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Ants Community Patterns in Native and Invaded Desert Habitats

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ABSTRACT

Over the four seasons, a total number of 121,488 individuals representing 43 ant species in 16 genera and 5 subfamilies which belong to the family Formicidae were collected by the pitfall traps. The one-way ANOVA's showed no significant difference between all groups of sites for the species abundance, the Shannon diversity index H and evenness, while the Simpson species diversity D and richness showed a significant difference. Despite the similarities between the forest and desert habitat in terms of univariate analysis, the multivariate analysis showed a clear differentiation between them. The PCA, cluster analysis and CCA reveal a significant difference in species composition, especially between all the forested sites and the control. The use of exotic tree species for plantation of woody forest in the Serabium region significantly does alter assemblage patterns, species richness and diversity of ants native to this habitat.

INTRODUCTION

The hazard of introduction and transmission of exotic species was facilitated by the increase in global trade and travel making it becomes invasive in many different biogeographic regions around the world (Vila & Hulme, 2017). Invasive alien species (IAS) refer to a species, subspecies, or lower taxon, are non-indigenous species whose entry and/or spread beyond their original range threaten biodiversity. They include any part, gametes, seeds, eggs, or propagules of these species that may remain alive and reproduce later (Kettunen *et al*., 2009). The extent to which introduced species may proliferate and spread is affected by the state of the receiving ecosystem. Exotic species may spread and proliferate when they find a vacant niche, or they may compete for one that is already taken by local species. Some IAS can reproduce easily because they do not have natural enemies in their new habitat (Chenje & Katerere, 2006). Invasive alien species (IAS) are one of the major and most rapidly growing threats to biodiversity, human and animal health, security, and food (Davis 2009). The increasing number of non-indigenous species movements and their subsequent settlement highlights the crucial need for more effective actions for early detection, prevention, and control of IAS (Seebens *et al.*, 2017).

Many invasive alien plants are disrupting the dynamics of ecosystems in ways that enhance their own existence and pushing native species toward extinction, through strengthening feedbacks, causing regime shifts (change states of ecosystem function and structure that may become irreversible). Examples include effects on soil-nutrient cycling produced by invasive shrubs and trees in forests and by non-native herbaceous in wetlands, through altering the composition of soil seed banks and modifying fire regimes (Gaertner et al., 2014; Shackleton et al., 2018) and altering microbial communities (Bowen *et al.,* 2017).

Humans are exponentially reshaping global biogeography by transferring species to regions outside their home ranges, where they may become permanently added to the resident biota (Meyerson & Mooney, 2007 and Turbelin, Malamud, & Francis, 2017). Invasive alien species are one of the five key drivers causing biodiversity loss, alongside over-harvesting, habitat destruction, pollution and climate change (Reid et al., 2005 and Blackburn, Bellard, &Ricciardi, 2019). The impacts of the IAS species on biodiversity loss are well known, as they are implicated in the extinction of 261 of 782 animal species and in 39 of 153 plant species worldwide (Bellard, Cassey, & Blackburn, 2016; Blackburn, Bellard, & Ricciardi, 2019). Invasive alien species have caused major environmental damages and economic loss of billions of dollars each year; in the energy, forestry, agriculture loss, health sectors and the negative effects on the delivery of ecosystem services (Shackleton *et al.*, 2019 a).

The total area of forest plantations is growing throughout the world thereby helping to meet the demand for timber and the protection of natural forests (Verheyen *et al*., 2016). It is well documented that conversion from treeless landscapes to forests can have negative effects on living organisms that adapt to open habitats. Major land changes are likely to result in great changes in fauna and flora, so there is a need to assess the biodiversity value of habitats that could potentially be used in plantation forests. This will establish which habitats may be of less ecological or conservation importance, and hence should be more readily selected for afforestation (Pawson *et al.,* 2013).

Ismailia is one of many Egyptian governorates that follow the national programme for safe use of treated sewage water for afforestation aspects, which is applied in Serabium forest. The Egyptian environmental affairs agency had introduced many timber trees in many Egyptian governorates. Examples of trees introduced in the Serabium forest are *Agave sisalana*, *Cupressus sempervirens*, *Pinus halepensis*, *Khaya senegalensis*, *Eucalyptus camaldulensis* and *Eucalyptus citriodora* (Hammad H.H., *et al.*, 2020).

