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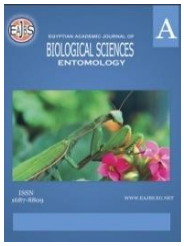

Morphological Variation Within Populations of Darkling Beetles *Pimelia carinata* Solier, 1836 (Coleoptera: Tenebrionidae) Inhabiting in Different Regions in Egypt

SABER A. RIAD
Department of Zoology, Faculty of Science, Al Azhar University, Nasr City, Cairo, Egypt.
***E-mail:** saberiad60@azhar.edu.eg

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ABSTRACT

Most eukaryotic animals described in the world are insects. However, studies of morphometric measurements, isolation, and habitat differences are still very few for insects, especially desert insects. This study aimed to compare measurements of morphological traits of dissimilar *Pimelia carinata* populations as darkling beetle models in the Egyptian desert. A morphometric variations variable comparison was taken by a micrometer microscope for samples of 6 ecoregions from Egypt including; the Western Coastal Desert, El-Faiyum depression, oases of the Western Desert, Eastern Desert, Delta, and south Sinai. Morphological measurements depend upon twenty-one traits that were studied, using cluster analysis and principal component analysis to distinguish the different traits of populations. The first and second of the discriminant scores (Score 1 and Score 2) were registered at 77.64% and 24.61% of the complete variation in different samples. Multiple discriminant analyses detected clear morphometric variations between the populations of Western Desert, and Western Coastal Desert in the first cluster. while the second cluster comprises of Eastern Desert, El-Faiyum, and Nile Delta. The population of Sinai is present in a separate cluster. The traits showing maximum variability across beetle populations were those associated with morphological estimates.

INTRODUCTION

Egypt is distinguished by its unique position among the world's faunal regions because it enhances the features of both the ancient and Afrotropical and is closer to the Palaearctic. Despite this, Afrotropical elements appear more frequently than usually thought (Mahmoud *et al.*, 2022). Egypt is a part of a great desert belt with a rainless and warm climate. Only the strip of coastal, Mount Elba, the high mountains in Sinai are characterized by relatively heavy rainfall, which shows the diversity of the flora and the fauna. Recently, Egypt divided into 8 ecoregions, in particular: Eastern Desert, Western Desert, North Coastal Strip, Lower and Upper Nile Valley, Delta, Depression of El-Fayoum, Gebel Elba, and Sinai (Steyskal and ElBialy, 1967; El Hawagry and Gilbert, 2014; Riad 2022a).

Although insects represent most eukaryotes described worldwide, morphological measurements and the effects of habitat variation and isolation are still very scarce in most insect orders, including beetles (Coleoptera) (Mahmoud *et al.*, 2022; Riad, 2022b). The family Tenebrionidae is the largest desert-dwelling family of Order Coleoptera, which includes approximately 1,700 genera including more than 20,000 species known from a global distribution (Riad 2022a; Bream *et al.,* 2019; Haggag *et al.,* 2018; Booth *et al.,* 1990). Among all beetle families, Tenebrionidae ranks 7th in terms of species diversity. There is also an absence of information on the systematic evolution of this group, its subfamilies, and its clans (Hassan *et al.,* 2017a; Riad 2022a). *Pimelia carinata* Solier, 1836 (Coleoptera: Tenebrionidae) is found in the Sahara Desert (North part of Africa and all Middle East countries) and is characterized as a typical dark beetle (Larsen, 1991; Nyári *et al.,* 2020; Ghahari *et al*., 2010a; Riad 2022b). Adaptation of genus Pimilia to desert environments and arid climates allows it to survive and reproduce in sand dunes, and adaptations of morphology include the fused sclerites, lipid layer, epicuticle, and sub-lateral cavity. All adaptations of pimelia morphology make it a good desert model for studying isolation in the Egyptian desert (Mahmoud *et al.*, 2022; Hassan *et al.,* 2015; Riad, 2019).

One of the approved methods used in the study of biology to detect biodiversity is morphometric measurements (Mahmoud and Riad, 2020) and phylogenetic resolution (Ober and Connolly, 2015; Mahmoud and Riad, 2020; Hassan *et al.*, 2017a). Morphometric measurements are commonly used in an integrated way to lateral systematics through molecular information (Hassan *et al.*, 2017b; Marugan-Lobon, 2013), which may lead to a taxonomic revision (Ghahari *et al*., 2010b; Riad 2019; Mahmoud *et al.,* 2022).

The morphological characteristics are the most important questions that will be taken for evaluation. The frequent use of multiple characters can cause confusion in obtaining results for phylogenetic analysis that rely on morphological differences. One of the most common tools for discovering suitable measurements is linear discriminant analysis (LDA) (Hassan *et al.,* 2017b; VanRensburg *et al.*, 2003; Riad 2019).

Morphometric measurements might be useful in incorporating phylogeny, particularly if the lack of diagnostic traits is the problem in the identification of species or even their absence (De Bivort *et al.*, 2010; Janse van Rensburg *et al.*, 2003; Navia *et al.*, 2015; Mahmoud *et al.*, 2022). During the current study, the possible subspecies differences between some Egyptian populations of *Pimelia carinata* in different ecogeographical regions in Egypt will be elucidated using cluster analysis and LDA.

