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Habitat heterogeneity, altitudinal gradients in relation to beetle diversity in South Sinai, Egypt

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ABSTRACT
Using pitfall traps, ground-dwelling beetles (Coleoptera) were sampled in a nested design from three different localities in the mountainous arid ecosystem of South Sinai at low, middle and high altitudes. Each locality was represented by three different 20x20-m sites, and each site had twenty individual traps distributed systematically. Habitat type and altitude were clearly different among the three localities and to a less extent within localities. Species diversity varied spatially and temporally among the different localities and sometimes within localities. Altitude was positively correlated with beetle species diversity, and habitat heterogeneity within a locality may also play a role in influencing species diversity. The different localities had distinct and characteristic groups of species responding to altitude and habitat characteristics.

KEYWORDS: Coleoptera, diversity, habitat heterogeneity, altitude, Sinai, Egypt.

INTRODUCTION

One of the ultimate aims of community ecology is to understand the processes that regulate the composition, structure and ultimately the diversity of communities. Such an aspiration, however, is dependent to a great extent on an adequate knowledge of variation in the abundance and distribution of the species assemblages of a particular community in space and time. It also depends on an ability to delimit the community itself and the spatial scale on which population dynamics are controlled. Beetle communities offer a very tractable study system, given their often clearly defined boundaries, restricted temporal activity period, and to a great extent well-studied taxonomy (Finn *et al*. 1999).

Understandably, most studies are on small spatial and temporal scales, necessitated by the intensive fieldwork associated either with monitoring programmes or field experimentation. For example, many studies are confined to a single plot or field and are conducted for a short time (10-30 days). They can suffer from a lack of replication within seasons, among seasons, and among years, as well as lacking replication in space. Similar studies at several sites that incorporate a measure of variation on a spatial scale are often temporal restricted or lacking in temporal replication (Finn *et al*. 1999).

One of the best places to study spatial variation is among sites that are semi-isolated from one another, even though being physically quite close. The high mountains of southern Sinai in Egypt contains systems of dry valleys called wadis that appear to be relatively isolated from one another by the intervening mountain ridges (Gilbert *et al.* 1996). The location of the peninsula of Sinai makes it one of the most characteristic of the Egyptian faunistic regions, and it contains very different geomorphological units. It lies at the confluence of three zoogeographic regions (Afrotropical, Palaearctic & Oriental), which makes its fauna and flora special. South Sinai contains a large high-mountain massif covering about 7000 km^2, with several Wadi systems with very different microclimatic conditions. Altitude and microclimate lead to the existence of a wide range of habitats, which in turn may give rise to quite different biodiversities at different localities. The climate of South Sinai is extremely arid with long, hot rainless summers and cool winters. It lies in the low-rain belt of

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Egypt with an average rainfall of 57 mm per year, but the high mountain massif centered on the town of St. Katherine receives higher amounts of precipitation (100mm per year) as rain and sometimes snow (Ayyad *et al*. 2000). The entire massif is now being conserved as the St Katherine Protectorate, and the management plan urgently requires information on the distribution of its unique biota.

The current study therefore aims to explore the effect of altitude and habitat heterogeneity on the structure and composition of the ground-dwelling beetles of the Protectorate. It also sheds light on seasonal fluctuations of the species and their altitudinal and spatial variation.

MATERIALS AND METHODS

The study was conducted over a period of 12 successive months in the year 1998 at three widely separated localities of South Sinai: El-Mafareq, Sahab and St. Katherine. El-Mafareq is a lowland site (altitude 120 m) and lies 106 km from the St Katherine sites (altitudes 1620-1670 m), while Sahab lies in between (altitude 950m). A full description of the study area is given in Willmer *et al.* (1994), Semida (1994), Gilbert *et al.* (1996,1999) and Ayyad *et al.* (2000).

Pitfall traps were used to sample the beetle assemblage at the study localities. Each trap consisted of a rounded plastic bottle 13 cm deep with an opening of 5.7 cm diameter, and filled one-third full of water with a little detergent. Three different sites were sampled in each locality, chosen to represent as much as possible of the local habitat heterogeneity. There were 20 replicate traps per site, at five-metre intervals within a 500-m^2 area. Each individual trap remained in exactly the same position during the entire period of study, allowing comparable results on the cumulative catches per trap. Traps were closed except for a 48-hr period of trapping once per month throughout the study period. This period of 48 hours is considered adequate to minimize depletion of the insect fauna (Southwood & Henderson 2000).

Beetles were identified to the species level wherever possible; occasionally only generic or even family designations were possible, but even though without a name, we are confident that each morphotype represents a separate species. Three replicate soil samples were collected from each site for quantitative physical and chemical analysis (Hausenbuiller 1985; Wilde *et al*. 1976), which were analysed using a multivariate nested Anova since there were three replicates of three sites from each of three localities. The plants in each site were identified from specimens in the herbaria of the St. Katherine Environmental Research Centre and the Faculty of Science, Suez Canal University in Ismailia. The geographical position and altitude of each site was recorded using a hand-held GPS receiver (Trimble Navigation Europe, Hampshire, UK).

