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Diversity and community structure of beetles and their role as bioindicators in Ashtoum El- Gamil protectorate Port Said, Egypt

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Abstract

The diversity of invertebrate fauna across many different types of environments means that invertebrates are likely to be sensitive indicators of land use. Particularly, on a global scale beetles meet most of bio indication criteria. The aim of the present study is to investigate the effects of different aspects of disturbance on beetle diversity and community structure, as well as evaluate the beetles assemblages as bioindicators in Ashtoum El-Gamil protectorate using pitfall traps. A total of 658 adult specimens were collected seasonally from 12 sites belonging to 22 species and 13 families. Beetles abundance showed spatially significant difference among different study sites; where, ($P< 0.05$). The most abundant site was the disturbed site of Quail farm (90 individuals); while, the natural sites were the lowest (6). The ordination result of the DCA analysis for beetles species sampled during the study period separated the natural sites with their characteristic species from the disturbed sites. Also, The CCA showed that the plant species *Mesembryanthemum forsskalei* & *Sarcornia fruticos* and sand percentage of the soil parameters ($P < 0.01$) were correlated with the natural sites. In conclusion, it was found that there is a significant effect of disturbance on the species composition of beetles in Ashtoum El-Gamil protectorate.

Keywords: Beetles, Ashtoum El-Gamil protectorate, Habitat disturbance, Risk assessment, Bioindicators and Diversity.

1. Introduction

Coleoptera are the largest order including more species known to science than any other order not only in the class Insecta, but also in the entire animal kingdom (Animalia), constituting almost 25% of all known life-forms. About 40% of all described insect species are beetles (about 400,000 species). (Powell [1], Rosenzweig [2], Hammond [3]). The diversity of beetles is very wide, they occur at all trophic levels, inhabiting a multitude of environmental niches. Terrestrially beetles can be found living in soil, leaf litter, decomposing wood, dung and in the fruiting bodies of many types of fungi. Also, they found under dead trees and stones. Some species live in the nests of other animals such as termites or in silos where grains are stored. (Gullan and Cranston [4]).

Coleoptera share a number of qualities that make them highly adequate as biological indicators. These include their sensitivity to several abiotic and biotic factors, they are stable taxonomically, respond quickly to habitat alteration and can be easily and cost-effectively collected by using classic pitfall traps (Avgin and luff [5], Niemelä et. al. [6], Muona and Rutanen[7]). A number of studies surveyed the beetle fauna of Mediterranean region, investigated ecological factors, and evaluated habitat management opportunities (Salgado et. al. [8], Brandmayr et. al. [9], Nunes et. al. [10]).

Egypt has a unique position; it is home to a wide diversity of terrestrial habitats (fauna and flora), which although relatively low in species numbers and with few endemics, is extremely varied in composition (El-Badry [11]).This fairly low number of species and the relatively large number of eco-zones and habitats makes the preservation of both highly important. Recently Egypt has been active in the conservation of wildlife, natural resources and natural habitats, it has 30 protectorates, and they cover around 15% from the entire area (Hussein Salama [12]). Natural environment in Egypt has exposed to many shapes of impairment that menace its safety, such as the presence of preserved natural area within the urban context, short of funding. Also some of Egypt protected areas suffer from conflict in responsibilities between relevant agencies (El Khateeb [13]).

Ashtoum El-Gamil protectorate was declared as protected area in 1988 and is located 13 km^2 to the west of Port Said town .It covers an area of about 180 km^2 lying, majorly inside Lake Manzala. The protectorate include new and old El-Gamil inlets; as well as the historical Tennis Island, with an area of about 8 km^2, that lies on the south west of Port Said city .The historical Tennis island surrounded with water at a distance of about 300 m from all sides. The protectorate aims to conserve the biological and natural, as well as cultural feature of Lake Manzala, through the wise and sustainable utilization of its resources for the benefit of contemporary and future generations. (EEAA [14]).

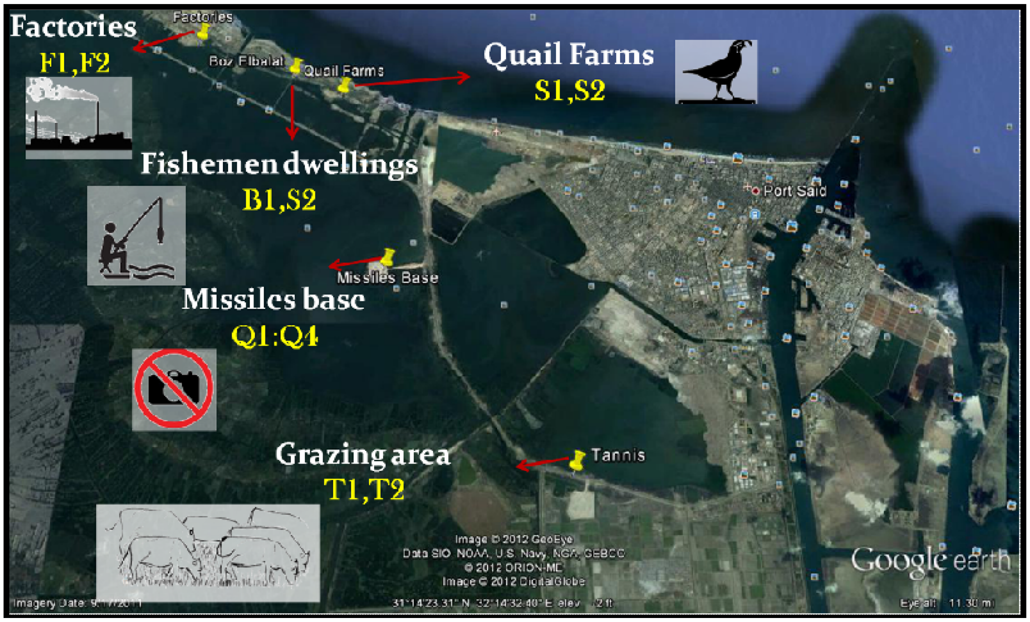
The wetland sites of Ashtoum El-Gamil (Lake Manzala) are under escalating stress due to extensive development of natural gas investments and urbanization. Lake Manzala is suffering from land reclamation, industrial and nutrient pollution and overgrowth by water hyacinth. Furthermore, urban expansion, dryness, and constant increase in usage of lands that leads to minimize areas of wetlands and water surfaces, accordingly deterioration of Manzala area from 1200 km^2 to about 800 km^2. (Baha El Din [15], Hamed et. al. [16], Salib and Khalil [17]) Additionally, the new excessive investment of natural gas prospecting and exploration around the protectorate has impacted negatively on the biodiversity of protectorate.