MATERIALS AND METHODS

Study Site and Sampling:

The study was started from January 2020 to February 2021 in fourteen different sites in Egypt (Table 1). The *Pimelia carinata* population specimens were collected by Pitfall traps and in some cases collected by hand. five different locations were selected in each target site to use the pitfall traps. Traps distributed were designed according to Riad (2019). Classification and identification of samples were according to the keys illustrated by El-Shewy *et al.* (2016) and Löbl and Smetana (2008) at the Plant Protection Research Institute, Egypt. Due to the difficulty of determining the gender of specimens by morphological examination, some specimens were dissected to confirm sex determination. All collected samples were registered and deposited at the Ecology lab, Faculty of Science (Boy), Al-Azhar University. GPS locations and altitudes of each ecoregion were recorded using GPS determined by eTrex 30 GPS, Garmin; the mapping of the study area was prepared by the software program ArcGIS 10.2. Sites of the study were grouped into six ecogeographical regions of the Egyptian desert (Table. 1 and Fig.1).

Table. 1: Study locations, coordinates, museum codes, and gender of specimens of *Pimelia carinata* collected from 2020 to 2021.

Locality		Coordination		Specimen Numbers	Specimen Gender		Museum Code
		Latitude	Longitude		Male	Female	
Sharm El Sheikh, South Sinai	SS	27.84990 N	34.22448 E	42	17	25	IC02456 - IC02498
Tablea, Sinai		29.53391 N	34.70312 E	42	19	23	IC02499 – IC2540
Siwa	WDO	29.18073 N	25.47638 E	42	12	30	IC02541 - IC02582
Bahariya		28.27596 N	28.80067 E	42	22	20	IC02583 - IC02624
Farafra		27.07763 N	27.97546 E	42	19	23	IC02625 - IC02666
Dakhla		25.49454 N	28.97892 E	42	18	24	IC02667 - IC02708
Kharga		24.67444 N	30.60799 E	42	24	18	IC02709 - IC02750
El-Faiyum Depression	FD	29.27999 N	30.57639 E	42	16	26	IC02751 - IC02792
Bagush, Matruh	WCD	31.10422 N	27.41474 E	42	19	23	IC02893 - IC02834
Mersa Matruh		31.30902 N	27.29444 E	42	20	22	IC02835 - IC02876
Wadi El-Tarfa, Ras Gharib	ED	28.26184 N	32.16267 E	42	13	29	IC02877 – IC02918
Wadi Dabr, Marsa Allam		25.15159 N	34.39105 E	42	21	21	IC02919 - IC02960
10th of Ramadan City	ND	30.32248 N	31.78177 E	42	18	24	IC02961 - IC03002
El Salhiya City, Sharquiya		30.85409 N	32.06419 E	42	23	19	IC03003 - IC03044

IC: Insect Coleoptera, SS: South Sinai, WCD: Western Coastal Desert, WDO: Oases Western Desert, ND: Nile Delta; ED: Eastern Desert.

