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Spatial Morphometric and Biochemical Variation within Populations of *Scelosodis castaneus* castaneus (Coleoptera: Tenebrionidae) from Different Eco-geographical Regions in Egypt

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ABSTRACT

Spatial variation in morphological traits associated with biochemical changes as a result of habitat isolation is still a lacking study for most Egyptian insect groups especially darkling beetles. The study of spatial variation in adaptation of morphometric and biochemical traits is the current aim. Therefore, the different populations of *Scelosodis castaneus* castaneus were sampled at thirteen sites belonged to four different Egyptian ecoregions in their nature: South Sinai, Nile Delta, the western desert Oases and the western Mediterranean coastal desert. Twenty-one morphometric measurements were taken by a threaded micrometer in addition to the assessment of whole body metabolites. Results showed a spatial significant variation within morphometric traits between different populations; where the morphometric trait in South Sinai was clear different than others, followed by, the population of the Nile Delta, the clade of the western desert Oases and the Mediterranean coastal desert. According to Canonical Correspondence Analysis, the total amount of protein and carbs in their food was significantly correlated with the diversity in biochemical features. The closer population was between the western desert Oases and Nile Delta regions. Finally, spatial variation in habitat nature has an important role in adaptive morphometric and biochemical traits for the same species.

Keywords: Darkling beetles; Egyptian Coleoptera; Morphometric; Spatial variation; Tenebrionidae.

INTRODUCTION

Egypt's unique location and the diversity of environments have still continued to pique the interest of naturalists, as it is linked to both Palaearctic and Afrotropical regions. It has commonly been considered to be spatially related to the Palaearctic, but there is an evidence that the Afrotropical component is a more noteworthy part than is commonly believed, especially in the southeast (Gebel Elba). In light of this all, the Egyptian fauna is one of the more unique species of wildlife in the world (Steyskal, 1967).

Egypt's environment is described as being warm and almost rainless because it is a part of the Great Desert Belt. According to an Egyptian Environmental Affairs Agency (EEAA) report, the northern Coastal Strip, Gebel Elba, the Eastern Desert, and higher piles of the southern Sinai mountains receive relatively higher precipitation, with a long-term average of about 200 mm per year at the top of the Gebel Elba Mountain. This is reflected in their organization of greenery. As a result, Egypt is divided into eight distinct eco-topographical regions: the Coastal Strip, Lower Nile Valley, Delta, and Upper Nile Valley, El Faiyum Depression, the Eastern and Western Desert, Gebel Elba, and Sinai (Larsen, 1991, El-Hawagry and Gilbert, 2014).

In Egypt, the majority of insect groups had their morphological characteristics evaluated and the consequences of different nesting spaces examined, but the Coleoptera, the group of insects with the greatest number of species, had neither of these studies (Riad, 2019; Riad and Mahmoud, 2020). Tenebrionidae is probably the biggest group of requested Coleoptera in the desert habitat, with over 20.000 known species and nearly 2307 genera of overall conveyance (Booth *et al.*, 1990; Löbl and Smetana, 2008; Riad and Mahmoud, 2020). In spite of the fact that among all groups of beetles, Tenebrionidae (darkling beetles) ranks 7th in terms of species diversity, due to the degree of the scarcity of knowledge regarding the phylogeny and systematics of the group, its monophyly has been addressed, as well as those of the subfamilies and tribes that belong to it (Condamine *et al.*, 2011; Riad and Mahmoud, 2020).

Scelosodis castaneus castaneus (Eschscholtz, 1831) (Coleoptera: Tenebrionidae) is a common dark darkling scarab found in Sahara of the Middle East and northern Africa (Iwan and Löbl 2020). Tentyriini transformation to extremely arid environments and desert conditions permits getting by and creation in the rises, morphological variations including lipid layer, epicuticle, intertwined sclerites, and subelyteral cavity, these morphological transformations make it a genuine instance of concentrating on detached regions and the impact of isolation (Pierre, 1958).