A relatively little attention has been given to the fauna of invertebrates and beetles in particular of this area, and there is no any solid study to investigate, monitor and evaluate the biodiversity of these valuable organisms. So there is an urgent need to improve knowledge about its conservation status of Ashtoum El-Gamil protected area to assess the environmental impact of different human activities on beetles assemblages that exist amongst various habitats and identify environmental factors underlying the patterns of association in Ashtoum El-Gamil protectorate, Port Said, Egypt.

2. Materials and Methods

2.1. The study area:

Lake Manzala is located in the north east quadrant of the Delta; Satellite map (1), between 31° 00′ and 31° 30′ N latitude and 31 ° 45′ and 32° 22′ E longitudes. It is bounded by the Mediterranean Sea at the north, Suez Canal at the east, Damietta province in the North West, and Dakahlia province in the southwest. Ashtoum El-Gamil & Tennis Island is located in the western north corner of Lake Manzala including new and old El-Gamil inlets; as well as the historical Tennis Island, with an area of about 8 km^2, that lies on the south west of Port Said city.



Satellite map 1: The study sites at Ashtoum El-Gamil& Tennis island (via Google earth)

2.2. Sampling

Beetles were captured seasonally from July 2011 to May 2012 by pitfall traps. Twelve sites belonging to five different localities were chosen; four natural sites at Military missile base area Qada el saro7'ya (Q1, Q2, Q3 and Q4) and eight sites representing four different impacts two sites for each impact; Petroleum factories area (F1and F2), Fishermen's dwelling area Boz El Balat (B1and B2), Quail farm area Seman (S1 and S2), and Grazing area Tennis (T1and T2) respectively Figure (1). Within each site 15 traps fixed along 150 m. Line transect with 10 meters in between to minimize among-trap interference. The coordinates of each site were recorded using a hand – held Global Positioning System (Garmin, GPSШ plus) with description of habitat characteristics of soil and flora.

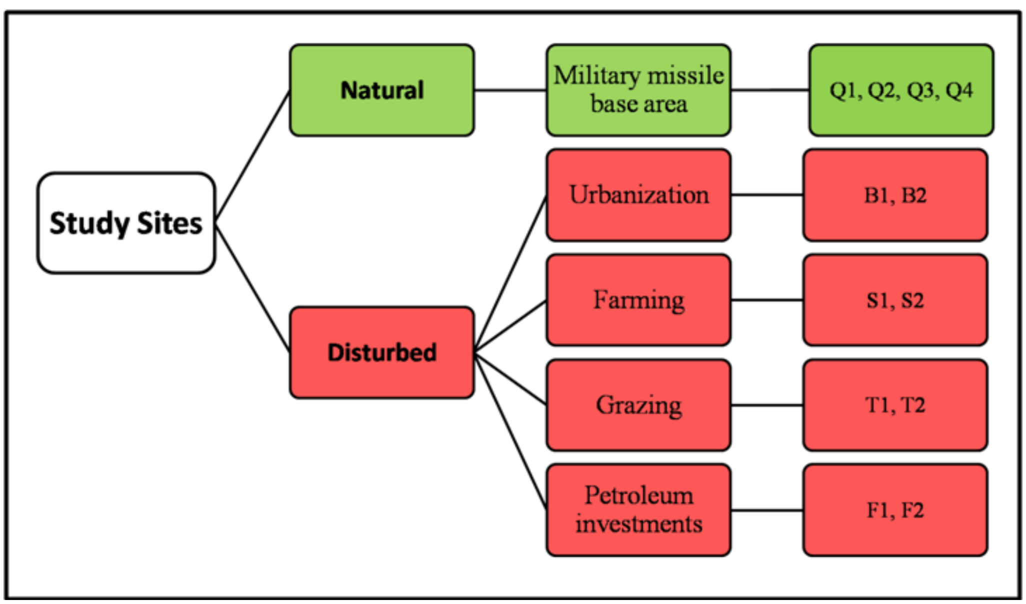


Fig 1: The study sites, Type of impact, Sites name and their codes

2.3. Soil Analysis
Three soil samples at each site, at a depth of 0-30 cm and at 50 m intervals along each line transect were taken. Physical and Chemical properties of Soil were measured at the different study sites (organic matter, moisture, pH values, electric conductivity and soil texture) according to Wilde et. al. [18].

