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Geographic and Interspecific Variation in Body Shape of Libyan Hoverflies (Diptera: Syrphidae): A Geometric Morphometric Analysis

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التباين الجغرافي والتباين بين الأنواع في شكل الجسم لدى ذباب الحوام في ليبيا تحليل باستخدام القياسات المورفومترية الهندسية(Diptera: Syrphidae)

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ABSTRACT

Hoverflies (Diptera: Syrphidae) are ecologically important flower-visiting insects whose morphology may vary among species and geographic populations. This study assessed interspecific and geographic variation in body shape in four hoverfly species—*Eristalinus taeniops*, *Meliscaeva auricollis*, *Eupeodes corollae*, and *Episyrphus balteatus* collected from Sirt, Shahat, and Elbaida in northern Libya. A total of 180 adults were sampled between September 2020 and August 2021. Dorsal body shape was quantified using landmark-based geometric morphometrics following Generalized Procrustes Analysis and analyzed using principal component analysis (PCA), canonical variate analysis (CVA), discriminant function analysis (DFA), Mahalanobis distances, and thin-plate spline visualization. PC1 and PC2 explained 51.67% and 12.08% of total shape variation, respectively, while the first five components accounted for 81.59%. Analyses revealed clear interspecific and geographic structuring. *E. taeniops* occupied a particularly distinct region of morphospace and showed the greatest Mahalanobis distances from the other species. Pairwise DFA reported classification accuracies of 80–91%. These results indicate substantial geographic phenotypic differentiation in hoverfly body shape. Whole-body geometric morphometrics may therefore provide a useful complementary tool for ecological and taxonomic studies of Syrphidae, provided that imaging, landmark placement, allometry, sex, and measurement error are carefully controlled.

الملخص :

تعد ذبابات الأزهار (Diptera: Syrphidae) من الحشرات المهمة بيئيًا التي تزور الأزهار، وقد تختلف خصائصها المورفولوجية بين الأنواع والمجموعات الجغرافية المختلفة. هدفت هذه الدراسة إلى تقييم التباين في شكل الجسم بين الأنواع ووفقًا للموقع الجغرافي لدى أربعة أنواع من ذباب الأزهار، وهي : *Eristalinus taeniops*، و*Meliscaeva auricollis*، و*Eupeodes corollae*، و*Episyrphus balteatus*، والتي جمعت من مناطق سرت وشحات والبيضاء في شمال ليبيا. شملت الدراسة 180 فردا بالغا جمعت خلال الفترة الممتدة من سبتمبر 2020 إلى أغسطس 2021. وقد جرى توصيف شكل الجسم من الناحية الظهرية باستخدام تقنية القياسات المورفومترية الهندسية المعتمدة على النقاط المرجعية (Landmark-based Geometric Morphometrics)، وذلك بعد إجراء تحليل بروكروستس المعمم .(Generalized Procrustes Analysis) وحللت البيانات باستخدام تحليل المكونات الرئيسية(PCA) ، وتحليل المتغيرات القانونية(CVA) ، وتحليل الدالة التمييزية(DFA) ، ومسافات ماهالانوبس (Mahalanobis Distances) ، بالإضافة إلى تمثيل التغيرات الشكلية باستخدام تقنية الشرائح الرقيقة (Thin-Plate Spline). أظهرت النتائج أن المكونين الرئيسيين الأول والثاني (PC1 و PC2)فسرا 51.67% و12.08% من إجمالي التباين في شكل الجسم، على التوالي، في حين فسرت المكونات الخمسة الأولى مجتمعة 81.59% من التباين الكلي وكشفت التحليلات عن وجود تمايز واضح في شكل الجسم بين الأنواع المختلفة وبين المجموعات الجغرافية. وقد تميز النوع *Eristalinus taeniops* بشغله منطقة منفصلة نسبيًا ضمن فضاء التباين الشكلي (Morphospace)، كما سجل أكبر مسافات ماهالانوبس مقارنة بالأنواع الأخرى. وأظهر تحليل الدالة التمييزية للمقارنات الثنائية (Pairwise DFA) نسب دقة في التصنيف تراوحت بين 80% و91%. تشير هذه النتائج إلى وجود تمايز ظاهري جغرافي ملحوظ في شكل الجسم لدى ذباب الأزهار. وبناءً على ذلك، يمكن أن تشكل القياسات المورفومترية الهندسية للجسم الكامل أداةً تكميلية مفيدة في الدراسات البيئية والتصنيفية لفصيلة ذباب الأزهار (Syrphidae)، شريطة الضبط الدقيق لظروف التصوير، وتحديد مواضع النقاط المرجعية، وتأثيرات القياس التنامي (Allometry)، والاختلافات المرتبطة بالجنس، وأخطاء القياس.