Morphometry has been one of the first techniques utilized in quite a while for finding biodiversity and settling phylogenies (Klingenberg and Marugan-Lobon 2013; Wanek and Sturmbauer 2015). Morphometric estimations are generally utilized in the integrative way to deal with systematics alongside molecular data which might bring about taxonomical modification (Grobler *et al.*, 2006; Ober and Connolly 2015). Quite possibly, the main question is which morphological traits ought to be picked for examination. The excess of utilized traits can prompt unsettling influence of got results to determine phylogeny dependent on morphological variety. Linear Discriminant Analysis (LDA) is perhaps the most well-known techniques for finding appropriate measurements (Van Rensburg *et al.*, 2003). Morphometric estimations might be exceptionally useful in establishing phylogeny, particularly of species that are difficult to recognize because of few or even no indicative traits (De Bivort *et al.*, 2010 and Navia *et al*., 2015).

On the other hand, all animals acquire the multiple supplements necessary for development, upkeep, and

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multiplication by eating. Proteins, lipids, and carbohydrates are especially significant dietary supplements (Behmer, 2009; Simpson and Raubenheimer, 2012). Despite the fact that they have the same caloric value, according to an animal's point of view they are practically totally different. Dietary proteins give the amino acids expected to fabricate new tissues, enzymes, and proteins, while carbohydrates and lipids are generally utilized as the key energy source expected to fuel this biosynthesis. Hence, any change in these levels reflects the nutritional content of these regions from which these animals are taken. The current study objectives are to clarify any potential sub-specific variations in the various eco-geographical populations of *S. castaneus* in Egypt by using both cluster and Linear Discriminant Analysis (LDA) and contrasting the varied biochemical compositions of populations.

MATERIALS AND METHODS

Study area and sampling

In thirteen distinct Egyptian regions, the survey was carried out between May 2019 and May 2020. (Table 1). Pitfall traps were implemented to sample the *S. castaneus* populations in the study areas. Each collecting site was selected from three distinct locations. The distribution of traps and the collection of sample data were planned in accordance with Hassan *et al*. (2017a). Following sample confirmation by the Department of Insect Classification and Survey, Plant Protection Research Institute, Dokki, Giza, the specimens were identified using keys provided by Löbl and Smetana (2008). The collected specimens have been deposited at Al-Azhar University Zoological Collection (AUZC), Faculty of Science, Al Azhar University, Cairo, Egypt. The geographical location and altitude of each location were recorded using a Garmin eTrex 30 GPS, the map of study area was designed with ArcGIS 10.2 software program. The study area (Fig. 1) was categorized into four different eco-geographical regions from which samples were collected (Table 1).

Specimen Measured parameters

The analyses of morphometric measurements were carried on all 241 adult samples of *S. castaneus*. For each sample, an eyepiece micrometer was used to measure seventeen absolute morphometric traits and four absolute ratios, all measurements were recorded. The following measurements were made: antenna length (AL), which is the length of the flagellum and pedicel combined; and head length (HL), which is measured dorsally from the front clypeal margin of the head to the margin of the occipital constriction; pronotum length (PL), taken dorsally from the front to the posterior border at the scutellar shield, and head width (HW), measured as the maximum width of the head across the eyes. Meanwhile, pronotum width (PW), the maximum width of the pronotum, was taken perpendicular to the length of the pronotum. Among the measured parameters were the length of the elytra (EL), as the distance between the anterior apex of the scutellum and the posterior border of the elytra along the midline. Elytra widths (EW) were also taken as well as the maximum width of the elytra; body Length (BL), the sum of head length including pronotum length and elytra length. Fore femur length (FF); fore tibia length; fore tarsus length (FTa); the length of the meso femur (MF); the length of (MT and MTa), the meso tibia and tarsus, respectively, were measured. The length of the meta femur (MeF); the Meta Tibia (MeT); and the Meta Tarsus (MeTa) were also included.

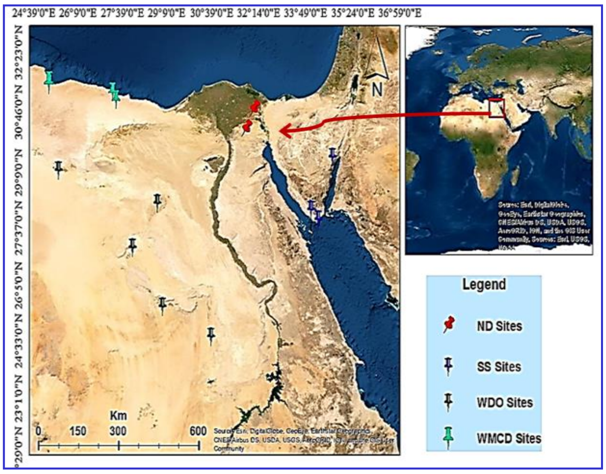

Figure (1): A map displaying the location of *S. castaneus* based on different eco-geographical regions in Egypt. The specimens were collected from the Western Mediterranean Coastal Desert (WMCD), Western Desert Oases (WDO), Nile Delta (ND), and South Sinai (SS).