There are many measures of diversity in use in the ecological literature (see Southwood & Henderson 2000); many researchers use the number of species (which strictly should be referred to as “species richness” rather than “diversity”) as a measure of diversity, but this is the least suitable diversity index since it is strongly sample-size dependent and is estimated with the largest error. The best diversity index by far is the Simpson diversity, which is unbiassed, estimated with the least error, is itself a variance (simplifying the analysis greatly), and has the great advantage of a simple interpretation (the probability that two random individuals from a community belong to different species) (Lande 1996). Simpson diversity (D) is calculated using the following equation (Lande 1996):

$$\lambda = \Sigma p^2_i \qquad D = 1 - \lambda$$

where p_i is the proportion of the community occupied by the i’th species. There are several different indices under the name ‘Simpson diversity’ in the literature; the one we use here is also called the Gini coefficient. A 'Simpson index' frequently used in the literature (e.g. Southwood & Henderson 2000) is the inverse $1/\lambda$; this is not at all the same as D, and has quite different and undesirable statistical properties (see Lande 1996).

RESULTS

Habitat characteristics: Both the localities (Rao's R = 12.7, df = 18 & 20, $p<0.0001$) and the sites within localities (Rao's R = 2.3, df = 54 & 55, $p<0.05$) had different soil environmental conditions, mainly due to St Katherine and Sahab having more gravel and coarse sand and less fine sand fractions than Mafareq. Differences among sites within localities were due mainly to the moisture and organic content of soils, with some contribution from the fine-sand fraction. Although both significant, locality differences were much more important than differences among sites within localities (see Table 1).

Table 1: The elevation and soil characters at different study sites in South Sinai. (M1-M3, studied sites 1-3 at El-Mafareq region; S1-S3, studied sites 1-3 at Sahab region; SK1-SK3, studied sites 1-3 at Wadi El-Arbaein: St. Catherine.

Variable	SK1	SK2	SK3	S1	S2	S3	M1	M2	M3
Elevation	1620	1650	1730	950	950	950	120	120	120
PH	8.19	8.04	8.11	8.29	8.24	7.55	8.12	8.44	8.26
	8.58	8.28	8.01	8.15	8.09	8.26	8.40	8.51	8.14
	8.56	7.86	8.03	7.86	8.06	7.51	8.18	8.06	7.87
Conductivity (micro-mhos)	159	240	499	3740	90	5230	816	295	2930
	78	82	502	380	168	547	208	3590	1858
	89	632	347	1311	287	5020	954	1570	1880
Organic Matter (%)	2.03	4.32	5.71	7.17	1.95	5.22	3.53	1.86	3.05
	1.19	4.56	6.99	2.09	3.78	2.46	3.46	3.58	3.62
	1.76	4.46	6.44	2.21	2.04	5.28	4.72	2.59	2.49
Moisture (%)	0.68	1.61	1.80	1.10	0.31	0.57	0.38	0.38	1.43
	0.31	2.00	3.25	0.35	0.34	0.51	0.92	1.77	1.44
	0.37	2.64	1.84	0.33	0.29	0.47	1.16	0.47	1.23
Gravel (%)	14.84	42.77	37.00	50.03	13.33	20.75	0.67	1.74	0.72
	54.39	44.15	45.15	18.95	61.67	23.83	1.59	10.60	1.70
	40.44	38.43	42.92	20.70	42.76	21.71	9.80	0.96	4.38
Coarse Sand (%)	30.55	43.50	52.25	35.05	47.35	33.85	25.45	12.75	5.25
	68.45	43.45	44.95	30.55	38.00	52.10	14.20	21.20	8.65
	47.05	42.55	57.55	28.55	53.15	32.45	25.45	23.30	10.95
Medium Sand (%)	40.40	25.60	20.00	20.35	29.15	36.10	29.15	39.50	26.30
	21.00	25.85	23.60	35.00	17.70	27.20	28.70	30.55	23.20
	28.30	19.95	21.60	37.80	21.10	22.20	25.75	36.85	33.70
Fine Sand (%)	23.40	23.80	19.75	25.10	18.80	22.90	39.75	45.00	60.55
	7.65	19.65	20.10	27.90	29.95	13.95	50.25	38.05	56.65
	14.75	26.75	14.70	29.45	19.80	30.05	43.20	36.30	48.75
Silt + Clay (%)	7.00	8.50	9.55	20.00	4.70	6.85	5.00	2.35	7.25
	3.85	8.50	7.25	6.55	13.75	6.15	6.40	4.85	10.90
	9.25	11.30	6.45	5.65	5.60	14.90	5.15	2.80	5.90

Species / effort curves: The number of species recorded during sampling is dependent on sampling effort . Fig. 1 illustrates the sampling effort curves, which have the same trend for the three different localities. The number of species recorded gradually increases with sampling effort (the number of traps) to an asymptote at about 50 traps. Thus we conclude that we used enough traps to catch almost all the species available in the sites, and therefore that our data are an accurate reflection of the species diversity of the sampled sites.