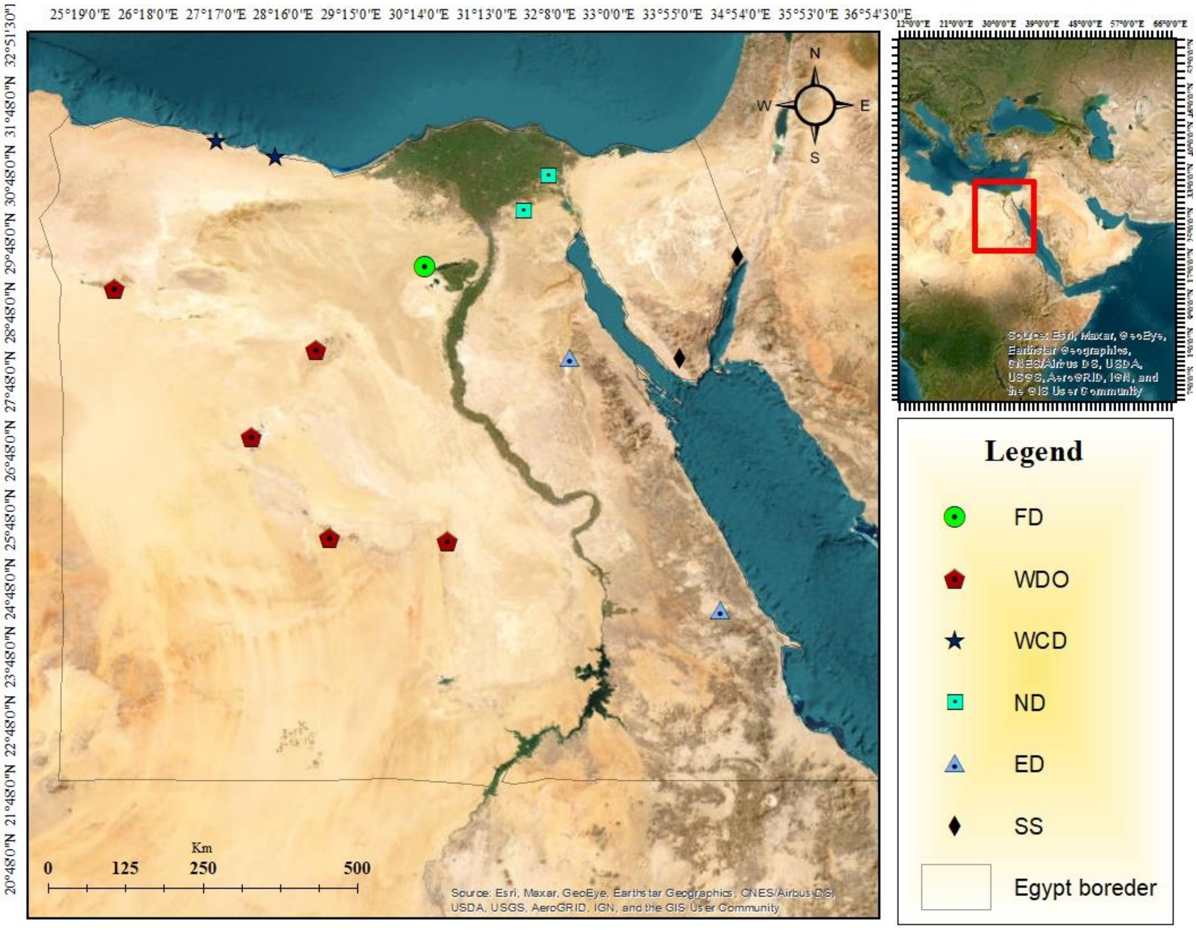

Fig. 1: Study area map of different collected sites of *Pimelia carinata*. SS: South Sinai, WCD: Western Coastal Desert, WDO: Oases Western Desert, ND: Nile Delta; ED: Eastern Desert, and FD: El-Faiyum Depression.

Morphometric measurements

During the study, 588 specimens were used for morphometric analyses of *Pimelia carinata*. An Eyepiece micrometer was used to measure 17 absolute morphometric traits in each specimen and also calculate 4 ratios (Table. 2).

Table. 2: Definitions of measurement abbreviations used during the study.

Symbol	Definition
AL	Length of pedicel + flagellum = Antenna length.
BL	HL + PL + EL = Body length.
EL	From anterior of scutellum to posterior of elytron = Elytron length.
EW	Width of elytron = Elytron width.
FF	Length of fore femur
FT	Length of fore tibia
Fta	Length of fore tarsus
HL	Start with anterior border of head to pronotum, taken dorsally = Head length
HW	Measured behind the eyes = Head width
MeF	Lengt+h metafemur
MeT	Length metatibia
MeTa	length metatarsus
MF	length mesofemur
MT	length mesotibia
Mta	length mesotarsus
PL	Anterior border to posterior scutellum, taken dorsally = Pronotum length,
PW	Pronotum width (maximum)

Statistical Analysis

The differences in each morphological measurement between specimens were examined with the F- test (with Dunns post-hoc test), according to the method of Levesque (2007) and using the SPSS software (SPSS Inc, version 20, Chicago, Illinois, United States of America). To conduct the Linear Discriminant Analysis LDA, NCSS11 software (NCSS, LLC, Kaysville, UT, United States of America) was used. Significant probability at $p \leq 0.05$ or $p \leq 0.01$.

RESULTS

A comparison of *Pimelia carinata* Solier, 1836 populations collected from different ecoregions depends on 17 absolute morphological traits and four ratios registered significant differences between all populations. Measurements of the total width of elytra (EW), the South Sinai (SS), Eastern Desert (ED), and Nile Delta (ND) populations were registered as the low similarity for elytra width EW, also appear high similarity ratios of elytron width per elytron length (EW/El). The high for elytra width (EL), was recorded in the El-Faiyum Depression population. While Pronotum width/ pronotum length recorded a high ratio in the South Sinai population PW/PL (Table. 3).

Table. 3: Morphometric measurements (mm) for *Pimelia carinata* Solier, 1836 specimens from the different ecogeographical regions of Egypt.

