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Sexual Dimorphism and Morphological Variation in the Populations of *Akis costitubera Marseul* (Coleoptera: Tenebrionidae) By Using a Geometric Morphometric Approach

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Abstract: The present study was conducted to evaluate the differences related to area of males and females of *Akis costitubera* Marseul by using morphometric geometric technique. The study was accomplished by using photographic records of each individual in ventral views by using a CELESTRON X-150 digital camera. A matrix of photographs for each view was constructed using the TpsUtil program. In each view, we used 26 homologous landmarks which were digitized in the TPSdig2 program. 30 males and 30 females individuals were collected, photographed, and 26 landmarks from ventral views were digitized. We used a multivariate analysis of morphological variation. The results revealed significant differences between male and female ($P<0.005$), and the surface area of females was larger than that for males. The study concludes that sexual dimorphism occurred in the population of *A. costitubera* Marseul where these differences raise the question of whether sexual dimorphism may be modulated by natural selection.

Keywords: *Akis costitubera*, sexual dimorphism, geometric morphology

INTRODUCTION

For centuries, comparison of organisms by anatomical characteristics has been a core element in comparative biology, taxonomic classification, and understanding of biological diversity have been based mainly on morphological descriptions (Adams, Rohlf, & Slice, 2004). In the early twentieth century, where morphological analysis had a similar revolution of quantification, comparative biology entered a transition from the description field and quantitative science (Bookstein, 1996). The study of morphology has had an important emphasis by developing statistical shape analysis. This made the combination of multivariate statistical methods possible and established new ways to visualize the structure (Adams & Funk, 1997 ; Dryden & Mardia,1998).

The main use of Morphometric analysis is for studying shape variations and covariance with other variables. In the last 10 years, the number of studies using geometrical morphometric methods has increased. These new methods have been used and proved to be relevant in a large spectrum of morphometric fields, including species systematic**,** phylogeny, and ontogeny (Auffray, Alibert, Renaud, Orth, & Bonhomme, 1996; David & Laurin, 1996; Fink & Zelditch, 1995; Klingenberg & McIntyre, 1998; Loy, 1993; Naylor, 1996; Zelditch, Bookstein, & Lundrigan, 1993; Zelditch, Fink, & Swiderski, 1995).

The differentiability degrees of pressure in insects and their outcome alteration of habitat suggested that the phenotypic disturbance degrees reflect the ability of an individual to overcome the effects of pressure (Hugo A

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Benítez, Briones, & Jerez, 2010; Hugo Alejandro Benítez, Vidal, Briones, & Jerez, 2010).

As a result of some difficulties taxonomical and biodiversity analysis have been based on morphological descriptions. The geometry captured data of the morphological structure is particularly an interesting method to analyze developed data (Alibert, Moureau, Dommergues, & David, 2001).

In the present study, we apply a geometrical morphometric technique to assess morphological differentiation among males and females of *A. costitubera* Marseul.

MATERIALS AND METHODS

The study was conducted by collecting beetle specimens from the Mass area that is located west of Al-Bayda city in Libya at (32°45' N, 21°37' E). In this study we analyzed morphological differences in 30 males and 30 females during the summer of 2015-2016.

The study site is an area of 10 hectares located very close to Massa region (5 km west), surrounded by *Cupressus sempervirens* L*, Ceratonia silique* L*., Pistacia lentiscus* L*., Phillyrea latifolia* L*., Arbutus bavarii, Olea europaea Rhamnus lycioides L. Erica multiflora L., Globularia alypum*linn*.,Cistusparvi florus*lam., and *Calicotome villosa* trees.

The specimens were collected by using a Pitfall traps that made of glass, about 30 glass jars that measured of 10×6 cm and were buried in the soil in both sites, equipped by an attractant item such as a banana or banana extract, and buried in 12 cm depth. The samples were transferred to the Entomology lab. at the Department of Zoology, OMU, and were killed by Ethyl acetate 99%. Then, the insects were stuffed and the samples were identified, and the target species were chosen for the study conduction.

The study was performed by using photographic records of each individual in ventral views with using a CELESTRON X-150 digital camera. A matrix of photographs, with each photo constructed by using the TpsUtil program (F. Rohlf, 2015). In each photo, 26 homologous landmarks were used (Figure,1), and digitized by using the TPSdig2 program (F. J. Rohlf, 2001). Then we calculate the surface area for all samples, and All statistical tests were performed with the Minitab 16 version program by using t-test to compare the differences between the two genders.

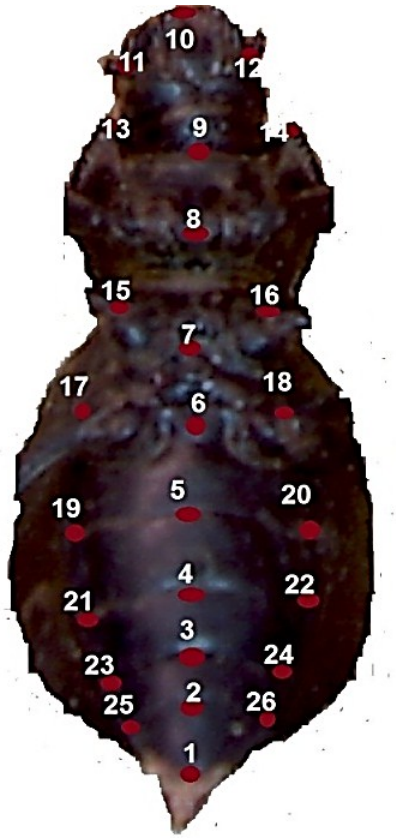

Figure (1). All landmarks description on ventral view of beetle's body without limbs and antenna

RESULTS AND DISCUSSION

By using T-test to compare body surface area in males and females, we noticed a high signification ($P<0.05$) in the population of *A. costitubera* Muresul (Table 1), and (Figure 2).