Overall pattern of diversity: Traps can be regarded as replicated samples of the beetles from the sites which they were fixed. A total of 4287 individual beetles belonging to 128 species

(26 families) were caught throughout the study period (Mafareq, 3083 individuals of 56 species; Sahab, 537 individuals of 30 species; St Katherine, 667 individuals of 65 species). Appendix 1 shows a full list of species and families collected during the study. There was a highly significant difference in Simpson diversity among locations (non-parametric one-way Anova, KW = 25.9, df = 2, $p<0.001$: see Fig 2), and among months of the year (KW = 132.7, df = 11, $p<0.001$).

Fig (1): Species/ effort curve for the three different localities at South Sinai

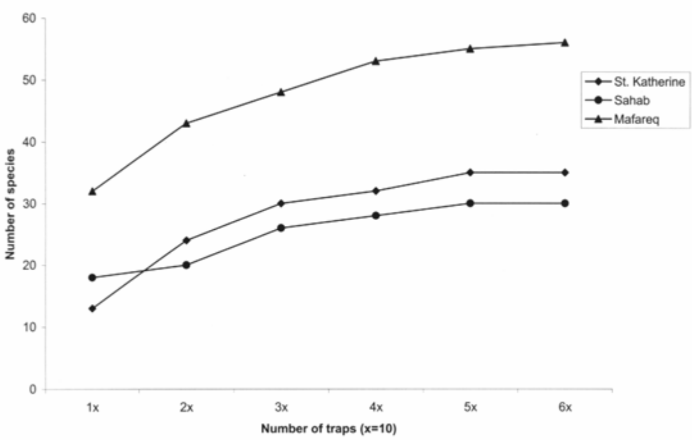
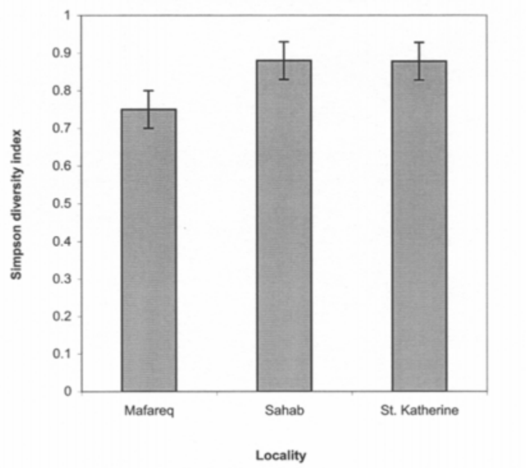


Fig (2): Overall simpson diversity index in the three localitiesof study in South Sinai



Spatial pattern of variation in diversity of the beetle assemblage: To determine the spatial variation of beetle diversity in the study area, three different parameters were analysed: species abundance, species richness and Simpson diversity. The design was a parametric nested analysis of variance. A highly significant difference was found among the three different localities in species abundance ($F_{2,57} = 192.2$, $p<0.001$), species richness ($F_{2,57} = 788.3$, $p<0.001$) and species diversity ($F_{2,57} = 499.7$, $p<0.001$). Within localities, sites were significantly different in species abundance ($F_{1,57} = 83.6$, $p<0.001$) and species richness ($F_{1,57} = 126.3$, $p<0.001$), but there was no significant difference among sites within localities in species diversity (Fig. 3a-c).

Fig (3a): The mean number of individuals cought per trap throughout the year at the study areas in South Sinai (1=Mafareq, 2=Sahab, 3=St. Katherine)

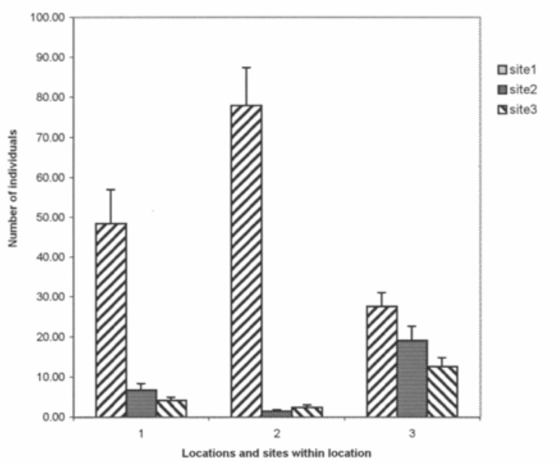


Fig (3b): The mean number of species cought per trap throughout the year at the study areas in South Sinai (1= Mafareq, 2= Sahab, 3= St. Katherine)