Biochemical studies

Sample preparation

To ensure consistency in the analytical conditions, all samples submitted for biochemical analysis were collected at the same time and they were then processed as follows: the mature *S. castaneus* castaneus was weighed in entirety before being homogenised in a saline solution (1 gm. of insect tissue per 1 ml of 0.7 % saline solution) using electric homogenizer. The homogenization process was conducted for two minutes, after which the homogenates were centrifuged at 4000 rpm for fifteen minutes. The supernatant was either used directly or frozen to be used for determination of nutrient contents.

Total protein content

The estimation of the quantitative content of the full protein (mg/g) was done in the whole body of adult *S. castaneus* castaneus homogenate according to the way of Weichselbaum (1946) and using the Bio-diagnostics kit. This method is based on forming a violet complex protein with copper ions in an alkaline medium, and then measured the absorbance by a spectrophotometer at 550 nanometers.

Total carbohydrate content

A quantification of the total carbohydrate content (mg/g) was performed for the whole body of adult *S. castaneus* castaneus homogenate via an anthrone reagent using spectrophotometer at wavelength of 620 nm following the method of Singh and Sinha (1977).

Table (1): The samples were collected from a variety of topographic areas within the study area. *S. castaneus* specimens were taken between May 2019 and May 2020. The global positioning system (GPS) coordinates and museum code were recorded.

Study area	Topographic regions	GPS Coordinations		Specimen Gender		Total	Museum listed Code
		Latitude	Longitude	F	M		
Bagush, North Coast Matruh	Western Mediterranean Coastal Desert	31.10422 N	27.41474 E	20	8	28	IC02210 – IC2237
Mersa Matruh, Matruh		31.30902 N	27.29444 E	16	6	22	IC02238 -IC02260
Sallum Plateau, Matruh		31.55774 N	25.15871 E	17	8	25	IC02261- IC02282
Siwa Oasis	Western Desert Oases	29.18073 N	25.47638 E	9	4	13	IC02283 -IC02295
Bahariya Oasis		28.27596 N	28.80067 E	7	3	10	IC02296 -IC02306
Farafra Oasis		27.07763 N	27.97546 E	6	3	9	IC02307 -IC02316
Dakhla Oasis		25.49454 N	28.97892 E	9	4	13	IC02317 -IC02330
KhargaOasis		24.67444 N	30.60799 E	8	4	12	IC02331 -IC02343
10th of Ramadan City	Nile Delta,	30.32248 N	31.78177 E	18	6	24	IC02344 -IC02368
El Salhiya, Sharquiya		30.85409 N	32.06419 E	21	10	31	IC02369 -IC02400
Sharm El Sheikh, South Sinai	South Sinai	27.84990 N	34.22448 E	10	7	17	IC02401 -IC02417
Taba, South Sinai		29.53391 N	34.70312 E	12	7	19	IC02418 -IC02437
Saint Katherine, Sinai		27.84990 N	34.22448 E	10	8	18	IC02438 -IC02456

IC, Insect Coleoptera; F, Female number; M, Male number.

Total lipid content

Determining the quantitative amount of the full lipid content (mg/g) was carried out in the whole body of adult *S. castaneus* castaneus homogenate following the method of Folch *et al*. (1957) and the estimation of lipid was carried out by phosphovanillin reagent depending on Knight *et al.* (1972) by using the spectrophotometer with a wavelength of 520 nm.

Statistical Analysis

The differences in each morphometric measured parameters were distributed normally and analysed using Statistical Package for Social Sciences "SPSS program" computer software package, version (20) according to Muenchen (2009). Linear discriminant analysis (LDA) and Canonical correspondence analysis (CCA) were conducted in NCSS11 statistical software and CANOCO 4.5 package (2003), respectively. For comparative analysis Tukey's range test, at $p \leq 0.05$, was performed.