2.4. Vegetation
The plant cover in the studied areas was recorded as presence and absence data . Three quadrates (20 x 20 m) were placed at 30 m regular intervals along the study site. Species were collected and identified in the lab of botany at Ashtoum El- Gamil protectorate.

2.5. Data analysis
Beetles species richness, abundance, diversity (Shannon and Simpson diversity indices) and evenness were calculated using the PC-ORD program for Windows version 4.14 (McCune and Medford [19]). Differences in beetles abundances, richness and evenness between sites were compared using one-way analysis of variance (ANOVA) (Zar [20]) using the SPSS for Windows 12 statistical software package (SPSS, Inc. 1996), Only the adults specimens were included in the analysis.

Cluster analysis was carried out using the statistical package PC-ORD for Windows version 4.14 (McCune and Mefford [19]). Two ordination techniques were applied: Detrended correspondence analysis (DCA) (Hill and Gauch [21]) and canonical correspondence analysis (CCA) (Ter Braak [22]). Only common species that were found at three or more sites were used in the DCA and CCA analysis. The CCA was done in the forward selection mode of the CANOCO program and the significance of each variable was tested in a sequential fashion using a Monte-Carlo simulation algorithm before it was added to the final model. All variables that were significant at $p<0.05$ were included in the final model.

2.6. Indicator Species Analysis
Indicator species analysis was performed using the PC-ORD package on the species abundance data using the number of groups shown in the cluster and the two ordination methods. In this analysis both of the species frequency and the relative abundance values are combined to estimate the degree that each species is characteristic for a group of sites. This degree is given by the species' indicator value (IV). The highest indicator value for a given species across group is saved as a summary of the overall indicator value of that species and evaluated by the Monte Carlo method, with randomly reassigned SUs (sample units) to groups taking place 1000 times (McCune and Grace [23]).

3. Results
3.1. Adequacy of Sampling
During the study period, a total of 22 beetle species were collected by pitfall traps, which represent 70 % of the estimated total species richness by the First-order jackknife estimate. The curve showed a considerable flattens after the third trip which means we got most of the common species at the study area. Figure (2).

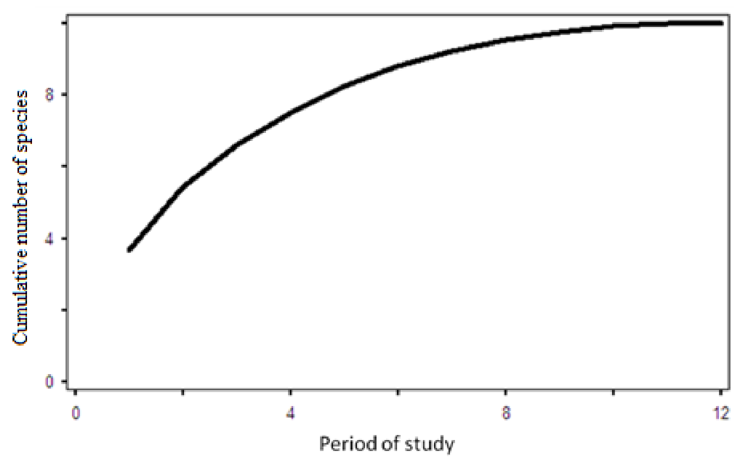


Fig 2: Species /effort curve. During the study period July 2011- May 2012.

3.2. Species abundance, richness, diversity, and evenness:
A total of 658 coleopteran individuals were collected during the period of the study from the study area, representing 22 identified adult species belonging to 22 Genus and 13 families. Table (1).The most species-rich families were Carabidae (6 species), Staphylinidae (3 species), Anthicidae, (2 species) and Scarabaeidae (2 species) and the most abundant families were Carabidae (362 individuals) representing

approximately 55% of all individuals followed by Anthicidae (259 individuals) 39 % and Tenebrionidae (14 individuals) 2% .Ten families were represented by fewer than 10 individuals representing approximately 5% of the total number of beetles individuals.The most abundant species was *Megacephala euphratica* (Carabidae); totally about 307 individuals (46.6%). Followed by the *Anthicus armatus* (Anthicidae) (n = 239, 36.3%). Figure (3).

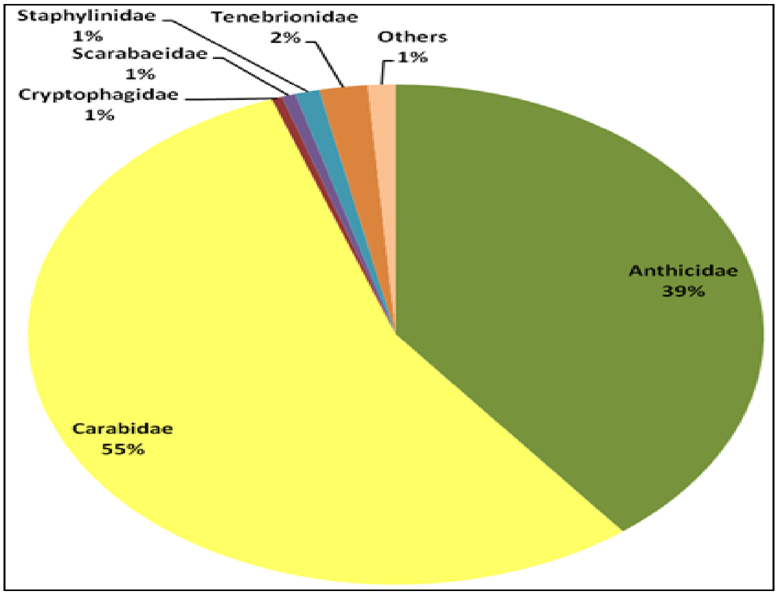


Fig 3: Beetles relative abundance per family

Table 1: Beetles families and species collected from different study sites in Ashtoum El-Gamil protected area (presence /absence).