Ants are considered as one of the most important groups taxonomically because of their numerical abundance, size and richness (Jahana. M.N. *et. al.*, 2022) These, besides the fact that ants occupy higher levels in the food chain and often specialized niches, suggest that they can be suitable bioindicators for various environmental parameters (Majer, *et. al.*, 2007 and Zina, *et. al.*, 2021). They are widely distributed, easily collected, and comprise an important part of the animal biomass in terrestrial ecosystems (Fittkau & Klinge, 1973). They also respond to stress more accurately on a much finer scale than do vertebrates (Andersen, 1997 & 2018). Moreover, ants are particularly prominent among insects for their ecological dominance as predators, scavengers, and indirect herbivores (Wilson & Holldobler, 2005 and Verdinelli, *et. al.*, 2017). Ants have been promoted as particularly useful biological indicators, in particular, to detect the colonization of alien species and potentially invasive species, and to determine the success or failure of land management and reclamation plans that cannot be identified by monitoring vegetation cover alone and monitoring the permanent impacts of land use and changes (Philpott *et al*., 2010).

This study aims to assess the environmental impact of woody forest plantation in Serabium region using ants as a bioindicator, assessment of the spatial and temporal variation in the diversity of ants at the study area, comparing the ants in terms of the abundance, species composition and diversity between native habitat and the newly established forest habitat and studying the relationship between the environmental variables at different studied sites and how these variables can affect the composition of species at each site and Evaluation of the changes in the community structure of ants at the study area in relation to afforestation.

MATERIALS AND METHODS

Study Area:

The study area is located in the northeastern parts of the Arab Republic of Egypt 16 km south of Ismailia, in Serabium forest (30°29'N, 32°14'E, elevation 10 m) at the middle part of Suez Canal (Fig. 1). The semi-arid climate has characterized the region, with mean temperatures varying from 8.4 °C in the coldest month to 36°C in the warmest month. Annual rainfall is 35 mm. Ismailia is one of many Egyptian governorates that follow the national programme for safe use of treated sewage water for afforestation aspects, which is applied in Serabium forest in 2002. The Egyptian environmental affairs agency had introduced many timber trees in many Egyptian governorates. The widest spread of six canopy tree species in Serabium forest are Eucalyptus *camaldulensis Eucalyptus citriodora Agave sisalana*, *Khaya senegalensis*, *Cupressus sempervirens* and *Pinus halepensis* over nearly 600 feddans (Hammad H.H., *et al.*, 2020).

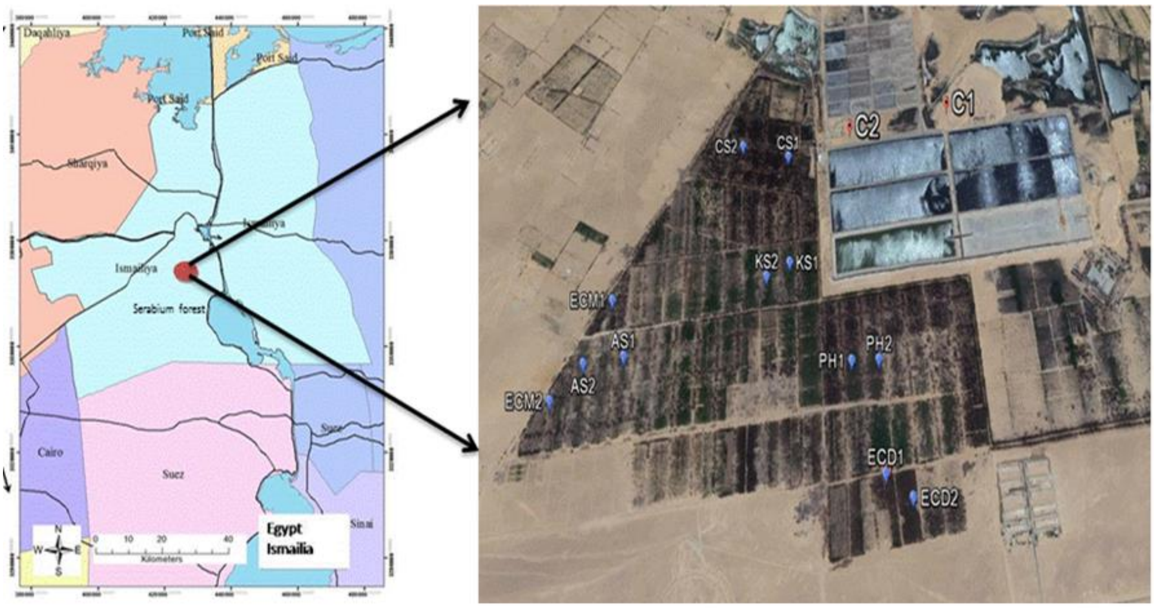

Fig. 1: Satellite photo showing the studied sites in forested area and deserted one in Serabium region, Ismailia governorate.