RESULTS

Morphometric traits of different populations

A comparison of *S. castaneus* populations, collected from four different eco-geographical areas, based on 17 absolute morphometric characters and 4 ratio parameters was undertaken and clarified in Table (2). These measured parameters showed significant differences among the four studied populations. The Western Desert populations were ranked highest for one ratio, EL/PL, and one absolute value, PW. Conversely, the South Sinai inhabitants were ranked the highest for HW/HL, EW/EL, and two absolute values, AL and EW (Table 2). Regarding to the head length, South Sinai populations had mean values of 1.05 mm ±0.12. However, the pronotum width of the Western Desert population had mean values of 3.15 mm ±0.12; this difference was statistically significant ($p \leq 0.05$). South Sinai population had the highest ratios of head width to head length and pronotum width to pronotum length, whereas the Western Desert population had the highest ratio of elytron length to pronotum length (Table 2).

Spatial variation in morphometric traits

Spatial variation in morphomic traits among different populations was evaluated by cluster and discriminant analysis. Comparing all morphological characters of *S. castaneus*, using cluster analysis showed that the four sampled populations were differentiated into two discrete groups (Fig. 2). The first cluster represented South Sinai (SS) population only. The second cluster contained other populations at Nile Delta (ND), Western Mediterranean Coastal Desert (WMCD) and Western Desert Oases regions (WDO). On the other hand, discriminant analysis was carried out using 21 variables and revealed important intergroup factors. This analysis clarified about 79.7% and 20.3% of morphometric variation in total samples throughout both discriminant scores; first and second ones, respectively.

Based on Linear Discriminant Analysis, a clear similarity was recorded between the two populations of WMCD and other one of WDO with ND (Fig. 3). Meanwhile, these specimens distinctly separated from South Sinai specimens and appeared as a distinct group different from all other populations. Some morphometric traits shared in these variations include an increase in the ratios of head width to head length (HW/HL) and elytron width to elytron length (EW/EL), as well as longer antenna, pronotum, foretarsus, and metatarsus with broader elytron. The ratio of elytron length to pronotum length, as well as minor features like head length and elytron length, changed, were also present. These traits all served as the most significant markers for differentiation between the *S. castaneus* population in the South Sinai region and those nearby.

Spatial variation in whole body metabolites

Biochemical analysis of whole body metabolites shows a spatial variation between the different ecogeographical regions (Table 3). The discrepancy in the levels of protein, lipid and carbohydrates were significantly shown between populations of *S. castaneus* at different regions. Populations of Western Desert Oases and Nile Delta had higher level contents rather than Western Mediterranean Coastal Desert and South Sinai regions. Meanwhile, Figure (4) illustrates the spatial variance in the morphological traits and biochemical investigations among the *S. castaneus* population collected at various eco-geographical zones. Canonical Correspondence Analysis (CCA) revealed the variation of the four regions along both axes (1 and 2), elucidating the location of *S. castaneus* (Coleoptera: Tenebrionidae) in South Sinai along the right direction of axis (1) and negatively correlating with the rising content of total protein and carbohydrates in its whole body metabolites. Others, in contrast, were on the axis' left side (1). Axis (2) divided the Western Mediterranean Coastal Desert, which was on the upper left of this axis, from the other two regions, which were the Western Desert Oases and the Nile Delta. The latter was more positively correlated with the rise in the total content of protein and carbohydrates in their whole body metabolites taken (Fig. 4).

DISCUSSION

Morphometric data set has become one of an important tool in linking geographically separated populations and exerting a role in the discovery of species variations that have recently been discovered (Mamouris et al., 1998). This study tried to reduce additional variants in this type of data by standardizing the size, transforming the data and by performing separate Linear Discriminant Analysis.

With regard to the various eco-geographical zones, including WDO, ND, SS, and WMCD, the populations under study showed a wide variety of morphometric variations. Meanwhile, no significant difference was recorded within sub-regions; as within the WDO, the Siwa, Farafra, Bahariya, and Kharga populations were the most similar.