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Table (1). Comparisons using the mean statistical analysis for body surface area (mm²) among Massa region for males and females of *Akis costitubera* Marseul

Sex	N	±SE	DF	F	P
Females	30	1208.3±41	53	2.99	0.004
Males	30	999 ±56			

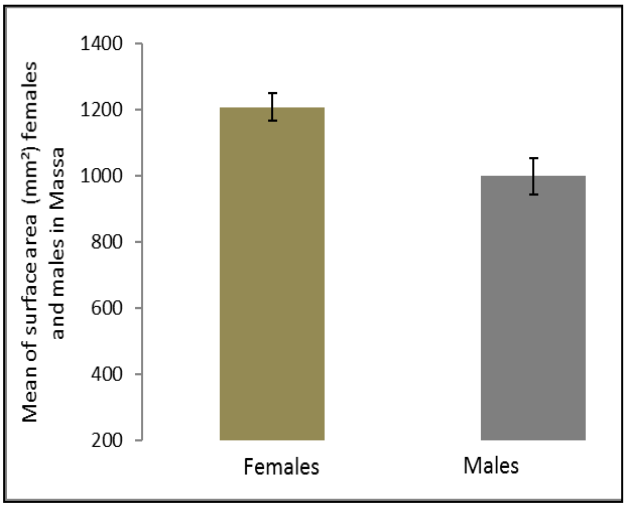

Figure (2). Surface area (mm²) representation of all samples in Massa region for males and females of *A. costitubera* Marseul

This study is the first attempt to statistically examine morphological variation in *Tenebrionidae* species in Libya. As morphology is determined by both genotype and phenotype, it can provide insights into the phylogeny and ecology of beetles, and the selective pressures driving their evolution (Losos & Miles, 1994). A morphological study can also aid the development of a reliable and accurate identification for this species, which is fundamental for studying *Tenebrionids* biology, and ultimately for a better conserving of the species.

The adoption of new techniques to determine variation in the shape of both animals and plants is currently a widely discussed issue. (Lawing & Polly, 2010), geometric morphometric technique can unify methodologies to quantify and visualize shape in all the ways that are possible.

The current study results suggest that there was a significant difference in the body surface area between both adult males and females of *A. costitubera* population in Massa region ($P<0.05$).

As the result suggested that the surface area in females (1208.3±41) is larger than that for males (999 ±56), so the sexual dimorphism is very clear between the individuals of this species in this region. Although these variations are not visible to humans by ocular inspection, they may be sufficient to produce a sexual selection in insects. The variation in the abdomen surface size was greater in females; this is an essential morphological character which allows a female to produce more eggs, and therefore have a greater fecundity and fitness (Andersson, 1994; Hugo A Benítez et al., 2010; Hugo Alejandro Benítez et al., 2010; Cepeda-Pizarro, Vásquez, Veas, & Colon, 1996). Studies of body shape in *Ceroglossus chilensis* have demonstrated that the abdomen surface-size variation between males and females is directly associated with the sex ratio in this species (Hugo A Benítez et al., 2010). Morphological sex dimorphism is much reduced and only visible under a microscope. However in terms of geometric morphometric, the differences are visible in two body regions; the abdomen of females, these variations have been reported to have an adaptive value due to the presence of eggs and changes in the pronotum of the thorax in males, which has been attributed to intrasexual competition in this species (Hugo A Benítez et al., 2010; Hugo Alejandro Benítez et al., 2010).

CONCLUSION

We concluded that studying sex dimorphism differences by using TPSdig techniques could help in taxonomic classification and understanding of biological diversity.

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التمايز الجنسي والاختلاف المورفولوجي لعشائر النوع *Akis costitubera* Marseul (Coleoptera: Tenebrionidae) باستخدام تقنية القياس الهندسي المورفولوجي

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المستخلص: هذه الدراسة بحثت الاختلافات الخاصة بالمساحة السطحية للخنافس من عائلة Tenebrionidae للنوع. *Akis costitubera* M باستخدام تقنية القياس المورفولوجي الهندسي، وقد أجري البحث بالتصوير الرقمي البطني للخنافس وتم تحويل الصور إلى مصفوفات رقمية باستخدام برنامج TpsUtil وشملت كل صورة 26–معلماً متجانس لبطن الحشرة ثم نقلت للبرنامج TPSdig2. تم تصوير 60 عينة بمعدل (30 ذكر–30 أنثي) جمعت في الفترة ما بين شهر يونيو 2015 لغاية شهر أكتوبر 2015، من منطقة الدراسة. بينت النتائج أن هناك فرقا معنوياً كبيراً في مساحة الجسم السطحية بين الذكور والإناث بين أفراد هذا النوع ($P<0.05$) وكانت المساحة السطحية للجسم عند الإناث أكبر من المساحة السطحية للجسم عند الذكور وتستخلص الدراسة وجود اختلافات في المساحة السطحية بين النماذج الجنسية للنوع الواحد، وهذه الاختلافات قد تقودنا للمزيد من الأسئلة التي تتحدث عن علاقة الشكل الظاهري بالاختيار الطبيعي.

الكلمات المفتاحية: *Akis constitubera*، التمايز الجنسي، القياس الهندسي المورفولوجي.

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