Measured parameters (mm)	Ecogeographical studied region					
	Western Coastal Desert	Western Desert	El-Faiyum	Eastern Desert	Nile Delta	Sinai
	Sample size (n=42)					
AL	10.28 ± 0.06^{a}	10.39 ± 0.09^{b}	10.31 ± 0.09^{c}	10.19 ± 0.09^{b}	10.39 ± 0.09^{b}	10.28 ± 0.09^{a}
EL	22.28 ± 0.06^{a}	22.39 ± 0.09	22.39 ± 0.09^{a}	22.33 ± 0.09^{a}	22.39 ± 0.09^{c}	22.38 ± 0.09^{a}
EW	17.69 ± 0.06^{a}	17.79 ± 0.09^{a}	17.77 ± 0.09^{a}	17.59 ± 0.09^{a}	17.69 ± 0.09^{a}	17.67 ± 0.09^{a}
FF	8.69 ± 0.05^{a}	8.67 ± 0.05^{a}	8.64 ± 0.05^{a}	8.59 ± 0.05^{a}	8.55 ± 0.05^{a}	8.59 ± 0.05^{a}
FT	6.70 ± 0.06^{a}	6.69 ± 0.09^{a}	6.49 ± 0.09^{a}	6.59 ± 0.09^{a}	6.69 ± 0.09^{c}	6.68 ± 0.09^{a}
Fta	4.55 ± 0.09^{a}	4.56 ± 0.09^{a}	4.54 ± 0.09^{c}	4.53 ± 0.09^{a}	4.52 ± 0.09^{a}	4.49 ± 0.09^{a}
HL	3.68 ± 0.06^{a}	3.39 ± 0.09^{a}	3.30 ± 0.09^{a}	3.39 ± 0.09^{a}	3.49 ± 0.09^{a}	3.38 ± 0.09^{a}
HW	7.38 ± 0.06^{a}	7.49 ± 0.09^{a}	7.39 ± 0.09^{a}	7.29 ± 0.09^{a}	7.39 ± 0.09^{a}	7.39 ± 0.09^{a}
MeF	11.28 ± 0.06^{a}	11.31 ± 0.09^{cb}	11.22 ± 0.09^{a}	11.39 ± 0.09^{a}	11.29 ± 0.09^{a}	11.30 ± 0.09^{a}
MeT	10.50 ± 0.06^{a}	10.49 ± 0.11^{a}	10.59 ± 0.11^{b}	10.39 ± 0.11^{a}	10.41 ± 0.12^{a}	10.50 ± 0.09^{a}
MeTa	6.10 ± 0.06^{a}	6.09 ± 0.09^{a}	6.11 ± 0.09^{a}	6.11 ± 0.09^{a}	6.12 ± 0.09^{a}	6.10 ± 0.09^{a}
MF	10.69 ± 0.09^{a}	10.67 ± 0.09^{a}	10.66 ± 0.09^{a}	10.59 ± 0.09^{a}	10.67 ± 0.09^{a}	10.64 ± 0.09^{a}
MT	7.73 ± 0.11^{a}	7.80 ± 0.11^{a}	7.67 ± 0.11^{c}	7.69 ± 0.11^{a}	7.79 ± 0.11^{cb}	7.78 ± 0.09^{a}
Mta	6.48 ± 0.06^{a}	6.49 ± 0.09^{a}	6.59 ± 0.09	6.43 ± 0.09^{a}	6.42 ± 0.09^{a}	6.50 ± 0.09^{a}
PL	6.19 ± 0.07^{a}	6.12 ± 0.09^{b}	6.21 ± 0.09^{b}	6.20 ± 0.09^{a}	6.21 ± 0.09^{a}	6.30 ± 0.06^{b}
PW	12.18 ± 0.06^{a}	12.19 ± 0.09^{b}	12.19 ± 0.09^{a}	12.11 ± 0.09^{a}	12.21 ± 0.09^{c}	12.18 ± 0.09^{b}
TL	32.68 ± 0.06^{a}	32.79 ± 0.09^{a}	32.95 ± 0.09^{a}	32.69 ± 0.09^{a}	32.79 ± 0.09^{a}	32.86 ± 0.09^{a}
HW/HL	2.14 ± 0.03^{cb}	2.20 ± 0.03^{a}	2.17 ± 0.03^{b}	2.22 ± 0.03^{a}	2.18 ± 0.03^{c}	2.24 ± 0.04^{b}
PW/PL	1.95 ± 0.01^{b}	2.03 ± 0.02^{a}	2.02 ± 0.02^{a}	1.98 ± 0.01^{a}	1.95 ± 0.01^{bc}	2.03 ± 0.01^{a}
EW/EL	0.78 ± 0.00^{a}	0.78 ± 0.00^{b}	0.71 ± 0.00^{b}	0.75 ± 0.00^{a}	0.78 ± 0.00^{a}	0.78 ± 0.00^{b}
EL/PL	3.62 ± 0.03^{a}	3.67 ± 0.04^{a}	3.62 ± 0.04^{a}	3.62 ± 0.04^{a}	3.62 ± 0.04^{a}	3.68 ± 0.04^{a}

Data as mean ± sd. Per column, significantly different by different letters at $p \leq 0.01$ or $p \leq 0.05$ according to the level on Tuckey's-b test. AL: length of antenna, see abbreviations in table 2.

Using cluster analysis to compare all morphological traits, the analysis showed that the specimens of different populations grouped in three separate distinct cluster (Fig. 2). The 1st cluster includes the populations of the Depression of El-Faiyum, Eastern Desert, and Delta. The 2nd group includes Western Desert and Coastal populations. The 3rd cluster includes the South Sinai population only.

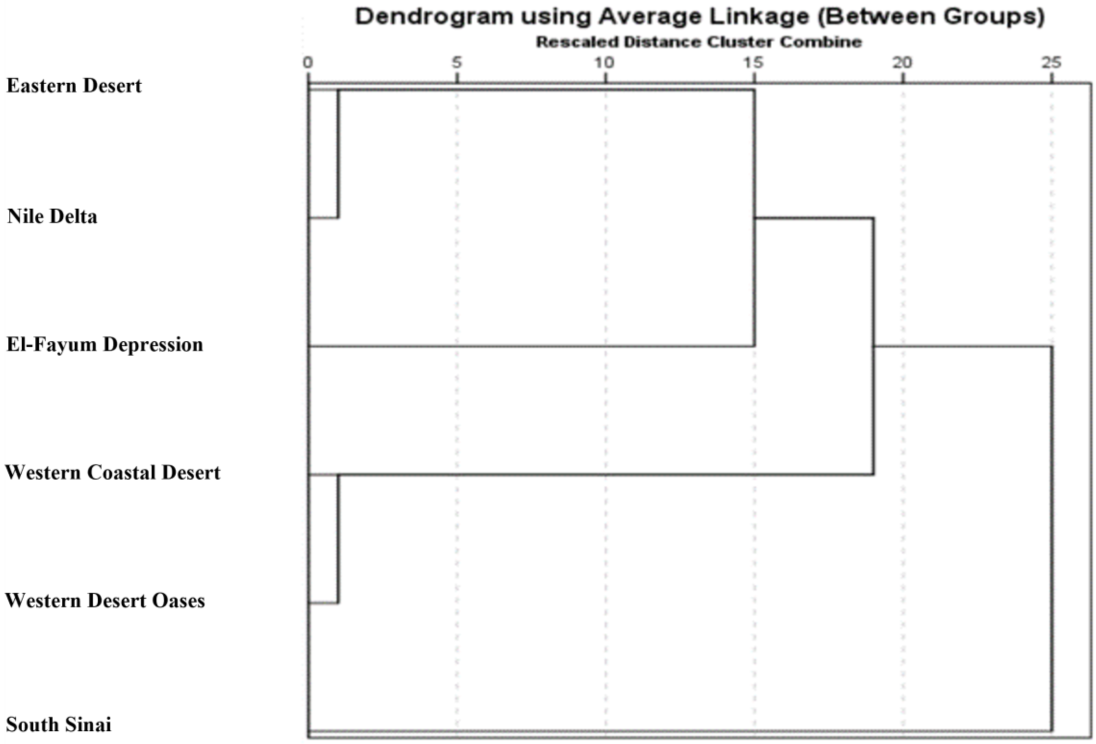

Fig. 2: Dendrogram showing the similarity between different *Pimelia carinata* populations.