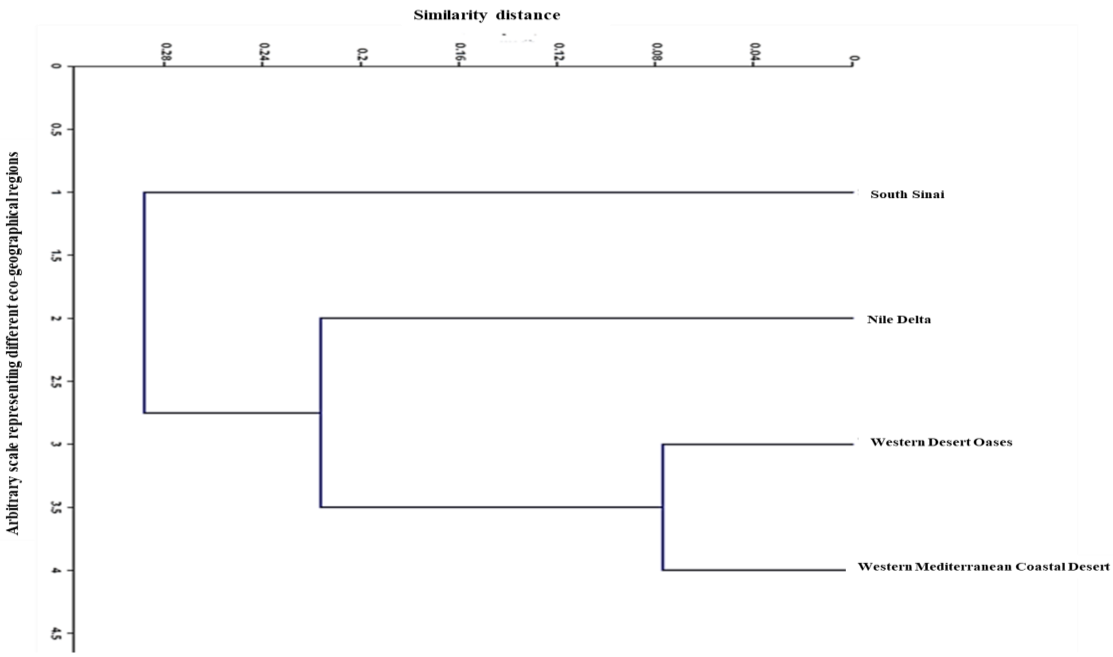

Figure (2): A dendrogram illustrating the spatial variation of *S. castaneus* populations in the chosen eco-geographical regions: Western Mediterranean Coastal Desert, Western Desert Oases, Nile Delta, and South Sinai based on the morphological measured parameters.

Table (2): The morphological trait measured parameters for *S. castaneus* specimens collected from various topographic areas in Egypt. Data are presented in mean ±SE. Different sample size were collected based on the proportions of the existing populations

Measured parameters (mm)	Topographic studied region			
	Western Mediterranean Coastal Desert	Western Desert Oases	Nile Delta	South Sinai
	Sample size			
	n =70	n =57	n =55	n =54
TL	8.834 ±0.07 [a]	8.833 ±0.06 [a]	8.830±0.07 [a]	8.83 ±0.07 [a]
AL	2.730 ±0.07 [a]	2.673 ±0.11 [b]	2.632±0.07 [c]	2.73 ±0.07 [a]
HL	1.211 ±0.07 [a]	1.198 ±0.09 [a]	1.21 ±0.07 [a]	1.05 ±0.12 [b]
HW	1.880 ±0.09 [a]	1.874 ±0.08 [a]	1.876±0.09 [a]	1.88 ±0.09 [a]
PL	2.051 ±0.10 [b]	2.051 ±0.10 [b]	2.14±0.09 [a]	2.14 ±0.09 [a]
PW	3.253 ±0.10 [a]	3.150 ±0.12 [b]	3.077 ±0.07 [c]	3.25 ±0.09 [a]
EL	5.62 ±0.08 [a]	5.61 ±0.10 [a]	5.62 ±0.08 [a]	5.52 ±0.11 [b]
EW	3.630 ±0.07 [a]	3.582 ±0.08 [a]	3.531±0.06 [b]	3.63 ±0.07 [a]
FF	1.332±0.07 [b]	1.321 ±0.08 [b]	1.412 ±0.08 [a]	1.41 ±0.08 [a]
FT	1.031±0.07 [a]	1.031 ±0.06 [a]	1.031 ±0.07 [a]	1.03 ±0.07 [a]
Fta	0.622±0.03 [a]	0.621 ±0.03 [a]	0.611 ±0.03 [a]	0.61 ±0.03 [a]
MF	2.031±0.07 [a]	2.031 ±0.06 [a]	2.031 ±0.07 [a]	2.03 ±0.07 [a]
MT	1.221±0.08 [a]	1.222 ±0.07 [a]	1.221 ±0.08 [a]	1.22 ±0.08 [a]
Mta	1.330±0.07 [a]	1.330 ±0.06 [a]	1.330±0.07 [a]	1.33 ±0.07 [a]
MeF	2.031±0.07 [a]	2.031 ±0.06 [a]	2.031±0.07 [a]	2.03 ±0.07 [a]
MeT	2.031±0.07 [a]	2.031 ±0.06 [a]	2.030±0.07 [a]	2.03 ±0.07 [a]
MeTa	1.840±0.07 [a]	1.840 ±0.07 [a]	1.840±0.07 [a]	1.84 ±0.07 [a]
HW/HL	1.566 ±0.07 [b]	1.587 ±0.12 [b]	1.554 ±0.07 [c]	1.797 ±0.17 [a]
PW/PL	1.591 ±0.03 [a]	1.541 ±0.05 [a]	1.430±0.04 [c]	1.511 ±0.02 [b]
EW/EL	0.648±0.01 [b]	0.644 ±0.01 [b]	0.631 ±0.01 [bc]	0.667 ±0.01 [a]
EL/PL	2.753 ±0.10 [a]	2.735 ±0.10 [a]	2.621 ±0.08 [bc]	2.581±0.09 [c]