Family	Taxa name	Sites											
		T1	T2	S1	S2	Q1	Q2	Q3	Q4	F1	F2	B1	B2
Anthicidae	*Anthicus armatus*	1	1	1	1	1	1	1	1	1	1	0	1
Anthicidae	*Anthelephila caeruleipennis*	0	0	0	1	0	0	0	0	0	0	0	0
Carabidae	*Megacephala euphratica*	1	1	1	1	1	1	0	0	1	1	1	1
Carabidae	*Cephalo tatibialis*	0	0	0	0	0	1	0	0	0	0	0	0
Carabidae	*Lophyridia aulica*	0	0	0	0	1	1	0	0	0	0	0	0
Carabidae	*Scarites sinaiticus*	0	0	1	1	0	0	0	0	1	0	0	1
Carabidae	*Daptus vittatus*	0	0	0	0	1	1	0	1	0	0	0	1
Carabidae	*Dyschirius beludscha*	0	0	0	0	1	0	0	0	0	0	0	0
Coccinellidae	*Rodolia cardinalis*	0	0	0	0	0	1	0	0	0	0	0	0
Cryptophagidae	*Atomaria* sp.	0	0	1	0	0	0	0	0	0	0	0	0
Curculionidae	G1 sp.	0	0	1	1	0	0	0	0	0	0	0	0
Dermestidae	*Dermestis* sp.	0	0	1	0	0	0	0	0	0	0	0	0
Heteroceridae	*Heterocerus* sp.	0	0	0	0	0	1	0	0	0	0	0	0
Histeridae	*Pactolinus major*	0	0	1	0	0	0	0	0	0	0	0	0
Hydrophilidae	*Berosus* sp.	1	0	0	0	0	0	0	0	0	0	0	0
Nitidulidae	*Urophorus humeralis*	0	0	0	1	0	0	0	0	0	0	0	0
Scarabaeidae	*Pentodon algerinum*	0	0	0	0	0	0	0	0	0	0	0	1
Scarabaeidae	*Tropinota squalid*	0	1	0	0	0	0	0	0	0	0	0	0
Staphylinidae	*Tachinus* sp.	0	0	0	0	0	0	1	0	0	0	0	0
Staphylinidae	*Philonthus* sp.	0	0	0	1	0	0	0	0	0	0	0	0
Staphylinidae	*Cafius* sp.	0	0	0	0	0	0	0	0	1	1	0	0
Tenebrionidae	*Trachyderma hispida*	1	0	1	0	0	0	1	1	0	0	1	0

The site S1 had the highest values for beetles species abundance, richness, Simpson and Shannon diversity indices (90, 9, 0.7022, and 1.512) respectively. While, the highest value in species evenness was in Q3 site (0.896). The sites Q3 and T1 recorded the lowest value of species abundance and evenness (6 and 0.359) respectively. B1 site has the lowest value of Simpson and Shannon diversity indices (0.1271and 0.249) respectively. B1 site showed the lowest species richness as well (2). Figures. (4 and 5).

The One-Way ANOVA analysis showed that there was a significant difference of species abundance between the twelve sites (χ^2 = 195.41,d.f. = 11 and P< 0.05) , while, the species evenness , species richness and Simpson diversity index showed no significant difference between different sites. The most abundant site was the disturbed site of Quail farm (90 individuals); while, the natural sites were the lowest (6 individuals). Figures. (4 and 5)

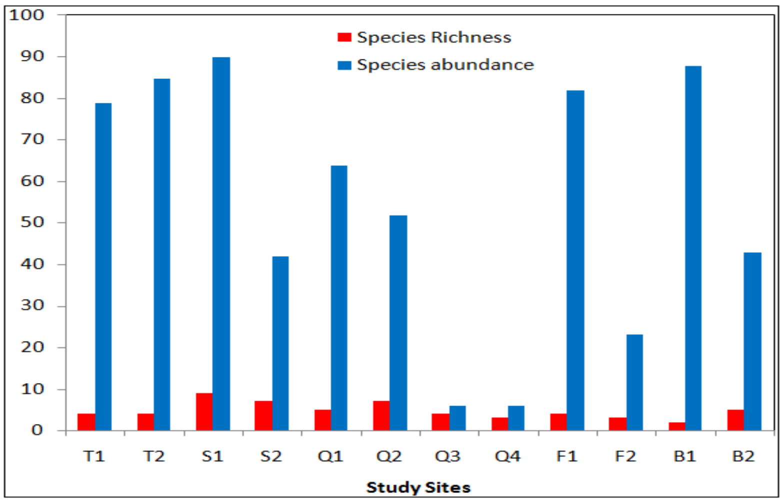


Fig 4: The Spatial variation in species abundance, and richness of beetles among study sites during the period of study July 2011- May 2012