الكلمات المفتاحية: SYRPHIDAE؛ القياسات الشكلية الهندسية؛ شكل الجسم؛ التباين الجغرافي؛ التمايز المظهري؛ ليبيا؛ ذباب الحوامات (**HOVERFLIES**)

1. INTRODUCTION

Hoverflies (Diptera: Syrphidae) are a species-rich family of flies with more than 6,000 described species worldwide. Adults commonly visit flowers for nectar and pollen and can contribute substantially to pollination, while the larvae of many syrphine species prey on aphids and other soft-bodied arthropods. These ecological roles make Syrphidae relevant to pollination biology, biological control, biodiversity assessment, and environmental monitoring (Gilbert, 1981; Sommaggio, 1999; Rotheray & Gilbert, 2011; Rader et al., 2020). Morphological variation among insect populations can arise from multiple sources, including genetic differentiation, developmental plasticity, sex, allometry, and local environmental conditions. Quantifying such variation therefore requires methods that separate geometric shape from differences in scale, position, and orientation while preserving the spatial relationships among anatomical structures. Landmark-based geometric morphometrics provides this framework through Procrustes superimposition and multivariate analysis of shape coordinates (Rohlf & Slice, 1990; Rohlf & Marcus, 1993; Rohlf, 1999). Geometric morphometric approaches have been used successfully in Syrphidae to distinguish closely related taxa and to describe intraspecific morphological variation (Francuski et al., 2009; Milankov et al., 2009). Most syrphid morphometric studies have focused on relatively rigid structures such as wings. Whole-body configurations can provide additional information, but they are potentially more sensitive to specimen posture, preservation, imaging orientation, and landmark repeatability. Careful standardization is therefore essential when interpreting body-shape variation. Syrphidae of the Mediterranean and North African regions have received considerable taxonomic attention, but quantitative morphometric information from Libya remains limited. Historical catalogues document a Libyan syrphid fauna, yet little is known about whether geographically separated populations show consistent body-shape differentiation (Zavattari, 1934; Dirickx, 1994). This gap is important because geographic morphological patterns may provide useful baseline information for subsequent ecological, genetic, and conservation studies.The present study examines body-shape variation in four hoverfly species sampled from three Libyan localities. The analyses address three questions: (1) do the four species occupy distinct regions of body-shape morphospace; (2) is body shape structured by sampling locality; and (3) do species differ in the magnitude of geographic structuring? The study is descriptive with respect to environmental causation: locality is treated as a geographic grouping factor, not as direct evidence that altitude, climate, or habitat caused the observed differences

2. METHOD

Study area and specimen collection

Adult hoverflies were collected between September 2020 and August 2021 from three localities in northern Libya: Sirt (31.1897° N, 16.5702° E; 28 m a.s.l.), Elbaida (32.7564° N, 21.7376° E; 623 m a.s.l.), and Shahat (32.8034° N, 21.8628° E; 513 m a.s.l.). These localities span a broad geographic and elevational gradient from the low-elevation Mediterranean coast near Sirt to the Jebel Akhdar highlands represented by Shahat and Elbaida.

A total of 180 specimens were collected: 60 from Sirt, 50 from Elbaida, and 70 from Shahat. Adults visiting wildflowers were captured using hand-held aerial nets, euthanized with ethyl acetate, pinned, labelled with collection date and locality, and stored in insect boxes in the Zoology Laboratory, Faculty of Science, Omar Al-Mukhtar University.

Species identification

Specimens were identified using morphological diagnostic characters and published taxonomic keys and descriptions (Stackelberg, 1958; Datta & Chakraborti, 1983; Dusek & Laska, 1980; Thompson & Ghorpadé, 1992; Ghorpadé, 1994; Van Steenis, 2000; Hippa et al., 2001; Claußen & Weipert, 2004; van Veen, 2004). Four species were recognized: *Eristalinus taeniops*, *Meliscaeva auricollis*, *Eupeodes corollae*, and *Episyrphus balteatus*.

Image acquisition and landmark digitization

Standardized dorsal images of the specimens were obtained using a Canon digital camera. Homologous anatomical landmarks distributed across the head, thorax, and abdomen were digitized in tpsDig2 to characterize body shape (Figure 1). The same anatomical definitions and landmark order should be applied consistently to all individuals.



Figure (1). Dorsal body landmark configuration used for geometric morphometric analysis. Red points indicate the anatomical landmarks digitized on each specimen.

Generalized Procrustes Analysis and shape variables

Landmark coordinates were imported into MorphoJ and subjected to Generalized Procrustes Analysis (GPA). GPA translates configurations to a common origin, scales them to unit centroid size, and rotates them to minimize summed squared distances among corresponding landmarks.