Data with different letters, per column, are significantly different at $p \leq 0.05$ or $p \leq 0.01$ level based on Tuckey's-b test. TL, total length; AL, antenna length; HL, head length; HW, head width; PL, pronotum length; PW, pronotum width; EL, elytron length; EW, elytron width; FF, forefemur length; FT, foretibia length; FTa, foretarsus length; MF, mesofemur length; MT, mesotibia length; MTa, mesotarsus length; MeF, metafemur length; MeT, metatibia length; MeTa, metatarsus length; HW/HL, head width/head length; PW/PL, pronotum width/pronotum length; EW/EL, elytron width/elytron length and EL/PL, elytron length/pronotum length.

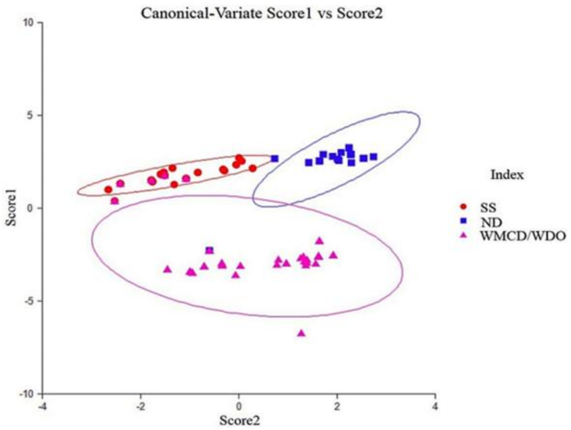

Figure (3): Principle component analysis of the morphological measurements of the four *S. castaneus* populations

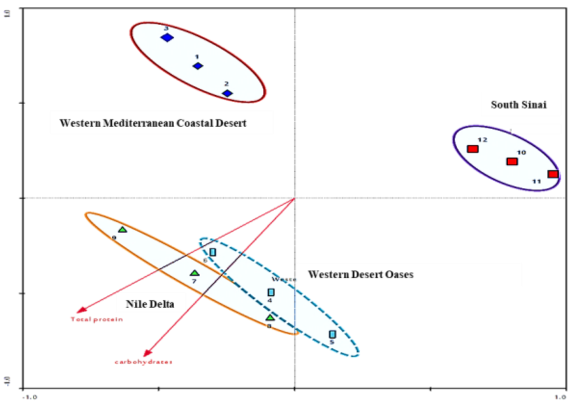

Figure (4): Ordination diagram of Canonical Correspondence Analysis (CCA) explain the correlation between spatial variation of the comm-unities with the habit of food contents of *Scelosodis castaneus* (Coleoptera: Tenebrionidae) at different eco-geographical regions