Using the LDA based on 21 variables showed that significance between the group variables recorded that the discriminant scores (Score 1 and Score 2) were 77.64% and 24.61% of the total difference in samples (Table 4). Also, the Table (5) shows the factor loading values for each morphometric measurement.

According to Linear Discriminant Analysis, a clear similarity between different populations collected from the Eastern Desert, the Nile Delta in one group, and the Western Coastal Desert population with Oases of the Western Desert in other groups was detected (Fig. 2). These specimens were distinctly separated from El-Faiyum Depression specimens and South Sinai specimens. also, the two populations appeared as separate groups different from other populations. Depending upon both linear discriminant analysis and cluster statistical analysis, the studied populations of *Pimelia carinata* from El-Faiyum Depression and South Sinai showed a high phenetic distance from other ecoregion populations.

Table. 4: Results of Linear Discriminant Analysis based on twenty-one morphometric variables.

Linear Discriminant Analysis		
	Score 1	Score 2
Eigen value	10.98	3.39
Explained (%)	77.64	24.61
Cumulative (%)	78.21	48.32

Table. 5: Morphological character factor loading values.

Character	Score 1	Score 2
AL	0.0084525	0.25341
EL	0.0084525	0.25341
EW	-0.059617	-0.10538
FF	0.0037487	0.1122
FT	-0.0084525	-0.25341
Fta	-0.0084525	-0.25341
HL	-0.0061006	-0.1828
HW	0.02043	0.29002
MeF	0.0084525	0.25341
MeT	0.0084525	0.25341
MeTa	-0.013962	0.057341
MF	-0.0084525	-0.25341
MT	-0.0084525	-0.25341
Mta	0.0014026	0.018628
PL	0.0084525	0.25341
PW	0.0084525	0.25341
TL	0.010804	0.32402
HW/HL	0.0091793	0.17841
PW/PL	-0.0034264	-0.022821
EW/EL	-0.003381	-0.10136
EL/PL	0.99748	-0.043085

See abbreviations in Table 2

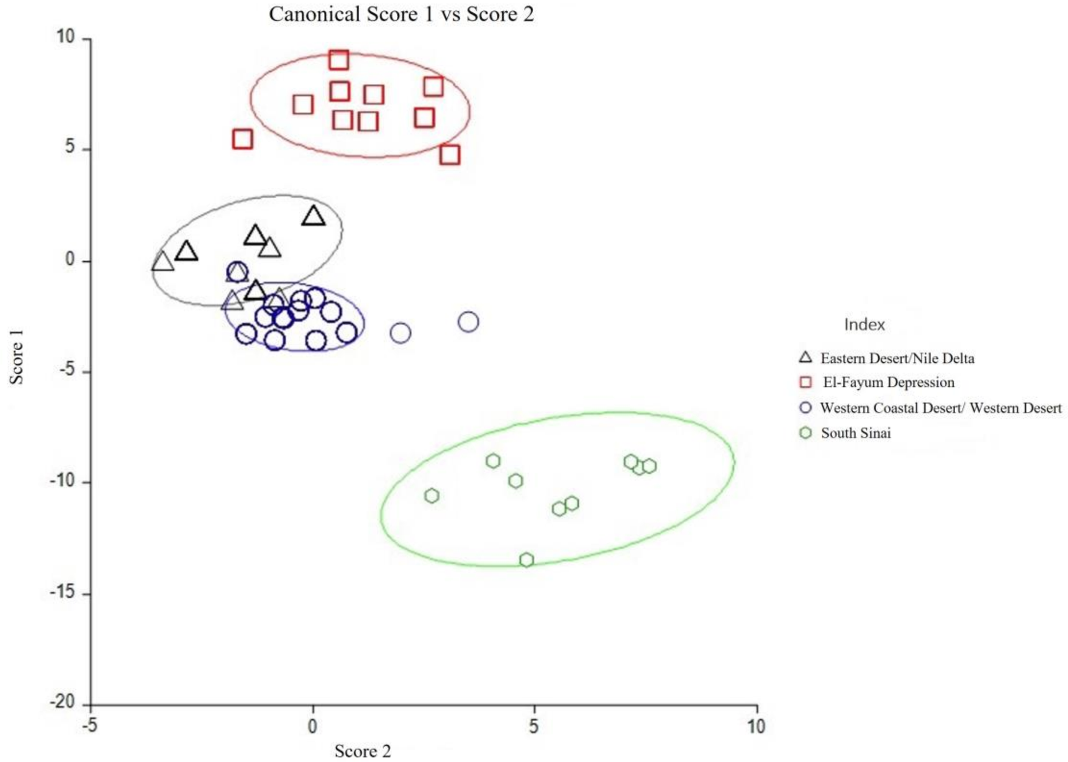

Fig. 3: Principal component analysis of the different morphometric measurements of the six *Pimelia carinata* populations.

DISCUSSION

When comparing discrete populations collected from different geographical sites by employing a morphological information group, it will disburse some impact on the ascertained variations (Hassan *et al.,* 2017a; Mamuris *et al.*, 1998). through sample size standardization this study minimizes additional variances, data collection, and separate linear discriminant analysis. Vast variation in variables of morphometric traits occurred between the compared populations. In addition, the collected specimens from the Oasis of the Western Desert (Kharga, Dakhla Oasis, Farafra, Bahariya, Siwa Oases), and Coastal Desert populations were utmost similar. On the other hand, within the population of Eastern Desert, the populations of Mersa Allam, and Ras Gharib were also similar, whereas the populations of El-Faiyum Depression and the South Sinai of the darkling beetles were recorded as highly dissimilar. All collected data is supported by linear discriminant analysis and cluster analysis.