The resulting Procrustes coordinates describe shape variation independently of position, orientation, and overall scale, while centroid size can be retained as a separate measure of size (Rohlf & Slice, 1990; Klingenberg, 2011).

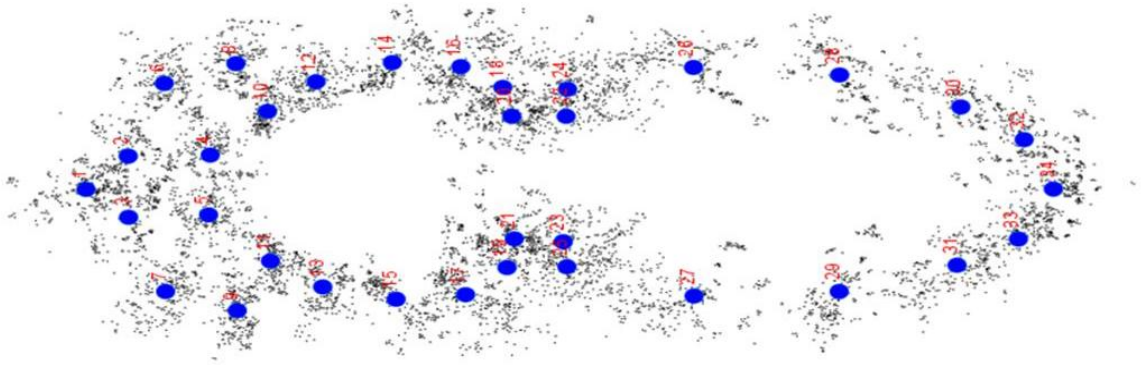


Figure (2). Superimposition of the body landmark configurations after Generalized Procrustes Analysis, illustrating variation around the consensus configuration.

Statistical analysis

Principal component analysis (PCA) was used to summarize the major axes of body-shape variation without predefined group membership. Canonical variate analysis (CVA) and discriminant function analysis (DFA) were used to visualize and evaluate differentiation among predefined species or locality groups. Thin-plate spline deformation grids were used to illustrate anatomical regions contributing to shape differences. Mahalanobis distances were reported as multivariate measures of dissimilarity among group means.

The supplied manuscript does not provide a complete factorial model for species, locality, sex, or allometry. For a final inferential analysis, a permutation-based Procrustes model should explicitly test species, locality, their interaction, sex where adequately sampled, and the relationship between shape and centroid size. Classification analyses should also report the cross-validation procedure and a complete confusion matrix.

3. ETHIC APPROVAL

For research to be considered ethical, adult insect specimens were sampled in accordance with standard institutional guidelines for non-regulated invertebrates, with collection and specimen storage hosted at the Zoology Laboratory, Faculty of Science, Omar Al-Mukhtar University.

4. RESULT

Principal component analysis of body shape

The source analysis reported 30 non-zero principal components. PC1 accounted for 51.67% of total shape variation and PC2 for 12.08%, so the first two axes together summarized 63.75% of the reported variation. PC3 accounted for a further 5.65%. The first five components were reported to explain 81.59% of total variation, indicating that most of the observed shape variation was concentrated in a relatively small number of axes (Figure 3).

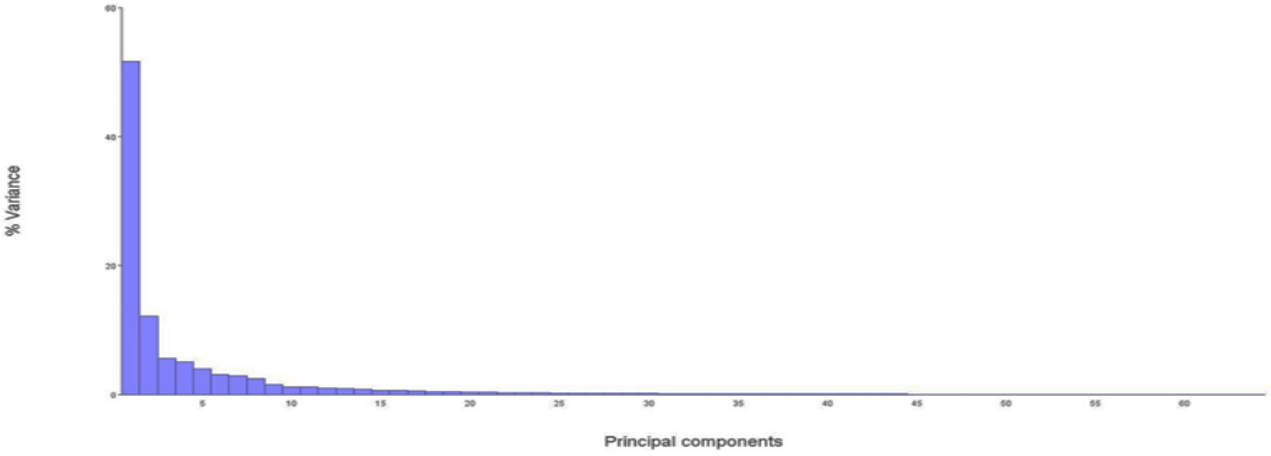


Figure (3). Scree plot of the principal component analysis of body shape, showing the decline in variance explained across successive principal components.