Additionally, the populations of the Sallum Plateau, Mersa Matruh, and WMCD were roughly equal. This also includes sites in the ND and those investigated in the SS region. This assertion is confirmed not only by cluster analysis but also by linear discriminant analysis. Meanwhile, wetlands and lakes of the Ismuth of Suez (which is currently spanned by the Suez Canal) extended severely with evolved broad marshland conditions blocking this doorway to Africa in early geological time. Additionally, Derricourt (2005) and Bailey *et al.*, (2007) made clear the significance of the Nile River and its constrained floodplain in the present, which act as a physical barrier between Egypt's Western and Eastern Deserts, impeding the distribution of desert animals. The Gulf of Suez, with its shallow profile appears to have remained an open basin throughout much of the Pleistocene, and until around 14,000–15,000 years ago, when sea levels surged over 50 meters, linking the Sinai Peninsula to the Eastern Desert After that, the Gulf of Suez was reduced in size during drier Pleistocene period. The Sinai Peninsula was easily accessible from the Eastern Desert, resulting in the two areas forming a single, mostly continuous desert zone (Riad, 2019; Riad and Mahmoud 2020). That all explained the differentiation of studied populations throughout different eco-geographical regions in the current study.

Although there have been other influences on different species, eco-geographical borders account for the majority of the variation in species traits. Seeking protection in regions with more consistent weather is one of these motivations. The Carabidae and Teneb-rionidae are two examples of the many animal and plant species and populations that are compelled to seek refuge for protection in places other than their natural habitats, or refugia. The Carabidae and Tenebrionidae are two examples of the many animal and plant species and populations that are compelled to seek refuge for protection in places other than their natural habitats, or refugia. On the contrary hand, all unique *Scelosodis* species share comparable ecological niches, which may lead to similar environmental adap-tations. Because of this, it's possible that some elements of morphology merely reflect adaptation to the shared environment rather than phylogeny (Hassan *et al.*, 2017, Riad and Mahmoud, 2020). In addition, it appears that the Saharan desert's geographical and temporal expansion and contraction was a significant driver of processes leading to speciation and faunal diversification. The borders bet-ween the desert, other ecosystems, and the related biodiversity were continuously modified by palaeo-climatic cycles (Dumont 1982; Le Houérou 1997; Drake *et al.*, 2011). Moreover, the key driver of post-Pleistocene allopatry diversification was the relation-ship between variance occurences and Saharan aridity episodes (Douady *et al.*, 2003; Nyári *et al.*, 2010; Riad 2020). These circumstances are therefore thought to have led to allopatric isolation, which disrupted gene flow and caused the emergence of distinct lineages or new species. On the other hand, depending on the needs of the taxon's environment, different animal taxa will react differently to Saharan vicariates events. Desert-adapted species are reduced to the remaining arid core of the Sahara or parts of desert habitat, much as they are during humid periods. They are anticipated to experience morphological and genetic allopatric diversity in isolation (Boratynski *et al.*, 2012). Meanwhile, the isolated populations of desert-adapted species will expand their ranges, possibly merging the altered meta-populations into larger populations during a subsequent arid episode. A uniform population with unfettered gene flow will develop from genetic mixing if the prior allopatric divergence was insufficient to cause reproductive isolation (Riad, 2019; Riad and Mahmoud, 2020). By acting as ecological refugia for several species and facilitating gene flow in favourable climatic circumstances, depressions throughout Desert oasis had a significant part in the pattern of diversi-fication across the Sahara.

The biochemical contents of food diet in *S. castaneus* highlighted a significant variation between different eco-geographical regions. The more similar food contents were reported between WDO and Nile Delta, but the Western Mediterranean Coastal Desert and South Sinai regions do. Increasing in total protein and

Table (3): Spatial variation in the content of total protein, lipid, and carbohydrates (mg/ml) in *Scelosodis castaneus* (Coleoptera: Tenebrionidae) at the different eco-geographical regions. Data are in mean ± SD.

Biochemical parameters (mg/ml)	Topographic studied regions			
	Western Mediterranean Coastal Desert	Western Desert Oases	Nile Delta	South Sinai
Total Protein content	53.5 ±2.5 [b]	64.8 ±1.5 [a]	68.5 ±2.5 [a]	39.5 ±2.5 [c]
Total Lipid content	38.7 ±4.3 [b]	86.5 ±1.0 [a]	82.5 ±1.1 [a]	29.0 ±1.6 [c]
Total Carbohydrate content	41.7 ±3.5 [b]	75.5 ±3.3 [a]	78.4 ±2.4 [a]	32.8 ±1.5 [c]