The variances of major importance in segregating El-Faiyum Depression and the South Sinai populations were related to the total size of the body of *Pimelia carinata* specimens in comparison with various populations (Mahmoud *et al.,* 2022; Riad 2019). Nevertheless, the comparatively highly discriminant analysis of the Eastern Deserts, Western Desert, Sinai, and El-Faiyum populations variables suggested an impersonation of sub speciation of *P. carinata*. These four eco-geographical areas are separated from each other by huge barriers of geography, these barriers prevent the species from transforming between them, in additionally to the expected limited range of homes of this darkling beetle (Klingenberg and Marugán-Lobón, 2013; Mahmoud *et al.,* 2022; Badry *et al.,* 2017; Riad 2019).

Today, the River of Nile and its branched narrow plain of flood act as a huge barrier for the desert fauna dispersal separating the Eastern Desert and the Western Desert in Egypt. Near the Valley of Nile and associated with the Nile River through an enormous Bahr Yusuf water channel, The Faiyum is geologically considered part of the Nile Valley. Lake Qarun is the lowest part of the depression and is a shallow Salt Lake that drops about 4.5 meters below sea level and has an area of about 200 square kilometers. It is flat simply over the level of the lake and is about 23 m asl (Drake *et al.,* 2011; Riad 2019). *P. carinata* populations were isolated from the Fayoum Depression within this huge area from other desert populations covered in the study. During the beginning of geological times, the wetlands, and lakes in and around the Gulf of Suez area (which is now separated by the Suez Canal) expanded widely, and environmental conditions characterized by numerous swamps are found near this only eastern African gateway. It appears that the Gulf of Suez, characterized by its shallowness, was like an open space throughout most of the Pleistocene age, about 14-15 thousand years ago, when sea levels began to rise by about 50 meters, linking the eastern desert with the Sinai Desert (Mahmoud *et al.*, 2022). During long periods of drought in the Pleistocene, the Gulf of Suez was a compact and connected area, and movement between the eastern desert and the Sinai Peninsula was easy, with the 2 regions forming a continuous dry zone over wide areas (Riad, 2019; Mahmoud *et al.*, 2022). This is perhaps the most likely explanation for the possible similarity between the Eastern Desert and South Sinai populations for *P. carinata* specimens.

During any strong Climatic changes, some populations and other species coexist exclusively in places with a more sTablele climate, and this is called a refuge. There are a few species that can adapt to these changes, for example, Coleoptera, especially Carabidae and Tenebrionidae (Wanek and Sturmbauer, 2015; Riad, 2019 Mahmoud *et al.*, 2022). There is a high probability that the processes of divergence and speciation in the genus Pimelia have been strongly influenced by subsequent changes and contractions of a series of populations due to climatic changes. For example, if two populations of the same species are separated in two different refugia, this may affect divergent speciation. This isolation in mountain refuges and similar refuges will lead to different patterns in morphological diversity, which are in many regards consistent across different lineages (Badry *et al.,* 2017; Riad 2019). Meanwhile, all distinct Pimelia species have the same ecological refuge, which may lead to more similar adaptations and evolution to coexistence in the same ecological niches. Because of this, there is a possibility that many morphological traits are not phylogenetically related, but are mainly adapted to the underlying condition, which is basically to be considered (Grobler *et al.,* 2006; Mahmoud *et al.,* 2022).

The temporal and spatial expansion and constriction of some desert conditions within the Sahara play a very important role in species events and faunal diversity. Paleoclimatic cycles have developed boundaries between alternative desert environments and their permanently associated biodiversity (Riad, 2019 Mahmoud *et al.,* 2022). Indirect events associated with drought cycles in the Sahara became the most significant force driving post-Pleistocene variability (Bream *et al.*, 2017; Riad 2022a). These changes are thought to cause the isolation of the homologous habitat, which in turn disrupt gene flow and thus the evolution of independent lineages and new species.

Depending on habitat requirements, the animal species' response to desert events varies. During wet times, desert-adapted animals are restricted to the remaining harsh areas of all parts of the Sahara or parts of remaining desert habitats. During isolation, they likely adapt to genetic and morphological diversity (Boratynski *et al.*, 2012; Mahmoud *et al.*, 2022). During the following dry period, isolated groups of desert-adapted species can expand their ranges, presumably merging different metagroups into the same larger groups. If recent divergence is not sufficient to lead to reproductive isolation, genes will be mixed and a similar population with free gene flow will form (Riad, 2022b; Mahmoud *et al.*, 2022). Desert oasis depressions play a large role in Sahara Desert expansion designs by acting as animal ecological refugia for various species and gene flow facilitating across typical climates.

CONCLUSION

The morphometric traits and measurements studied in this study may be an adequate way to differentiate between Egyptian desert darkling beetles *Pimelia carinata*. The population of South Sinai and the Depression of El-Faiyum of *P. carinata* recorded different morphometric measurements from the other populations collected from different ecoregions in Egypt. Results showed these two populations are most distinct from other populations. Finally, additional analysis of the phylogeny of *P. carinata* is required to confirm the data recorded in this work.

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REFERENCES

Badry, A.; Younes M.; Sarhan M. and Saleh M. (2018): On the scorpion fauna of Egypt, with an identification key (Arachnida: Scorpiones). *Zoology in the Middle East,* 64: 75-87.