PCA ordinations showed clear interspecific structuring within each locality (Figure 4). In Shahat, *E. taeniops* was separated from the remaining three species, which overlapped to varying degrees. In Sirt, the four species occupied more clearly separated regions of morphospace. In Elbaida, *E. taeniops* was again strongly separated, whereas *M. auricollis*, *E. balteatus*, and *E. corollae* showed partial overlap. When all localities were pooled, species clusters remained visible but with broader within-group dispersion.

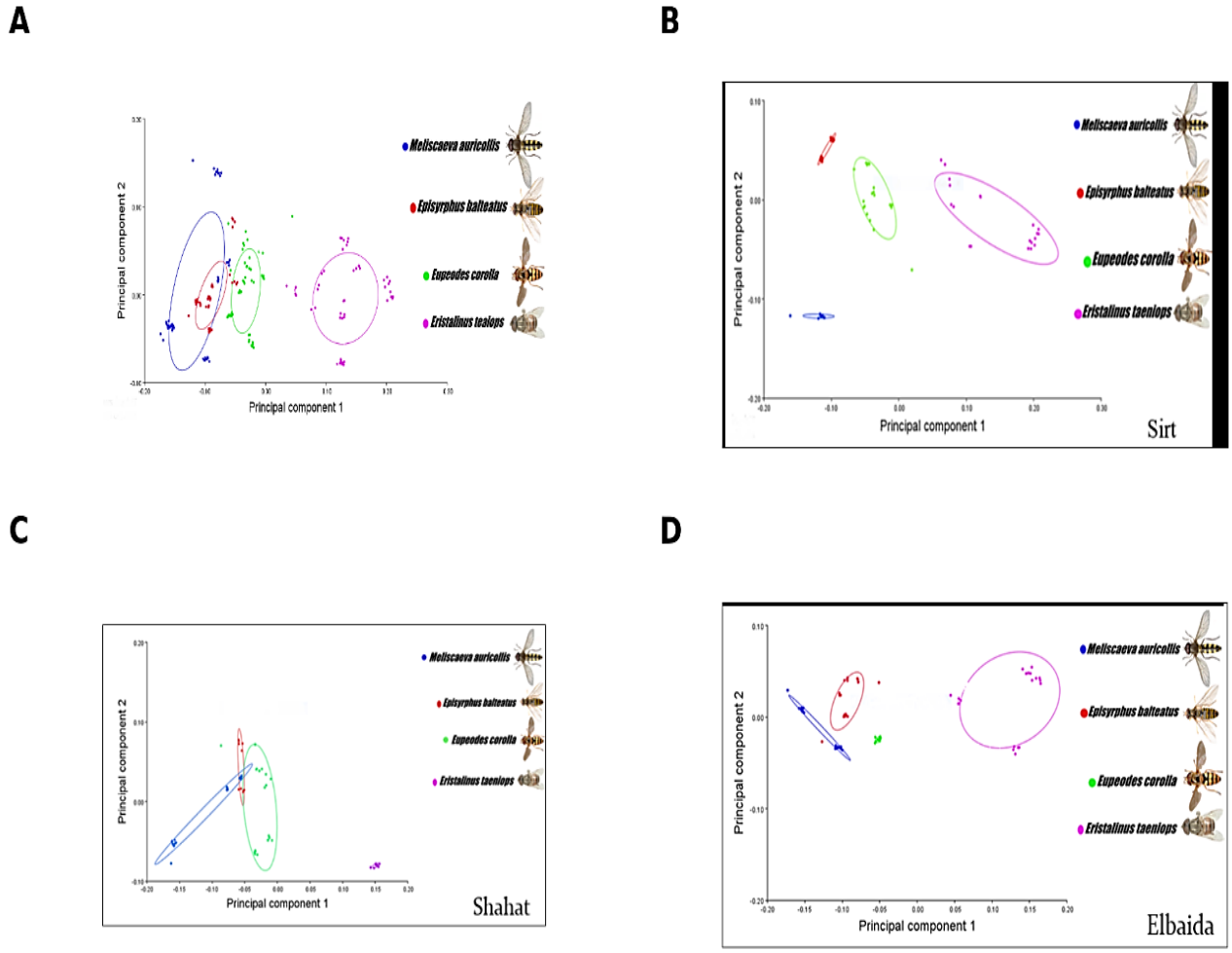


Figure (4). Principal component ordinations of body-shape variation. (A) pooled specimens from Sirt, Shahat, and Elbaida; (B) Sirt; (C) Shahat; and (D) Elbaida. Symbols/colors represent the four Syrphidae species as shown in the original plots.