Different superscript letters per raw are highly significantly different among different studied eco-geographical regions based on Tukey's range test (Tukey's tested post hoc tests created by one-way ANOVA) at $p \leq 0.05$.

carbohydrates was towards species populations in Nile Delta and Western Desert Oases as analyzed by CCA analysis. On the contrary, South Sinai regions followed by Mediterranean Coastal Desert had the lowest food content. As accordance withfood habit in herbivores, these seek out and consume meals that contain the greatest combination of proteins and carbohydrates in a high concentration. As known, the protein and carbohydrate composition of all diets varies, but the variance in these two nutrients in plants is considerably larger than in animals (Schoonhoven *et al*., 2005; Clissold *et al*., 2009; Behmer and Joern 2012). Protein and carbohydrate diversity may be seen at several levels, including across species (Yeoh *et al*., 1992), within species (Sattelmacher *et al*., 1994), and within an individual plant (Mattson, 1980), depending on the kind of tissue (stems, leaves, flowers, and seeds) and age (young versus old leaves). Furthermore, environmental variables such as the quantity of light a plant receives, the chemical makeup of the soil, and water inputs might affect its protein and carbohydrate content (Felton 1996; Walter et al., 2012).

In comparison to the South Sinai regions and the Mediterranean Coastal Desert, the *Scelosodis castaneus* population was higher in the Nile Delta and Western Desert Oases, which are distinguished by their abundance of nutrients rather than their drier environments. In light of this, *Scelosodis castaneus'* adaptive eating behaviour with the environment is compatible with our findings.

CONCLUSION

Distinguishing between different desert beetle species in diverse spatial eco-geographical zones can be facilitated by studying both morphological traits and biological variations. Populations of the same species living in several geographic areas develop adaptive features, such as morphological or dietary preferences, to survive in their environment. Therefore, it can be conclude that the *Scelosodis castaneus* population in South Sinai is considerably distinct from other populations in Egypt in terms of morphology and biochemical characterization. To support the findings of the current study, additional research on *S. castaneus* phylogeny is required.

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التباين في الصفات المورفوميترية والمحتوي الأيضي لمجتمعات السيلوسوديس كاستانوس (الخنافس الداكنة) في مناطق جغرافية مختلفة داخل مصر

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الملخص العربـــــي

يعتبر تغير المناخ من المواضيع الهامة التي يمر بها العالم اجمع. وتتأثر الكائنات الحية بتغير المناخ ومن ضمنها الحشرات. لا يزال الاحتياج الملح لدراسة مدى ارتباط الصفات المورفولوجية والتغيرات في المحتوي الحيوي الأيضي للحشرا ت بانعزال البيئات عن بعضها داخل مصر أمرا ضروريا، وخصوصا الخنافس الداكنة, لذا كان الهدف الرئيسي من تلك الدراسة هو دراسة دور التباين المكاني في تكيف الصفات المورفولوجية بالإضافة إلي المحتوي الأيضي للخنافس الداكنة ، تم تجميع مجتمعات حشرة السيلوسوديس كاستانوس (الخنافس الداكنة) في ثلاثة عشر موقعا تنتمي الي أربع مناطق بيئية مختلفة داخل مصر, وهي جنوب سيناء، دلتا النيل، واحات الصحراء الغربية، والصحراء الساحلية الغربية للبحر المتوسط ، كما تم قياس احدي وعشرين صفة موفورمترية ، وتقييم المحتوي الأيضي لتلك المجتمعات ، وقد أبرزت النتائج مدى التباين المعنوي في الصفات المورفوميترية بين تلك المجتمعات المختلفة ، حيث تميزت مجتمعات جنوب سيناء باختلاف الصفات المورفوميترية ، يليها مجتمعات دلتا النيل ، بينما تقاربت تلك الصفات بين مجتمعات واحات الصحراء الغربية وصحراء الساحلية الغربية للبحر المتوسط ، كما أكدت تلك النتائج بالتباين في المحتوي الأيضي بين تلك المجتمعات نتيجة الاختلاف في محتوي البروتين والكربوهيدرات داخل محتواها الغذائي ، كما بينت النتائج مدى تقارب مجتمعات واحات الصحراء الغربية ودلتا النيل في المحتوى الأيضى، لتوضح تلك الدراسة أن انعزال البيئات له دورا هاما في تكييف السمات المورفوميترية والمحتوي الأيضي داخل نفس النوع فى مصر.