Booth, R. G; Cox, M. L and Madge, R. B. (1990): IIE Guides to Insects of Importance to Man. 3. Coleoptera. CAB International, Wallingford, UK.

Boratynski, Z.; Brito, J. C. and Mappes, T. (2012): The origin of two cryptic species of African desert jerboas (Dipodidae: *Jaculus*). *Biological Journal of the Linnean Society,* 105: 435-445.

Bream, A. S.; Amer, M. S.; Haggag, A. A. and Mohammed, M. A. (2017): Valuation of water pollution using enzymatic biomarkers in aquatic insects as bioindicators from El-Mansouriya stream, Dakahlia, Egypt. *International Journal of Advanced Research Biological Science*, 4(3): 1-15.

Bream, A. S.; El-Surtasi, E. I.; Mohammed, M. A. and Hamza, Y. I. (2019): Industrial pollution evaluation through enzymatic biomarkers at different localities of El-Sadat Industrial City, Menofia, Egypt. *Egyptian Academic Journal of Biological Sciences (A. Entomology)*, 12(3): 31-48.

De Bivort, B.L.; Clouse, R.M. and Giribet, G. (2010): A morphometrics-based phylogeny of the temperate Gondwanan mite harvestmen (Opiliones, Cyphophthalmi, Pettalidae). *Journal of Zoology and Systematic Evolution Research,* 48(4): 294-309.

Drake, N. A.; Blench, R. M.; Armitagec, S.; Bristol, C. and White, K. (2011): Ancient watercourses and biogeography of the Sahara explain the peopling of the desert. *National Academy of Sciences of USA*, 108(2): 458-462.

El Hawagry, M. and Gilbert, F. (2014): Zoogeographical affinities and faunal relationships of bee flies (Diptera: Bombyliidae) in Egypt. *Zoology in the Middle East,* 60: 50-56.

El-Shewy, D.A.; Salem, M.M. and Elmetwally, N. E. (2016): Checklist of the Family Tenebrionidae (Coleoptera) In Egypt. *Egyptian Journal Agriculture Research,* 94: 39–56

Ghahari, H.; Bunalski, M.; Havaskary M. and Ostavan H. (2010a): Contributions to the knowledge the darkling beetles (Coleoptera: Tenebrionidae) of Arasbaran, Northwestern Iran. *Polish Journal of Entomology,* 79(4), 463-468.

Ghahari, H.; Bunalski, M.; Tableari, M. and Ostavan H. (2010b): Contribution to the knowledge of darkling beetles (Coleoptera: Tenebrionidae) from Iranian rice fields and surrounding grasslands. *Polish Journal of Entomology,* 79: 81-90.

Grobler, G. C.; Janse van Rensburg, L.; Bastos, D.S.; Chimimba, C.T. and Chown, S.L. (2006): Molecular and morphometric assessment of the taxonomic status of *Ectemnorhinus weevil* species (Coleoptera: Curculionidae, Entiminae) from the sub-Antarctic Prince Edward Islands. *Journal of Zoology and Systematic Evolution Research,* 44 (3): 200-211.

Haggag, A. A.; Mahmoud, M. A.; Bream, A. S. and Moner, S. A. (2018): Family variation of aquatic insects and water properties to assess freshwater quality in El-Mansouriya stream, Egypt. *African Entomology,* 26:162-173.

Hassan, M. I.; Bream, A. S.; El-Shewy, D. A. and Riad, S. A. (2017a): Variation of morphometric traits within populations of Ground beetles *Anthia sexmaculata* (Coleoptera: Carabidae) located in different ecogeographical regions in Egypt. *Journal of the Egyptian Society of Parasitology,* 47(3): 673– 680. DOI: 10.12816/0049796

Hassan, M. I.; Bream, A. S.; Younes, M. I.; El-Shewy, D. A.; Khalifa M. A. and Riad, S. A. (2017b): Morphometric Comparison Between Western, Eastern Deserts and Sinai Populations of *Mesostena angustata* (Coleoptera: Tenebrionidae) in Egypt. *Egyptian Journal of Zoology,* 67: 51-66. DOI: 10.12816/003-7794

Hassan, M. I.; Mohamed, A. F.; Amer, M. A.; Hammad, K. M. and Riad, S. A. (2015): Monitoring of the antiviral potential of bee venom and wax extracts against Adeno-7 (DNA) and Rift Valley fever virus (RNA) viruses' models. *Journal of the Egyptian Society of Parasitology,* 45(1): 195 -200. DOI: 10.12816/0010865

Janse van Rensburg, L.; Chimimba, C. T.; Bastos, A. D. (2003): Morphometric measurement selection: an invertebrate case study based on weevils from sub-Antarctic Marion Island. *Polar Biology,* 27: 38-49.

Klingenberg, C.P and Marugán-Lobón, J. (2013): Evolutionary covariation in geometric morphometric data: analyzing integration, modularity, and allometry in a phylogenetic context. *Systematic Biology*, 62: 591-610.

Larsen, T. B. (1991): The Butterflies of Egypt. Apollo Books, Svendborg, Denmark.

Levesque, R. (2011): Programming and Data Management for IBM SPSS Statistics 20: a Guide for IBM SPSS Statistics and SAS Users. SPSS Inc, Chicago, Illinois, USA.

Löbl, I. and Smetana, A. (2008): Catalogue of Palaearctic Coleoptera: Tenebrionoidea. Apollo Books, Svendborg, Denmark.