Thin-plate spline visualization

Thin-plate spline deformation grids illustrated differences in the mean landmark configurations of the four species, with deformation distributed across the head, thoracic, and abdominal regions (Figure 5). These visualizations identify where landmark configurations differ geometrically, but they should not by themselves be interpreted as evidence of functional adaptation.

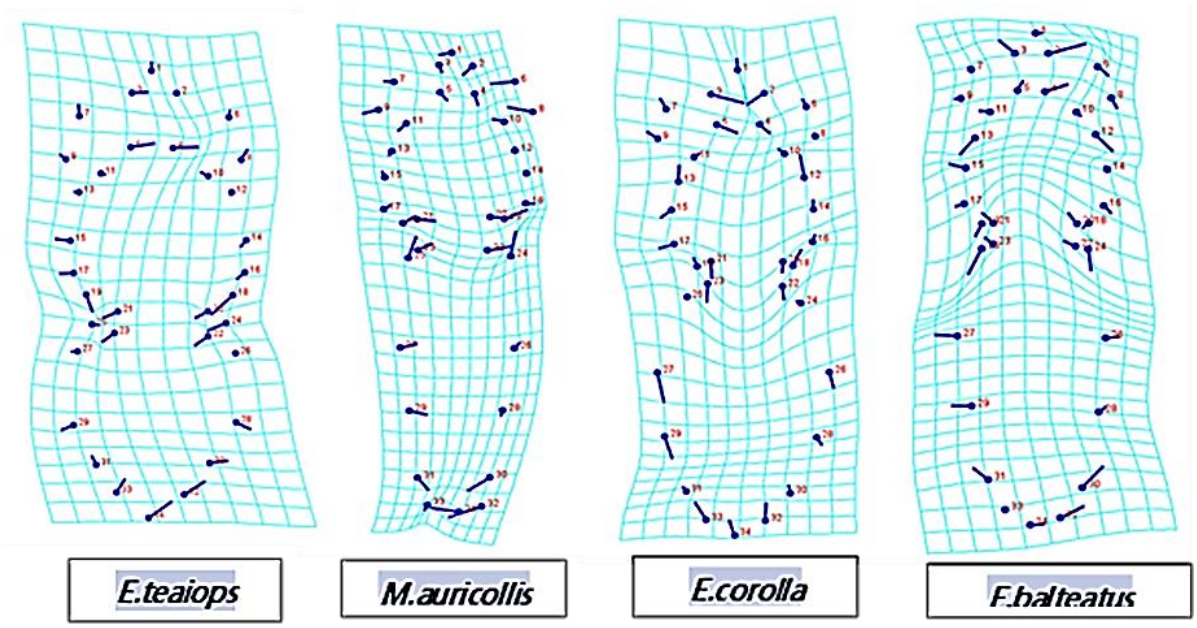


Figure (5). Thin-plate spline deformation grids illustrating mean body-shape differences among *E. taeniops*, *M. auricollis*, *E. corollae*, and *E. balteatus*.

Discriminant function analysis

Pairwise DFA score distributions indicated substantial separation among several locality comparisons (Figure 6). The source manuscript reports classification accuracies of 80–91%, including 91% for the Sirt–Shahat comparison and 80% for the Sirt–Elbaida comparison. These values suggest that body-shape information contains geographic signal, but their inferential strength depends on the sample sizes, number of shape variables, and the cross-validation procedure used.

