0.058	2	0.029	10.602	**0.003**
Vertex Length	0.003	2	0.001	2.993	0.096
Vertex Width	0.001	2	0.000	2.914	0.101

Taking head width, pronotum width, mesonotum width and forewing width into account, it seems that, the major effective factor was wind speed (or airflows) in the light of previous studies [10]. As a contrast, Sullivan and Miller [31] reported that forewing length increased significantly with increasing altitude in the studied six species of Macrolepidoptera. Similar with the results of Sullivan and Miller [31] for Lepidoptera, Mikitová et al. [32] determined increased forewing lenght based on altitude for *Argynnis paphia* (Lepidoptera). Differences in the tendency of forewing length size based on altitude may be related with insect species, body size and structure for easy fly.

Except forewing length, the decreas in the measurements may be caused by temperature reduction and nutrient quality. Hodkinson [10] explained that variation in nutrient content of plants through altitude determines food quality and this may be effective on insect body measurements. The results of the current study showed that, size of some body parts of *L. striatella* decreased according to increasing altitude.

In the previous studies, altitude-related decrease in insect body size was reported by Sveum and Solem [9], Rodríguez-Jimenez and Sarmiento [12], Bernadou et al. [13], and reverse by Geraghty et al. [11], Osorio- Canadas et al. [15], Lozier et al. [33]. The studies which reported increase in body size with increasing altitude explained the results by Bergan's rule. In contrast, decrease in body size based on altitude also found in the other studies. For example, Brehm and Fiedler [34] expressed no or only weak support for Bergmann's rule. Furthermore, an opposite tendency was reported in Geometridae and Ourapterygini. Similar with our results, body size decreased with increasing altitude in Geometridae.



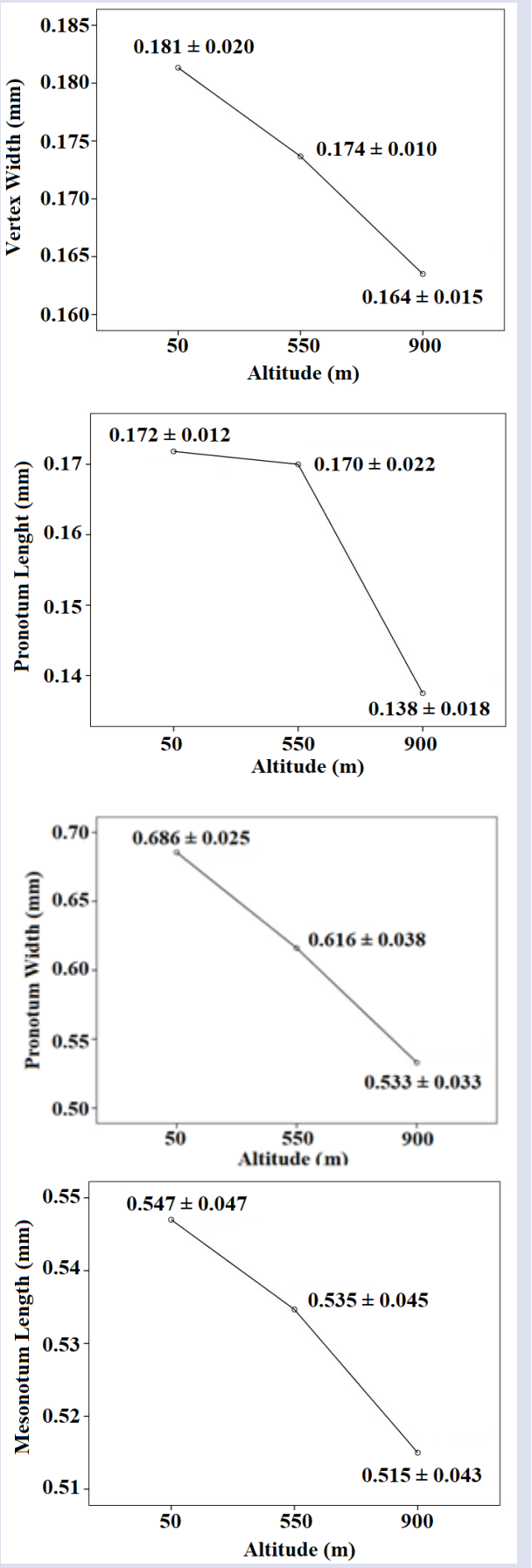


Figure 3. Mean values of measurement according to the altitude.

Significant relationships were determined between altitude and measurements of body width, head width, vertex length, vertex width, pronotum length, pronotum width, mesonotum width and forewing width (Table 2). These results verified the effect of altitude on insect body measurements.

Table 2. Relationships between measurements and altitude

Altitude	**Body length**	**Body width**	**Head width**	**Vertex length**	**Vertex width**	
	-0.477	-0.605**	-0.822**	-0.598*	-0.605*	
Altitude	**Pronotum length**	**Pronotum width**	**Mesonotum length**	**Mesonotum width**	**Forewing length**	**Forewing width**
	-0.673*	-0.926**	-0.324	-0.882**	-0.257	-0.816**

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Conclusion

As a conclusion, results showed that except wing length, all the measurements of the body parts varied proportionally with increasing altitude. Head width, pronotum length, pronotum width, mesonotum width and forewing width significantly decreased with increasing altitude. Relationships were determined between measured body parts and altitude, and these results verify the effect of altitude on *L. striatella*. The altitude-related variations in insect body size derived from combined ecological factors such as temperature, precipitation, wind, vegetation composition, food quality. According to the previous studies it was thought that temperature is the most effective factor for this variation. Because the physiology and structure of the insects differ from species to species, effect of altitıude on body measurements considerably vary among insects.

There are different results about impacts of altitude on insect body size. Since there are very different results on the effects of altitude on insect body size, a clear judgment has not yet been reached. So, it is thought that detailed studies on various species from different ecosystems may be required to clarifying the effect of altitude on body measurements of insects.

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Conflicts of interest

The authors stated that did not have conflict of interests.

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