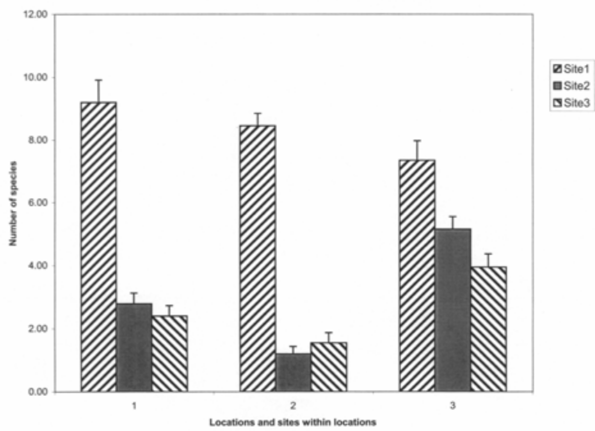


Fig (3c): The simpson diversty index of a trap catch over the year at the study areas in South Sinai(1= Mafareq, 2= Sahab, 3= St. Katherine)

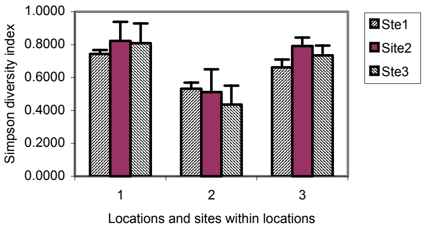


Fig (4a): The simpson diversity index of the mean catch per trap at El Mafareq region throughout the year

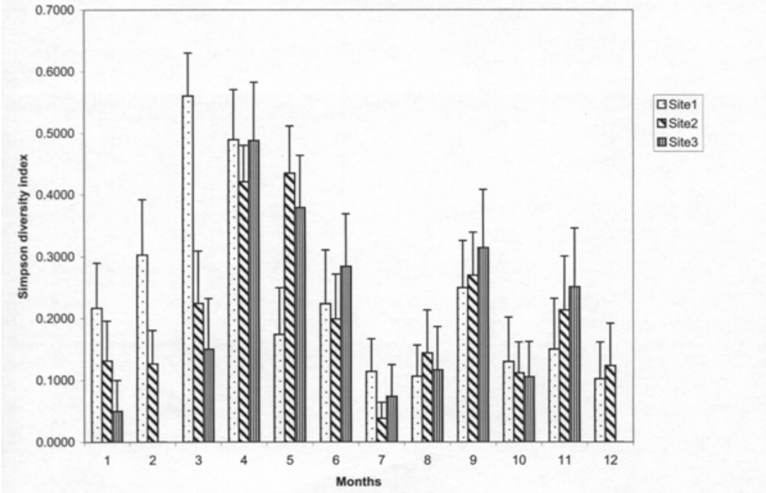


Fig (4b): The simpson diversity index of the mean per trap cought throughout the year at Sahab reagion in South Sinai

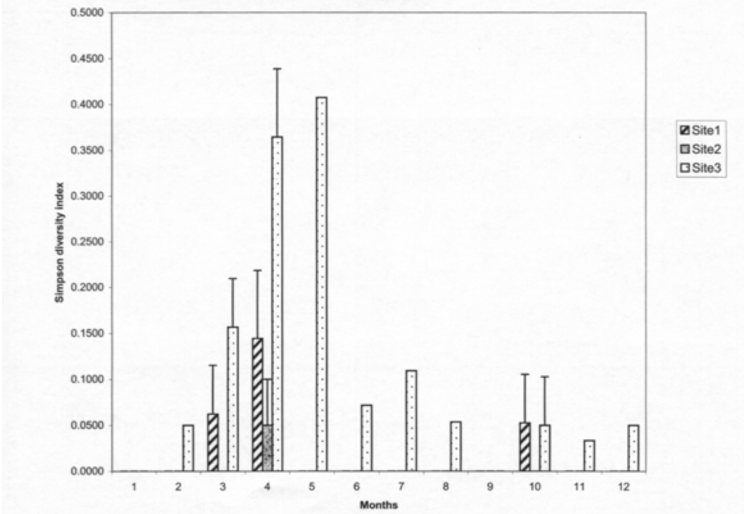
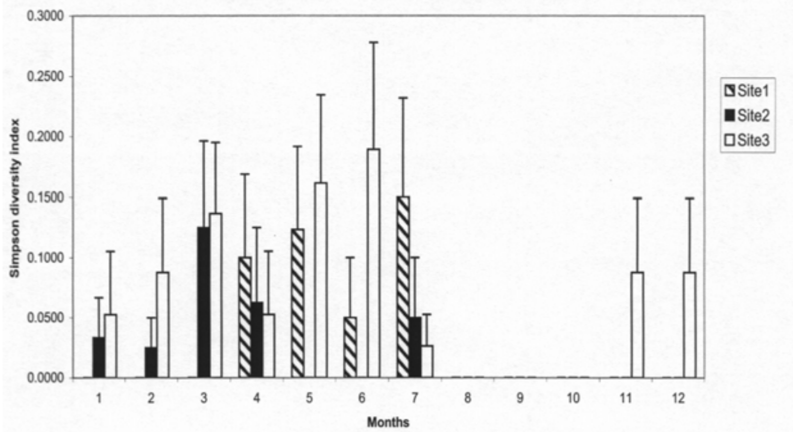