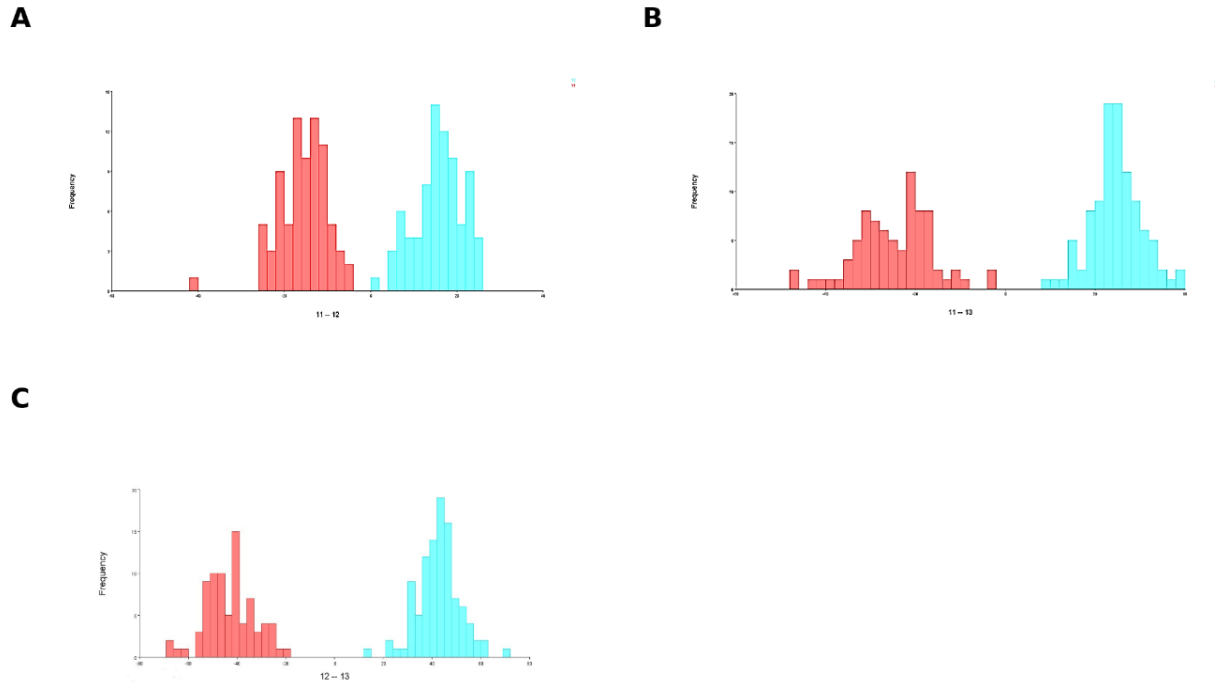


Figure (6). Pairwise discriminant-score distributions for body shape among sampling localities: (A) Shahat versus Sirt, (B) Shahat versus Elbaida, and (C) Sirt versus Elbaida.

Canonical variate analysis

CVA provided complementary visualization of group differentiation (Figure 7). When groups were defined by species, the four species occupied distinct regions of canonical morphospace. When groups were defined by locality, Elbaida specimens were more clearly displaced from the Sirt and Shahat groups, whereas the latter two showed partial overlap. These patterns describe multivariate group separation but do not identify the environmental variables responsible for it.

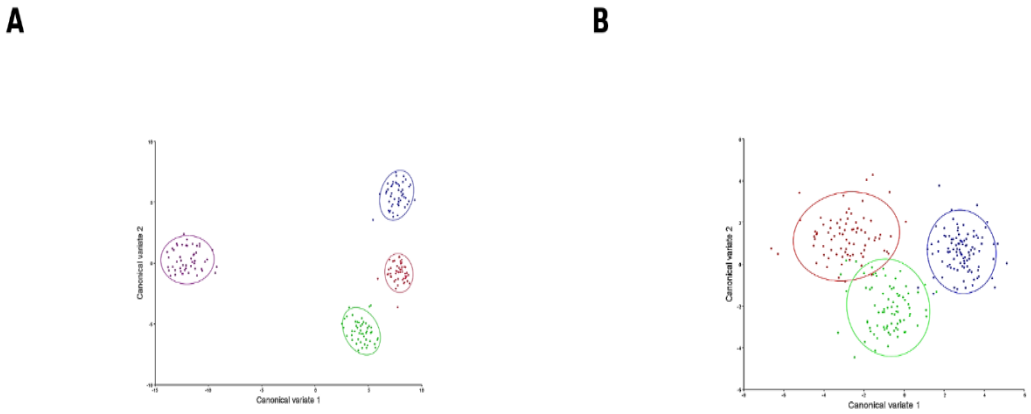


Figure (7). Canonical variate analyses of body shape with groups defined by (A) species and (B) sampling locality.

Mahalanobis distances

Mahalanobis distances were used as descriptive measures of multivariate dissimilarity among group means. Among localities, the reported distances were 4.0044 between Sirt and Shahat, 4.5425 between Sirt and Elbaida, and 5.8047 between Shahat and Elbaida (Table 1). Thus, the largest reported geographic distance was between Shahat and Elbaida, despite their geographic proximity.

Table (1). Reported Mahalanobis distances among sampling localities based on body shape. Distances are presented descriptively; significance requires an explicit inferential test.

Comparison	Distance	Comparison	Distance
Sirt–Shahat	4.0044	Sirt–Elbaida	4.5425
Shahat–Elbaida	5.8047		

Interspecific distances were substantially larger than locality distances. *E. taeniops* showed the greatest dissimilarity from the other species, with reported distances of 20.5339 from *M. auricollis*, 20.4155 from *E. balteatus*, and 17.7402 from *E. corollae* (Table 2). The smallest reported interspecific distance was 8.5871 between *E. balteatus* and *E. corollae*.