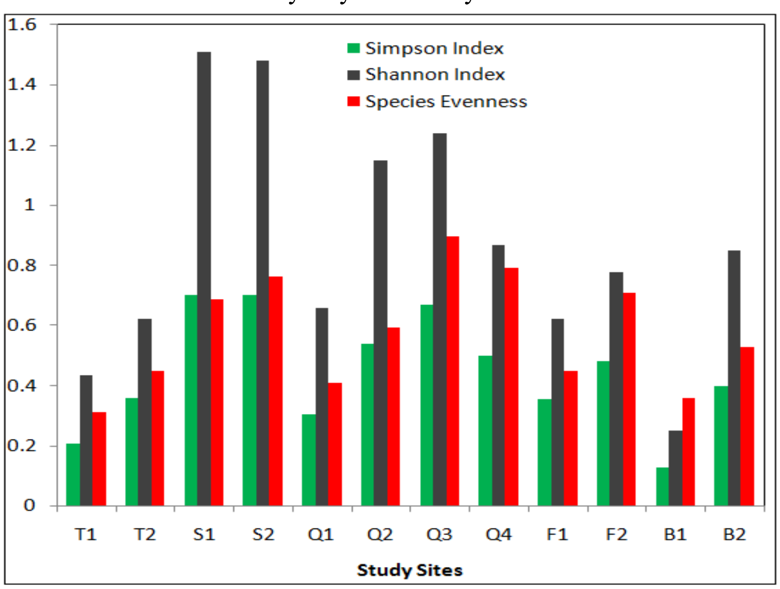


Fig 5: The Spatial variation in species evenness, Simpson, and Shannon diversity indices of beetles among study sites during the period of study July 2011- May 2012

3.3. Cluster Analysis

The data matrix was made for the twelve study sites. This matrix depended on species compositions during the study period. The dendogram showed that two out groups marked as “A “and “B” were recognized. The first out group “A” represented the natural (control) sites Q3 and Q4 were separated in the first phase. Two main branches “I” and “C” were branched out of the out group “B”. The branch “C” represented by the rest of natural sites Q1 and Q2 which are separated from the disturbed sites in the second phase .The branch “I” represented different disturbed (impacted) sites of farming, grazing, fishermen dwelling and petroleum investments sites. Figure (6).

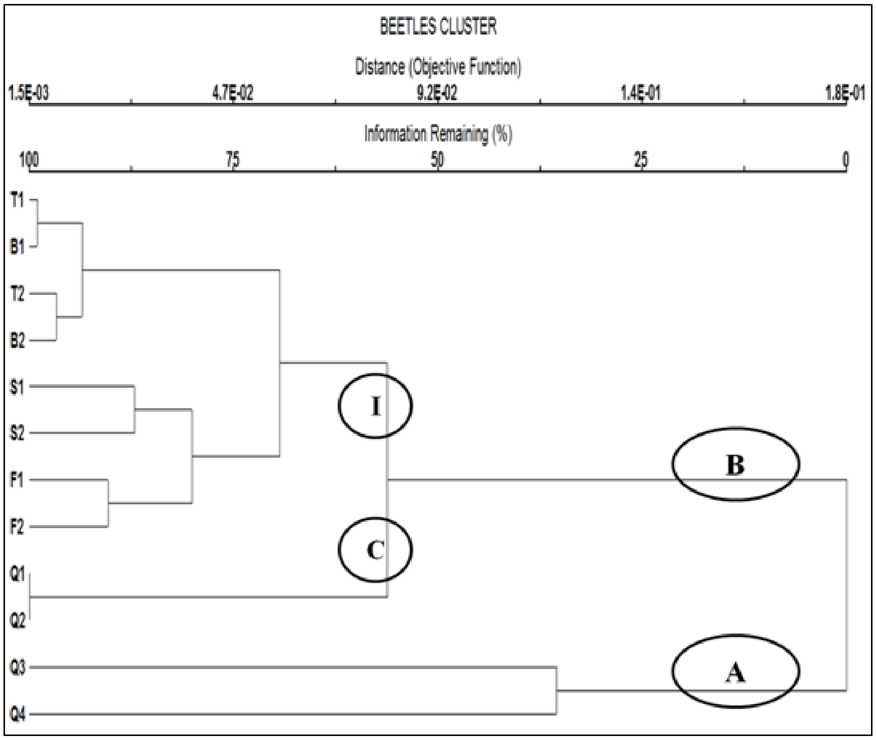


Fig 6: The Cluster dendogram for the twelve study sites depending on species occurrence during the study period July 2011- May 2012.

3.4. Detrended Correspondence Analysis (DCA)

The ordination result of the (DCA) analysis for beetles species sampled during the study period was illustrated in figure (7). The first two axes accounted for 42.43 % of the total variance of the data. The twelve study sites are plotted along axes 1 and 2, and tend to cluster into four groups that resulted from the cluster analysis described before.

The first axis separated the natural sites (Q1, Q2, Q3& Q4) on the upper side of the axis with their characteristic species (*Daptus vittatus, Lophyridia aulica , Cafius sp., Scarites sinaiticus*) from the disturbed sites on the lower side of the axis . The second axis splitted the disturbed sites into two groups; farming and petroleum investments disturbed sites together (S1, S2, F1&F2) on the left side of the axis. While, grazing and fisher men dwelling disturbed sites were separated together (T1, T2, B1&B2) on the right hand side of the axis.