Fig (4c): The simpson diversity index of the mean catch per trap throughout the year at St. Catherine area in South Sinai



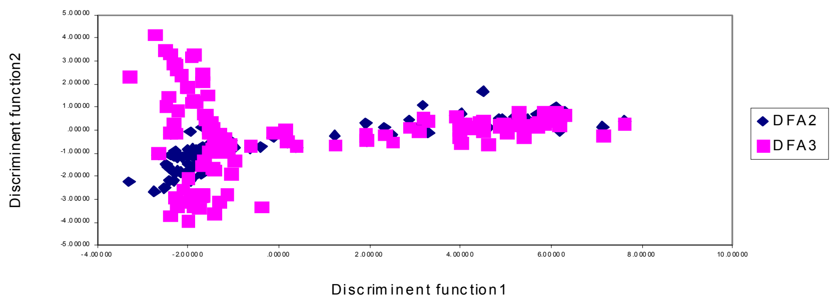
Temporal pattern of variation in diversity of the beetle assemblage: The monthly pattern varied significantly among localities in the study area in species abundance ($F_{11,35}$ = 14.73, p<0.01), species richness ($F_{11,35}$ = 19.63, p<0.01) and species diversity ($F_{11,35}$ = 16.5, p<0.01) (Fig. 4a-c).

Differences in beetle assemblage composition among localities: Diversity and species richness condenses the data for different species into a single number; an alternative analysis preserves the species-level data and looks for differences among localities using the multivariate data of each species as separate variables. A Discriminant Function Analysis (DFA) is the appropriate analysis for detecting differences among sites; rare species were excluded. The different localities were very distinct along the first axis (X^2 = 316, df = 2, p<0.001), the second axis (X^2 = 216.3, df = 2, p<0.001) and probably the third axis (X^2 = 132.9, df = 2, p= 0.068) (Fig 5).

Along the first axis, which represents 62% of the discrimination, the first location (Mafareq) has a positive values against negative ones for Sahab and St.Katherine. Positive values along this axis are correlated mainly with the occurrence of the beetle species *Adesmia bicarinata* (Tenebrionidae), *Mecyanotarsus semicinctus* (Anthicidae) and *Scelasodis castaneus* (Tenebrionidae). Along the second axis, which represents 26.6% of variation, St Katherine has positive values, correlated with the occurrence of *Brachinus latipennis* (Carabidae), *Ochthebius sp.* (Hydraenidae), *Dryops lurdius* (Dryopidae), *Chaetocnema tibialis* (Chrysomelidae) and *Lichenum* (Tenebrionidae). The third axis contrasts Sahab against the other localities, and represents 11.4% of discrimination; it is correlated with the occurrence of *Anthicus crinitus* (Anthicidae), *Opatroides punctulatus* (Tenebrionidae), *Laemostenus quadricollis* (Carabidae), *Aphodius granaries* (Scarabaeidae) and *Formicumus sp.* (Anthicidae).

The altitudinal gradient and the diversity of the beetle assemblage: To test for a correlation between the altitudinal gradient and the species abundance, richness and diversity, we used a rank correlation coefficient, r_S. A strong negative correlation was found between the altitude and both species abundance ($r_s = -0.91$, $n = 10$, $p<0.01$) and species richness ($r_s = -0.83$, $n = 10$, $p<0.01$), while a strong positive correlation was clear with species diversity ($r_s = 0.83$, $n = 10$, $p<0.01$).

Fig (5): Plot of the different locations of the study area at South Sinai along the fisrt three axis of the discim inent function analysis of the abundance of the commoner species (Mafareq,Sahab and St. Katherine)



DISCUSSION

The spatial and temporal patterns of biodiversity are considered good indicators of ecosystem quality (Primack 1993). In a region as large as South Sinai, there is strong habitat heterogeneity, and thus different sites may have quite different biodiversities even if they are fairly close to each other. A high diversity within the insect communities of a habitat is an important factor reflecting the richness of the overall quality of that ecosystem. This in turn may be a useful tool in conservation and management programs of the ecosystem.

Ground dwelling beetles are undoubtedly an essential factor in the desert habitat and they play an important role in food webs and nutrient cycling. They are highly diverse in their feeding habits, from scavengers to herbivores, and have a significant effect on the habitat, especially when locally abundant. They have an associated fauna of predators, prey and parasites and thus influence community composition beyond their own trophic level.