Table (2). Reported Mahalanobis distances among the four Syrphidae species based on body shape. Asterisks from the source manuscript were removed because no valid significance criterion or permutation P values were provided.

Species	*M. auricollis*	*E. balteatus*	*E. corollae*	*E. taeniops*
E. balteatus	8.8092			
E. corollae	11.8150	8.5871		
E. taeniops	20.5339	20.4155	17.7402	

5. DISCUSSION

The body-shape analyses revealed strong morphological differentiation among the four hoverfly species and additional structuring associated with sampling locality. Across the site-specific PCA plots, *E. taeniops* repeatedly occupied a distinct part of morphospace, particularly in Shahat and Elbaida, while the other three species showed varying degrees of overlap. The Mahalanobis distance matrix is consistent with this pattern: comparisons involving *E. taeniops* produced the largest interspecific distances.

These results support the usefulness of geometric morphometrics as a complementary quantitative approach for describing phenotypic differences among Syrphidae taxa, consistent with earlier morphometric work in the family (Francuski et al., 2009; Milankov et al., 2009).

Geographic structuring was also evident. The locality-based CVA showed Elbaida displaced from the Sirt and Shahat groups, and the reported locality Mahalanobis distances ranged from 4.0044 to 5.8047. Importantly, the largest distance occurred between Shahat and Elbaida rather than between geographically more distant Sirt and the Jebel Akhdar sites. The original discussion therefore cannot support a simple claim that geographic proximity predicts morphological similarity. The observed geographic pattern may reflect multiple factors, including differences in population composition, sex ratio, allometry, developmental conditions, habitat, gene flow, or sampling variation. The study design does not permit direct attribution of shape differences to temperature, rainfall, vegetation cover, evapotranspiration, altitude, or other environmental variables because these variables were not measured or entered into the reported statistical models. Locality combines many ecological and geographic differences simultaneously. The results should therefore be described as locality-associated or geographic phenotypic differentiation. Demonstrating environmental adaptation would require replicated sampling along environmental gradients, direct environmental covariates, and ideally genetic or common-garden evidence capable of separating inherited divergence from phenotypic plasticity.

Whole-body morphometrics also requires particular methodological caution. Unlike wings and other rigid structures, the apparent configuration of the head, thorax, abdomen, and appendage bases can be influenced by specimen posture, pinning, preservation, camera orientation, and abdominal contraction or expansion. These effects can create variation that is unrelated to biological shape differences. A final analysis should therefore document a strict imaging protocol, assess landmark repeatability through repeated digitization, inspect outliers, and quantify measurement error. If bilateral landmarks are included, object symmetry and asymmetry should be handled explicitly rather than treating mirrored coordinates as independent observations.

Allometry is another potential source of variation. Procrustes superimposition removes isometric scale from shape coordinates, but shape can still covary with centroid size. Because the study compares multiple species and potentially both sexes, a regression of shape on centroid size or a Procrustes ANCOVA/permutation model including centroid size—is needed to determine whether group differences persist after accounting for allometric effects. This is especially important before making ecological interpretations based on body form.

The reported DFA classification rates indicate promising discriminatory information in the body-shape data, but classification accuracy can be inflated when the number of shape variables is large relative to group sample size or when validation is not fully independent. The final manuscript should therefore report the number of specimens in each group, the exact input variables, the cross-validation strategy, and a complete confusion matrix. CVA should be interpreted with similar caution because apparent group separation can be exaggerated in small or unbalanced samples.

The study nevertheless provides a useful baseline for quantitative assessment of hoverfly body morphology in Libya. A reanalysis that resolves the landmark count, verifies the raw PCA and inferential outputs, incorporates sex and allometry appropriately, and reports validated group sample sizes would substantially strengthen the paper. Combining body-shape data with the wing-shape dataset, environmental measurements, and genetic markers in future work could help determine whether geographic morphological patterns are caused primarily by plasticity, population structure, or local selective processes.

6. CONCLUSION

Landmark-based geometric morphometrics revealed substantial interspecific and geographic variation in body shape among four Syrphidae species sampled from Sirt, Shahat, and Elbaida. *Eristalinus taeniops* were especially distinct from the other species in multivariate morphospace, and locality-based analyses indicated additional geographic structuring. These findings demonstrate that whole-body shape contains useful taxonomic and geographic information in the sampled hoverflies. However, the present dataset does not establish environmental causation, local adaptation, or sexual dimorphism without further analysis. Verification of the landmark configuration, sample composition, measurement error, allometry, and cross-validation procedures is required before final submission. With these issues resolved, the study can provide a valuable baseline for morphometric and ecological research on North African Syrphidae.

7. REFERENCES

Bookstein, F. L. (1996). Combining the tools of geometric morphometrics. In L. F. Marcus, M. Corti, A. Loy, G. J. P. Naylor, & D. E. Slice (Eds.), *Advances in Morphometrics* (pp. 131–151). Springer.