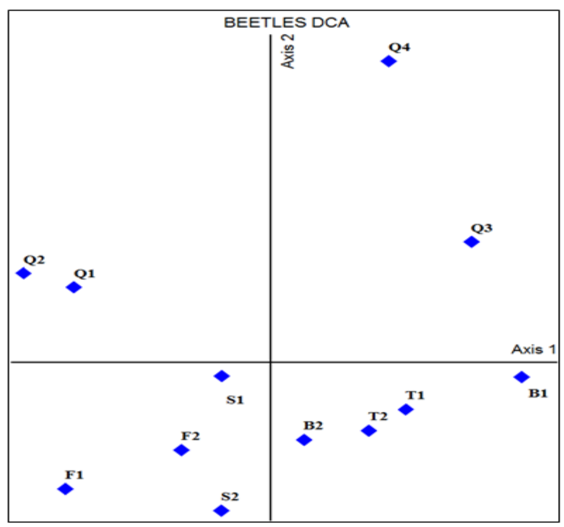


Fig 7: Detrended Correspondence Analysis (DCA) of beetle species for the study sites in Ashtoum El-Gamil protectorate

3.5. Canonical Correspondence Analysis (CCA).

The canonical correspondence analysis (CCA) was applied on the sampled beetle species on the basis of following environmental variables (vegetation cover, physical and chemical properties of soil).

3.5.1. CCA analysis between beetle species and vegetation cover:

Figure (8) shows the Canonical Correspondence Analysis (CCA) of beetle species collected by pitfall traps with the vegetation cover. The forward selection procedure of CCA resulted in the retention of three flora species from the tested flora species variables (*Tamarix aphylla*, *Sarcornia fruticos*, and *Mesembryanthemum forsskalei*).The natural sites (Q1, Q2, Q3 & Q4) were strongly associated with *Sarcornia fruticos* , *and Mesembryanthemum forsskalei*as they clustered at the right hand of the first axis (P <0.01). The disturbed sites (T1, T2, B1, B2&S2) were separated away from the natural sites by *Tamarix aphylla* (P < 0.01.), where, the disturbed sites were scattered around the left side of the first axis. The Sum of all canonical Eigen-values of the CCA axes was (0.7) with the first two axes accounted for 55 % of the total variation.

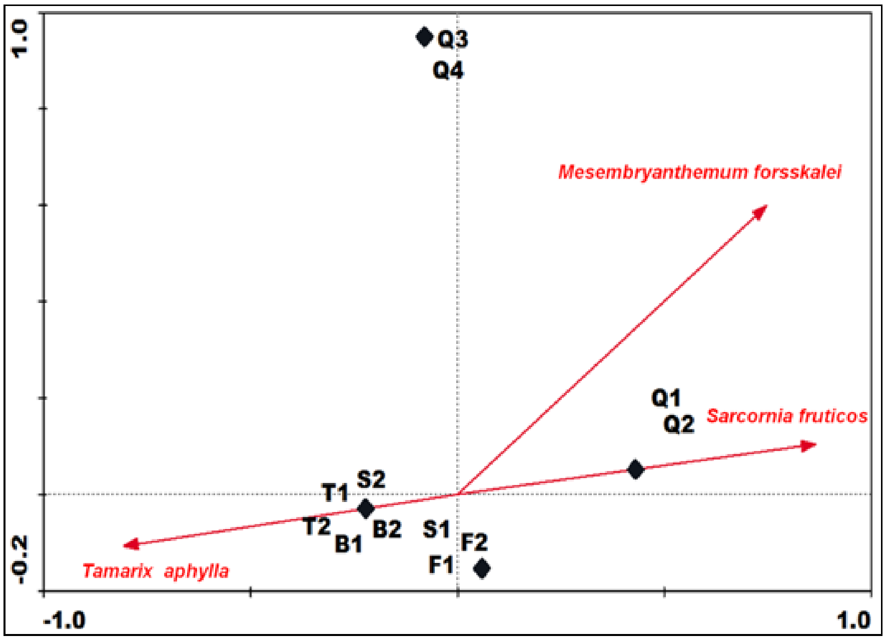


Fig 8: Ordination diagram based on a canonical correspondence analysis for the twelve study sites and flora variables bi plot in Ashtoum El-Gamil protected area.

3.5.2. Canonical correspondence analysis (CCA) between beetle species and soil parameters:

The biplot of the matrices corresponding to the sampling sites achieved by the two axes generated by the CCA .Figure (9), suggested eleven soil parameters were the most influential parameters which were significantly correlated (P<0.01) . These parameters located between the first two axes which had the highest Eigen-values (0.297, and 0.278). The arrow length indicates how much the sites differ along each environmental factor. The more important environmental factor has longer arrow. Water holding capacity (W.H.C %) shows the longest arrow followed by pH, Gravel%, clay %, Sand %, and Texture %(P<0.01) which were the main factors that affect the scattering shape of the studied sites.

The natural sites were mainly featured by pH, water holding capacity (W.H.C %), electric conductivity (E.C) , Nitrogen percentage (N%) and sand percentage (Sand%) parameters where pH, and sand percentage variables were shown to be mostly effective on Q1and Q2 sites .The disturbed sites S1 and S2were mainly correlated with Organic matter. It was clear that gravel %parameter was the most effective parameter on B2 and T1 sites. From the CCA analysis the two first axes accounted for 88 % of the total variation.