The overall biological diversity at the regional scale and different local diversities within a region are closely related (Edwardo Romero & Avila 2000). Local diversity is generated and maintained by a complex of factors such as altitude, latitude, productivity, climatic variability, age of ecosystem, predation, competition, spatial heterogeneity or the stage of the biological succession (Fjelsa & Lovett 1997). Human factors also are important in managed or semi-natural habitats. However, not only local habitat features determine local diversity, but other processes acting at coarse scales are also influential. Local diversity is then a complex function of regional diversity and faunistic turnover among localities (Caley & Schulter 1997). Area is one of the most important factors influencing regional diversity. Although different possible explanations have been argued to explain the positive relationship between area and diversity (Huston 1994), the basic fact remains: the larger the area, the larger the number of different types of habitats or microhabitats that can colonized by more species. As a consequence, habitat simplification in a given region driven by human activity may reduce species diversity at the landscape scale (Romero-Alcaraz & Avila 2000).

In the current study, the three different studied localities are spatially isolated and each locality has its own different habitat features. These probably lead to the existence of significant differences in their overall diversity. Habitat heterogeneity extends also to the level of sites within locality. The soil type, soil moisture and organic matter may be one of the main factors determining the composition of the beetle assemblage within the different types of habitats. The habitats within the Mafareq are much more heterogeneous than the other two localities, reflected in its higher species richness and species abundance. The lowest locality Sahab has the lowest species richness and species abundance. In contrast, St Katherine and Sahab have almost equivalent species diversity, significantly higher than Mafareq. It was not surprising to find that species richness and species abundance were negatively correlated, whilst species diversity index was positively correlated with altitude. Through the year, diversity varied among different months of the year between and within localities, perhaps explained by climatic changes.

The different localities had distinctive assemblages of insects. Most of these differences may be due to habitat heterogeneity and differential extinction in the different localities after climatic changes; some others may be due to the altitudinal gradients and its effect on climate. Mafareq is characterized by the presence of *Adesmia bicarinata* (Tenebrionidae), *Mecyanotarsus semicinctus* (Anthicidae) and *Scelasodis castaneus* (Tenebrionidae); Sahab is characterized by *Anthicus crinitus* (Anthicidae), *Opatroides punctulatus* (Tenebrionidae), *Laemostenus quadricollis* (Carabidae), *Aphodius granaries* (Scarabaeidae) and *Formicumus sp.* (Anthicidae); while St. Katherine is characterized by *Brachinus latipennis* (Carabidae), *Ochthebius sp.* (Hydraenidae), *Dryops lurdius* (Dryopidae), *Chaetocnema tibialis* (Chrysomelidae) and *Lichenum sp*. (Tenebrionidae).

This study has shed light on one of the most important regions of Egypt. The habitat heterogeneity of the region clearly affects species diversity and community composition very strongly. It illustrates the fact that this area of land needs much more attention in order to promote its conservation via a sustainable management programme.

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Appendix (1) :All beetle species collected from the study sites using pitfall traps at south Sinai during 1998.

Genus	Species	Family	Habit	Habitat
Adelostoma	*sulcatum*	Tenebrionidae	Scavenger	Under decaying plants
Adesmia	*bicarinata*	Tenebrionidae	Scavenger	Under decaying plants
Adesmia	*montana*	Tenebrionidae	Scavenger	Under decaying plants
Adleostoma	*sulcatum*	Tenebrionidae	Scavenger	Under decaying leaf
Aephnidius	*ruficornis*	Carabidae	Predator	Under stones
Akis	*elevata elevata*	Tenebrionidae	Scavenger	Under decaying plants
Anemia	*aegyptiaca Pic*	Tenebrionidae	Scavenger	Under decaying plants
Anemia	*fausti Solsky*	Tenebrionidae	Scavenger	Under decaying plants
Anthicus	*crinitus*	Anthicidae	Scavenger	Under decaying plants
Anthicus	*modestus*	Anthicidae	Scavenger	Under decaying plants
Anthicus	sp.	Anthicidae	Scavenger	Under decaying plants
Anthrenus	*crustaceus Rtt.*	Dermestidae	Polen feeder	Plant
Aphodius	*granarius*	Scarabaeidae	Dung feeder	Dung
Aphodius	*lucidus Klug*	Scarabaeidae	Dung feeder	Dung
Aphthona	sp.	Chrysomelidae	Phytophagous	Plant
Atheta	*sordida*	Staphylinidae	Predator	Under decaying plants
Attagenus	*trifasciatus*	Dermestidae	Polen feeder	Plant
Bembidion	*atlanticum*	Carabidae	Predator	Sandy soil beside water
Bembidion	*schmidti moses*	Carabidae	Predator	Sandy soil beside water
Blaps	*schweinfurthi*	Tenebrionidae	Scavenger	Under decaying plants
Brachinus	*latipennis*	Carabidae	Predator	Sandy soil beside water
Calosoma	*olivieri*	Carabidae	Predator	Under stones
Cardiophorus	*pharaonum*	Elateridae	Phytophagous	Low vegetation
Chaetocnema	*tibialis*	Chrysomelidae	Phytophagous	Plant
Chlaenius	*canariensis*	Carabidae	Predator	Sandy soil beside water
Chlaenius	*obscurus*	Carabidae	Predator	Sandy soil beside water
Cleonus	*hieroglyphicus*	Curculionidae	Phytophagous	Plant
Coptognathus	sp.	Scarabaeidae	Unknown	Unknown
Corticaria	*fulva*	Lathridiidae	Scavenger	Under decaying plants
Cryptophagus	*acutiangulus*	Cryptophagidae	Phytophagous	Plant
Ctenistomorphus	*elaniticus*	Pselaphidae	Scavenger	Under decaying leaf
Curimosphena	*villosus*	Tenebrionidae	Scavenger	Under decaying plants
Cymindis	*setifensis*	Carabidae	Predator	Under stones
Dasytiscus	sp.	Cantharidae	Predator	Plant
Drasterius	sp.	Elateridae	Phytophagous	Low vegetation
Dryops	*lurdius*	Dryopidae	Scavenger	Water