Claußen, C., & Weipert, J. (2004). Notes on the subgenus *Paragus (Pandasyopthalmus)* (Diptera, Syrphidae) from Nepal, with the description of a new species. *Volucella*, 7, 75–88.

Datta, M., & Chakraborti, M. (1983). On a collection of flower flies (Diptera: Syrphidae) with new records from Jammu and Kashmir. *Records of the Zoological Survey of India*, 81(1–2), 237–253.

Dirickx, H. G. (1994). *Atlas des Diptères syrphides de la région méditerranéenne* (Vol. 75). Institut Royal des Sciences Naturelles de Belgique.

Dusek, J., & Laska, P. (1980). Species of *Metasyrphus* from Afghanistan and Kirghizia, with keys and descriptions of three new species (Diptera, Syrphidae). *Acta Entomologica Bohemoslovaca*, 77, 118–130.

El-Hawagry, M. S., & Gilbert, F. (2019). Catalogue of the Syrphidae of Egypt (Diptera). *Zootaxa, 4577*(2), 201–248.

Francuski, L., Ludoški, J., Vujić, A., & Milankov, V. (2009). Wing geometric morphometric inferences on species delimitation and intraspecific divergent units in the *Merodon ruficornis* group (Diptera, Syrphidae) from the Balkan Peninsula. *Zoological Science*, 26(4), 301–308.

Ghorpadé, K. (1994). Diagnostic keys to new and known genera and species of Indian subcontinent Syrphini (Diptera: Syrphidae). *Colemania: Insect Biosystematics*, 3, 1–15.

Gilbert, F. S. (1981). Foraging ecology of hoverflies: Morphology of the mouthparts in relation to feeding on nectar and pollen in some common urban species. *Ecological Entomology*, 6(3), 245–262.

Hippa, H., Nielsen, T. R., & van Steenis, J. (2001). The West Palaearctic species of the genus *Eristalis* Latreille (Diptera, Syrphidae). *Norwegian Journal of Entomology, 48*, 289.

Klingenberg, C. P. (2011). MorphoJ: An integrated software package for geometric morphometrics. *Molecular Ecology Resources, 11*(2), 353–357. https://doi.org/10.1111/j.1755-0998.2010.02924.x

Milankov, V., Ludoški, J., Ståhls, G., Stamenković, J., & Vujić, A. (2009). High molecular and phenotypic diversity in the *Merodon avidus* complex (Diptera, Syrphidae): Cryptic speciation in a diverse insect taxon. *Zoological Journal of the Linnean Society, 155*(4), 819–833. https://doi.org/10.1111/j.1096-3642.2008.00462.x

Rader, R., Cunningham, S. A., Howlett, B. G., & Inouye, D. W. (2020). Non-bee insects as visitors and pollinators of crops: Biology, ecology, and management. *Annual Review of Entomology, 65*, 391–407. https://doi.org/10.1146/annurev-ento-011019-025055

Rohlf, F. J. (1999). Shape statistics: Procrustes superimpositions and tangent spaces. *Journal of Classification, 16*, 197–223.

Rohlf, F. J., & Marcus, L. F. (1993). A revolution in morphometrics. *Trends in Ecology & Evolution, 8*(4), 129–132.

Rohlf, F. J., & Slice, D. (1990). Extensions of the Procrustes method for the optimal superimposition of landmarks. *Systematic Zoology, 39*(1), 40–59.

Rotheray, G., & Gilbert, F. (2011). *The Natural History of Hoverflies*. Forrest Text.

Sommaggio, D. (1999). Syrphidae: Can they be used as environmental bioindicators*? Agriculture, Ecosystems & Environment, 74*(1–3), 343–356.

Stackelberg, A. A. (1958). The Palaearctic species of the genus *Spilomyia* Meigen (Diptera, Syrphidae). *Entomologicheskoe Obozrenie, 37*(3), 759–768.

Thompson, F. C., & Ghorpadé, K. (1992). A new coffee aphid predator, with notes on other Oriental species of *Paragus* (Diptera: Syrphidae). *Colemania*.

Thompson, F. C., Pape, T., & Evenhuis, N. L. (2013*). Systema Dipterorum*, Version 1.5.

van Steenis, J. (2000). The West-Palaearctic species of Spilomyia Meigen (Diptera, Syrphidae). *Mitteilungen der Schweizerischen Entomologischen Gesellschaft, 73*(1/2), 143–168.

van Veen, M. P. (2004). *Hoverflies of Northwest Europe: Identification Keys to the Syrphidae*. KNNV Publishing.

Zavattari, E. (1934). *Prodromo della fauna della Libia*. Tipografia già Cooperativa.