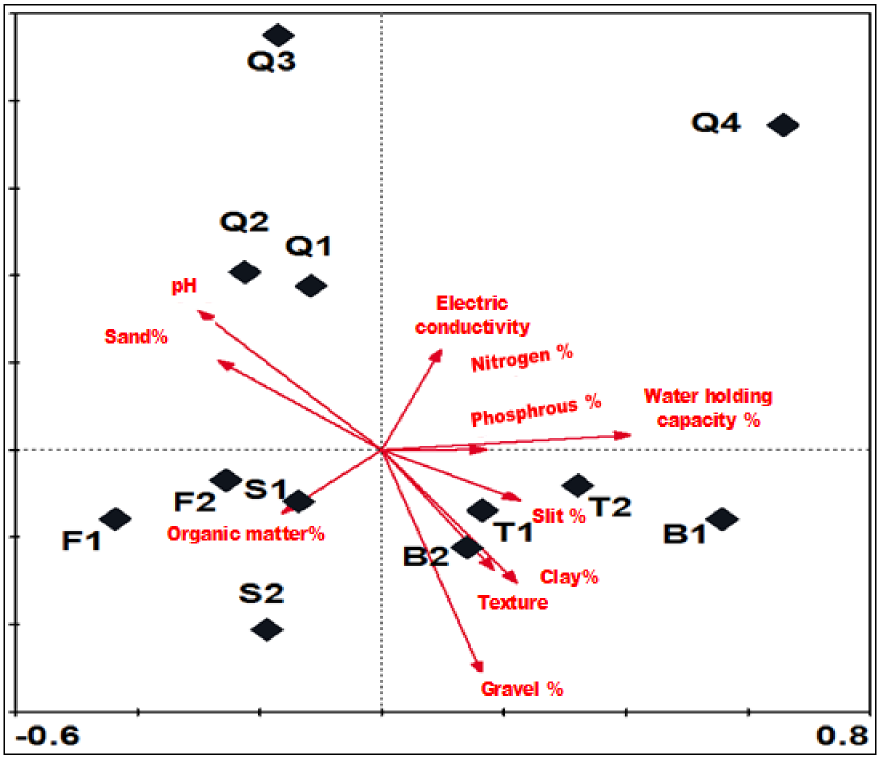


Fig 9: Ordination diagram based on a canonical correspondence analysis for the twelve study sites and most important Soil physical and chemical parameters bi plot in Ashtoum El-Gamil protected area.

3.6. Beetles indicator species

Beetles indicator species analysis showed three indicator species were significantly correlated with the study sites. Table (2).*Megacephala euphratica* (IV= 62.5, $p<0.01$) was found associated with disturbed sites (T1, T2, B1 & B2). The beetles indicator species *Scarites sinaiticus* (IV=62.5, $p<0.05$) recorded a significant correlation with disturbed sites (S1, S2, F1 & F2). On the other hand the natural sites (Q1&Q2) were characterized by the presence of indicative species *Lophyridia aulica.* (IV=100, $p<0.03$).

Table 2: The beetles indicators species showed by the indicator species analysis and the code of their groups.

Site	Group	Indicator Species	Indicator Value (IV)	P.value
T1, T2, B1 & B2	0	*Megacephala euphratica*	62.5	0.01
S1, S2, F1 & F2	1	*Scarites sinaiticus*	62.5	0.05
Q1, &Q2	2	*Lophyridia aulica*	100	0.03

T1	T2	B2	F1	F2	S1	S2	B1	Q1	Q2	Q3	Q4
0	0	0	0	1	1	1	1	2	2	3	3

4. Discussion

Over the last century, Mediterranean ecosystems have undergone important alterations as a result of extensive changes in land-use (De Fries et.al. [24]), however the Mediterranean basin has long been recognized as one of the biologically richest regions (Blondel and Aronson [25]). Ashtoum El-Gamil has been suffering from alteration in ecosystem – due to different forms of human use of the habitat– provokes an unbalanced situation which has, even when discrete, strong repercussions on the plant and animal communities. As a result, their specific compositions change, whether momentarily or over the long term. Beetles were used to evaluate local changes in ecosystems caused by different human activity.

The results obtained from beetles species effort curve showed stability of the population curve after the third trip which means that the most common species were trapped at the study area and both the sampling periods and the pitfall trap numbers are adequate for obtaining a complete picture of the beetle fauna at the study sites. However, to continue using these methods in their current form to add the remaining uncollected species would be an inefficient use of resources. This result agreed with Colwell and Coddington [26] where they argued that species accumulation curves based on trapping effort represent an even method, without bigotry of a collector's attention being given to rare species.

Comparison of the species compositions of beetles in the natural (control) and in the disturbed (impacted) sites showed clear differences in species occurrence and habitat preferences. Of the twenty two species only four were collected from both areas and slightly more species were found in the disturbed sites than in the natural ones.

Overall high beetle diversity was recorded in the disturbed sites, although these results are not statically significant, they provide support for previous studies which reported higher beetles diversity in disturbed sites (Niemelä et. al. [27], Ishitani et. al. [28]). In accordance, it is presumably because the increased complexity of the environment in the disturbed sites; a diversity of nutrient-rich plants, improved soil and water access and a resultant increase in prey provide resources for the beetles. (Baldissera et. al. [29], Silva et al. [30]).