Egadroma	*marginata*	Carabidae	Predator	Sandy soil beside water
Endomia	*bivitatta bivitatta*	Anthicidae	Scavenger	Under decaying plants
Formicumus	sp.	Anthicidae	Scavenger	Under decaying plants
G01	sp.	Tenebrionidae	Scavenger	Under decaying plants
G02	sp.	Tenebrionidae	Scavenger	Under decaying plants
G03	sp.	Curculionidae	Phytophagous	Plant
G04	sp.	Staphylinidae	Predator	Under decaying plants
G05	sp.	Anthicidae	Scavenger	Under decaying plants
G06	sp.	Anthicidae	Scavenger	Under decaying plants
G09	sp.	Dermestidae	Polen feeder	Plant
G10	sp.	Tenebrionidae	Scavenger	Under decaying plants
G11	sp.	Anthicidae	Scavenger	Under decaying plants
G13	sp.	Tenebrionidae	Scavenger	Under decaying plants
G14	sp.	Curculionidae	Phytophagous	Plant
G16	sp.	Anthicidae	Scavenger	Under decaying plants
G19	sp.	Dermestidae	Polen feeder	Plant
G20	sp.	Pselaphidae	Scavenger	Under decaying leaf
G21	sp.	Staphylinidae	Predator	Under decaying leaf
G27	sp.	Phalacridae	Unknown	Plant
G28	sp.	Staphylinidae	Predator	Under decaying leaf
G29	sp.	Staphylinidae	Predator	Under decaying plants
G30	sp.	Staphylinidae	Predator	Under decaying plants
G31	sp.	Staphylinidae	Predator	Under decaying plants
G32	sp.	Elateridae	Omnivorous	?
G33	sp.	Staphylinidae	Predator	Sandy soil beside water
G37	sp.	Tenebrionidae	Scavenger	Under decaying plants
Glycia	*castanea*	Carabidae	Predator	Under stones
Gonocephalum	*setulosum*	Tenebrionidae	Scavenger	Under decaying plants
Gonocephalum	*soricinum*	Tenebrionidae	Scavenger	Under decaying plants
Isidus	*letournexi* Pic	Elateridae	Phytophagous	Plant
Laemostenus	*quadricollis*	Carabidae	Predator	Sandy soil beside water
Lebia	*arcuata*	Carabidae	Predator	Under stones
Lichenum	*mulleri*	Tenebrionidae	Scavenger	Under decaying plants
Lichenum	*pulchellum*	Tenebrionidae	Scavenger	Under decaying plants
Lichenum	sp.	Tenebrionidae	Scavenger	Under decaying plants
Longitarsus	*albineus*	Chrysomelidae	Phytophagous	Plant
Mecyanotarsus	*bison*	Anthicidae	Scavenger	Under decaying plants
Mecyanotarsus	*semicinctus*	Anthicidae	Scavenger	Under decaying plants
Medon	sp.	Staphylinidae	Predator	Sandy soil beside water
Megadasus	*soricinum*	Tenebrionidae	Scavenger	Under stones
Mesostena	*angustata* F.	Tenebrionidae	Scavenger	Under stones
Mesostena	*puncticollis*	Tenebrionidae	Scavenger	Under decaying leaf
Micipsa	*philistina*	Tenebrionidae	Scavenger	Under decaying leaf
Mitotagenia	*arabs*	Tenebrionidae	Scavenger	Under decaying plants
Mitotagonia	sp.	Tenebrionidae	Scavenger	Under decaying leaf
Mitotagonia	sp.	Tenebrionidae	Scavenger	Under decaying leaf
Netocia	*afflicta*	Scarabaeidae	Polen feeder	Plant
Ochthebius	sp.	Hydraenidae	Scavenger	Sandy soil beside water
Ocnera	*hispida*	Tenebrionidae	Scavenger	Under decaying plants
Opatroides	*punctulatus*	Tenebrionidae	Scavenger	Under decaying plants
Pentodon	*bispinosus*	Scarabaeidae	Phytophagous	Straw