Mahmoud M. A. and Riad, S. A. (2020): Ecological studies on some aquatic insects in the Damietta branch, River Nile of Egypt as bioindicators of pollution. *Egyptian Journal of Aquatic Biology & Fisheries,* 24(4): 57 – 76

Mahmoud, M. A., Riad, S. A and El Surtasi, E. I. (2022): Spatial Morphometric and Biochemical Variation within Populations of *Scelosodis castaneus castaneus* (Coleoptera: Tenebrionidae) from Different Eco-geographical Regions in Egypt. *Catrina,* 25(1): 83-91

Mamuris, Z.; Apostolidis, A.P.; Panagiotaki, P.; Theodorou A. J. and Triantaphyllidis, C. (1998): Morphological variation between red mullet populations in Greece. *Journal of Fish Biology,* 52: 107-117.

Navia, D.; Ferreira, C.B.; Reis, A.C. and Gondim, M.G. (2015): Traditional and geometric morphometrics supporting the differentiation of two new *Retracrus* (Phytoptidae) species associated with heliconias. *Experimental Applied Acarology,* 67: 87-121.

Nyári, A. S.; Townsend Peterson, A. and Rathbun, G. B. (2010): Late Pleistocene potential distribution of the North African sengi or elephant-shrew *Elephantulus rozeti* (Mammalia: Macroscelidea). *African Zoology,* 45(2): 330-339.

Ober, K. A. and Connolly, C. T. (2015): Geometric morphometric and phylogenetic analyses of Arizona Sky Island populations of *Scaphinotus petersi* Roeschke (Coleoptera: Carabidae). *Zoological Journal of the Linnean Society,* 175: 107-118.

Riad, S. A (2022a): Ectoparasites Associated with Desert Raven Corvus ruficollis, Lesson, 1831 at the Eastern Desert, Red Sea, Egypt. *Egyptian Academic Journal of Biological Science (A. Entomology),* 15(4):13-21. DOI: 10.21608/EAJBSA. 2022.265488

Riad, S. A. (2019): Morphometric comparison between different isolated populations of *Ocnera sparsispina* (Coleoptera: Tenebrionidae) in Egypt. *Egyptian Academic Journal of Biological Sciences (A. Entomology),* 12(1): 89-99.

Riad, S. A. (2020): Quantity of Spring Migration of Migratory Soaring Birds Over the Eastern Desert of Egypt. *Egyptian Academic Journal of Biological Sciences, B. Zoology*, 12(2), pp, 161-171. 10.21608/EAJBSZ.2020.129646

Riad, S. A. (2022b): Ectoparasites Associated with Migratory Birds, Eastern Desert, Red Sea, Egypt. *Egyptian Academic Journal of Biological Sciences, B. Zoology*, 14(2), pp. 19-33. doi: 10.21608/eajbsz.2022.249312

Riad, S. A.; Al-Mongy, M. and Abdel-Halim, E. I. (2019): Movement patterns of the black kite (*Milvus migrans*) during spring migration over Rift Valley/Red Sea Flyway, Gulf of Suez, Egypt. *Egyptian Academic Journal of Biological Sciences (B. Biology)*, 11(3): 129-139.

Steyskal, G. C. and El-Bialy, S. (1967): A list of Egyptian Diptera with a bibliography and key to families, *Ministry of Agriculture Technical Bulletin*, 3: 12-18.

Wanek, K. A. and Sturmbauer, C. (2015): Form, function and phylogeny: comparative morphometrics of Lake Tanganyika's cichlid tribe Tropheini. *Zoologica Scripta*, 44 (4): 362-373. DOI: 10.1111/zsc.12110.

ARABIC SUMMARY

التباين المورفولوجي بين مجموعات الخنافس الداكنة PIMELIA CARINATA SOLIER، 1836 (غمدية الأجنحة: TENEBRIONIDAE) التي تعيش في مناطق مختلفة في مصر

صابر عبد المنعم رياض
قسم علم الحيوان، كلية العلوم، جامعة الأزهر، القاهرة، جمهورية مصر العربية

معظم الحيوانات حقيقية النواة المصنفة في العالم حشرات. ومع ذلك، فإن دراسة القياسات المورفومترية والانعزال واختلاف الموائل لا تزال قليلة جدًا بالنسبة للحشرات، خاصة الحشرات الصحراوية. هدفت هذه الدراسة إلى مقارنة قياسات الصفات المورفولوجية لعشائر *Pimelia carinata* المتباينة كنموذج للخنافس الداكنة في صحراء مصر. تم إجراء مقارنة المتغيرات المورفومترية بواسطة المجهر الميكرو متري لعينات ستة مناطق بيئية من مصر بما في ذلك؛ الصحراء الساحلية الغربية، منخفض الفيوم، واحات الصحراء الغربية، الصحراء الشرقية، الدلتا، وجنوب سيناء. تعتمد القياسات المورفولوجية على 21 صفة تمت دراستها، وذلك باستخدام التحليل العنقودي وتحليل المكونات الرئيسية لتمييز السمات المختلفة للعشائر. تم تسجيل درجتي التمييز الأولى والثانية (1 و2) بنسبة 77.64% و24.61% من التباين الكامل في العينات المختلفة. كشفت التحليلات التمييزية المتعددة عن اختلافات ظاهرية واضحة بين عشائر واحات الصحراء الغربية والصحراء الساحلية الغربية في المجموعة الأولى. بينما تضم المجموعة الثانية عشائر الصحراء الشرقية ومنخفض الفيوم ودلتا النيل. عشائر جنوب سيناء موجودون في مجموعة منفصلة. وكانت السمات التي تظهر أقصى قدر من التباين بين مجموعات الخنافس المرتبطة بالتقديرات المورفولوجية