As well, disturbed sites yielded higher abundance of beetles; however it exhibited a significant difference spatially among different study sites. While, species abundance can be a misleading indicator of conservation value because disturbed sites as high in species abundance, will often be characterized by widespread, abundant generalist species (Spence et. al. [31] , Koivula et. al. [32], Niemelä et. al. [33], Paquin et. al. [34]).The variance of diversity indices and species composition spatially between disturbed and natural sites may be referring to the differences of land use among the different studied sites, as many studies revealed that the differences of land use have indisputably a major impact on the structure of animal's communities (Andow [35] , Gurr et. al. [36]). Also, Lassau et. al. [37] found that higher complex habitats will create more different niches that can be utilized for the different beetle species. In consistence, some species composition varied between natural and disturbed areas, because some species have different adaption to disturbance. (Hansson [38]).

The species composition of beetles varied clearly and mirrored the entire variety of habitat forms investigated within the study area at Ashtoum El-Gamil protectorate. The result of Cluster analysis, DCA and CCA analysis showed that the beetle assemblages were differentiated among the habitats examined, with the four natural sites (Q1, Q2, Q3 and Q4) being particularly distinct from the other disturbed sites in terms of species composition. Species distribution was constrained mainly by environmental conditions (vegetation cover and soil type) in accordance with numerous other studies (Downie et. al. [39], Perner and Malt [40], Beals [41] and Lambeets et. al. [42]).

The significant differences between natural and disturbed habitats are revealed according to CCA analysis. Kaila et al. [43] found a similar trend that the natural and disturbed habitats varied significantly, due to various environmental factors and access to the resources.

As the correlation of soil water holding capacity, pH, percentages of gravel, clay, sand, and texture ($P < 0.01$) with the beetles dataset and the constrained ordination indicate that these measures reflect environmental parameters which influence the composition of beetle species assemblages at the studied sites. The fact that some species of beetles are sensitive to the factors associated with the soil properties has been clarified by many studies (Sądej et. al. [44], Birkhofer et. al. [45]). The soil texture and the percentage of the clay at a site have been found by other studies to be an important factor explaining beetles distributions; for instance the majority of scarabaeidae species prefer sandy soil to clay soil. The ability to produce more tunnels, and thus more offspring, in sandy soil would increase a beetle's fecundity. Increased fecundity of beetles inhabiting sandy areas would then increase population sizes and lead to a greater chance for diversity (Nealis [46]). Soil pH also has been cited as a significant environmental characteristic shaping ground beetle distributions (Sądej et. al. [44]).

As predicted, there was a significant effect of habitat vegetation in analysis of beetle species composition. The positions of the centroids of the different habitats in the CCA plot, and the arrangement of the different plant species as it was applied on the sampled beetles, shows that plot in the natural sites had a species composition that differed substantially from plots in the disturbed sites. Halophytic vegetation as *Sarcornia fruticos*, and *Mesembryanthemum forsskalei* were most associated with the beetles' assemblages of the natural sites. This result agrees with that provided by Erwin and Aschero ([47]) and Marcum ([48]), as beetles are salt tolerant assemblages particularly Carabidae species.
Similar tendency is evident in cluster analyses and DCA, they effectively classified study sites based on beetles species composition in two main habitat-

preference types; natural and disturbed sites. Heterogeneity between the studied habitats was found in terms of several exclusively collected beetle species. Several studies have succeeded in identifying distinct clusters based up on beetles assemblages (Willand et. al. [49], Kosewska et. al. [50]).

Globally, beetles are increasingly being considered in conservation biology. The use of carabids as environmental and ecological indicators has been supported by several studies (Niemelä et. al. [6], Larsen et. al. [51], Rainio and Niemelä [52]). Accordingly, of the beetles families evaluated in this study as indicators, Carabidae species appear to be the best indicators of natural sites. Our results indicate that specific carabid species are associated with natural sites, while other carabid species are generalists, occurring in most of sites. There are three species that could potentially serve as indicators of natural sites: *Cephalotatibialis, Lophyridiaaulica*, and *Dyschiriusbeludscha.*In accordance, Niemelä et al. ([27]) detected differences in carabid species composition, richness, and other diversity indices along an urban-rural disturbance gradient.

Additionally, indicator species analysis was used to examine whether species showed an affinity for different habitats.It identified 3 species were significant indicators. Carabid species *Lophyridia aulica* (Indicator Value (IV) =100, p<0.03) was found indicative with natural sites group. Where, IV equals 100 means that the presence of a species points in to a group without error (McCune et. al. [23]).In the same context previous studies on the effect of disturbance or management practices indicate that carabids are frequently used to indicate habitat alteration (Niemelä et. al. [6]; Spence et. al. [31], Koivula et. al. [32], Niemelä et. al. [33]).

5. Conclusion

Over the past decade there has been increasing recognition of the value of invertebrates as bioindicators globally. The results utilized in the present study were found applicable in evaluation of the conservation management at Ashtoum El- Gamil protectorate. It is clear that some invertebrate species such as beetles could be selected as bioindicator of different aspects of anthropogenic disturbance. They revealed that the environment of the protectorate is affected by disturbance around.

Increased efforts to compile knowledge and gather data by surveying other invertebrate fauna at the protectorate will help to improve our understanding of these valuable creatures' responses to disturbances. We advocate expanded monitoring of disturbed sites and other recommend invertebrates as potential bioindicators to complement environmental risk assessments.

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