Pimelia	*hirtella*	Tenebrionidae	Scavenger	Under stones
Pimelia	*spinulosa*	Tenebrionidae	Scavenger	Under stones
Pinophilus	sp.	Staphylinidae	Predator	Under decaying leaf
Porocleonus	*candidus* Olivier	Curculionidae	Phytophagous	Plant
Proscheimus	*arabicus*	Tenebrionidae	Scavenger	Under stones
Psylliodes	*hospes*	Chrysomelidae	Phytophagous	Plant
Pterolasia	*squalida* Solier	Tenebrionidae	Scavenger	Under stones
Ptinus	*testaceus* Olivier	Ptinidae	Omnivores	Birds' nest & old trees
Rhyssemodes	*kocheri*	Scarabaeidae	Root feeder	Under stones in rotting
Rhyssemodes	*orientalis*	Scarabaeidae	Root feeder	Under stones in rotting
Saprinus	*chalcites* Illiger	Histeridae	Predator	Under decaying plants
Saprinus	sp.	Histeridae	Predator	Under decaying plants
Saprinus	*sphingia* Peyerm.	Histeridae	Predator	Under decaying plants
Scaurus	*carinatus*	Tenebrionidae	Scavenger	Under decaying plants
Scelasodis	*castaneus*	Tenebrionidae	Scavenger	Under stones
Scleron	*multistriatum*	Tenebrionidae	Scavenger	Under stones
Scleron	sp.	Tenebrionidae	Scavenger	Under decaying plants
Scopaeus	*debilis*	Staphylinidae	Predator	Sandy soil beside water
Scymenus	*iterruptus*	Coccinellidae	Predator	Plant
Sitona	*crinitus*	Curculionidae	Phytophagous	Plant
Sitona	sp.	Curculionidae	Phytophagous	Plant
Stalagmosoma	*albella*	Scarabaeidae	Unknown	Unknown
Tentyria	sp.	Tenebrionidae	Scavenger	Under decaying leaf
Thraustocolus	sp.	Tenebrionidae	Scavenger	Under stones
Trogophloeus	sp.	Staphylinidae	Predator	Under decaying leaf
Typhaea	*stercorea* L.	Mycetophagidae	Fungus feeder	Under mouldy straw
Zophosis	*bicarinata*	Tenebrionidae	Scavenger	Sandy soil
Zophosis	*complanata*	Tenebrionidae	Scavenger	Sandy soil
Zophosis	*punctata*	Tenebrionidae	Scavenger	Sandy soil

الملخص العربي

تباين البيئات وتدرج الارتفاع وعلاقته بتنوع الخنافس في جنوب سيناء

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تم تجميع الخنافس الأرضية الزاحفة باستخدام المصائد الأرضية من ثلاثة أماكن مختلفة في صفاتها البيئية من حيث الإرتفاع والكساء النباتي وطبيعة التربة وذلك بمنطقة جنوب سيناء (منطقة المفارق – سهب – سانت كاترين) وذلك لمدة عام كامل (زيارة لمدة أسبوع كل شهر خلال عام 1998م). وقد تم إستخدام عدد كبير من المصائد الأرضية فى كل موقع (60 مصيدة لكل موقع موزعة على ثلاثة أماكن داخل الموقع) وقد تم دراسة الاختلاف المكاني والزماني لعناصر التنوع البيولوجي داخل تلك المناطق وقد أوضحت الدراسة وجود اختلافا معنويا فى تنوع الخنافس بين المناطق الثلاثة وكذلك ما بين شهور السنة داخل المناطق. وقد وجدت علاقة طردية بين ارتفاع المكان عن سطح الأرض ومعامل التنوع البيولوجي في حين كانت تلك العلاقة عكسية مع كل من عدد الأنواع وكذلك عدد الأفراد في كل نوع. بالإضافة إلى ذلك ثبت أن كل مكان يتميز بمجموعة من الحشرات التي تختلف عن الأماكن الأخرى وذلك استجابة للاختلاف في الارتفاعات والصفات البيئية المميزة لكل مكان. وخلصت الدراسة إلى أهمية التركيز على دراسة الفونا الحشرية والنباتية والحيوانية فى منطقة جنوب سيناء على مستوى الأماكن والإرتفاعات المختلفة حيث تتنوع النظم البيئية بالمنطقة مما أدى إلى تنوع فونتها الحشرية وكانت الخنافس مثال واضح لهذا التنوع مما يستلزم إتباع وسائل حماية وإدارة لهذه الأماكن على أساس تباينها الحيوانى والحشرى والنباتى ولا يكتفى بإنتهاج سياسة حماية موحدة لكل النظم البيئية فى المنطقة