Table 1: Study sites abbreviation code.

Code	Site name	Code	Site name	Code	Site name
C1	Control 1	**PH2**	*Pinus halepensis* 2	**ECM1**	*Eucalyptus camaldulensis* 1
C2	Control 2	**KS1**	*Khaya senegalensis* 1	**ECM2**	*Eucalyptus camaldulensis* 2
CS1	*Cupressus sempervirens* 1	**KS2**	*Khaya senegalensis* 2	**ECD1**	*Eucalyptus citriodora* 1
CS2	*Cupressus sempervirens* 2	**AS1**	*Agave sisalana* 1	**ECD2**	*Eucalyptus citriodora* 2
PH1	*Pinus halepensis* 1	**AS2**	*Agave sisalana* 2		

Sampling Methods:

Within each canopy species, two sampling sites were established along with two sites also chosen in the Serabium open desert to represent the natural ecosystem as the control site (Fig. 1 and Table 1). Ants were trapped by the Pitfall trap technique over a period of four successive seasons of 2010 (winter, spring, summer and autumn). The pitfall traps consisted of a plastic cup (5 cm diameter and 11 cm depth) flush with the ground and filled to the half with a preservative solution (45% water, 45% methanol alcohol, 10% glycerin). In each site, 45 pitfall traps were fixed; traps were arranged on rectangular quadrate (50 m X 150 m) in three rows, with 25 m between lines and 10 m intervals among traps giving a total of 630 pitfall traps in 14 sites. Traps were active for one week and then collected. Specimens were stored, separated into morphospecies, counted and preserved in 70% ethanol alcohol with few drops of glycerin for further identification. The ant collection was identified by Dr. Mostafa R. Sharaf (Associate Professor) at the economic entomology research unit (EERU), at King Saud University in the Kingdom of Saudi Arabia.

Environmental Variables:

The total percentages of the trees' cover for each line were estimated and wild plants were mostly identified in the field. Species that can't be identified in the field were universities. Four 1 m² quadrats were randomly laid out within each transect. Within each quadrat, the percentage of bare ground, the depth and percentage of ground covered by litter, the percentage of the woody debris and the percentage of plant cover were recorded.

Three random soil samples from depth 0-30 cm were taken from each transect for physical and chemical analysis. The chemical variables included: pH, electric conductivity (EC), soil organic matter (SOM), total phosphorus (TP), nitrogen (N), total Soluble salts (TSS: HCO_3, Cl^-, So_4^{-2}, Ca^{+2}, Mg^{+2}, Na^+ and K^+). The physical variables included: soil texture (percentages of gravel, sand, silt, and clay) and water-holding capacity (WHC), Soil analysis was conducted at the Agricultural Research Center at Suez Canal University.

Data Analysis:

The data were analyzed using the PC-ORD 4.10 package (McCune & Mefford, 1999), Canoco 4.5. (ter Braak , 1994) and the SPSS for Windows 12 statistical software package (SPSS, Inc. 1996).

The five univariate parameters; Simpson's diversity index, Shannon's diversity index, species evenness and species richness and mean abundance were measured by PC-ORD. Differences in spider's univariate measurements per plot between sites were compared using one-way analysis of variance (ANOVA) by the SPSS program (Zar, 1999).

Classification:

The aim of the classification is to get groups of objects (samples, species) that are internally homogeneous and distinctive from other groups. Cluster analysis is a data exploration tool for dividing a multivariate dataset into "natural" clusters (groups) so it can distinguish homogeneous groups formed from heterogeneous ones of variables (Leps & Smilauer, 2003).

Ordination:

Ordination is an analytical method of "ordering" species and/or samples along ecological gradients. It is applied to illustrate patterns of species distribution and abundance that reflect an underlying and causal environmental gradient. Ordination methods depend on a unimodal model of species that interacts with environmental gradients (Baxter, 2014).

Graphical diagrams illustrate the main structure of multivariate tables in two or three dimensions. This depends on the model used to create the graphs how the data tables are illustrated, and thus how to interpret the graphs. In nearly all applications in ecology, the interpretation is either by distance among points (distance diagram) or via directions across the diagram (biplots) (Ter Braak, 1994).

Two methods of ordination were performed: Principal component analysis (PCA) and canonical correspondence analysis (CCA) using the PC-ORD program. Principal component analysis (PCA) is one of the most widely used ordinations and oldest methods. The main idea of principal component analysis (PCA) is to reduce the dimensionality of a data set consisting of many variables while preserving as much variability as possible (Forkman et. al. 2019). On the other hand, canonical correlation analysis (CCA) ordination was used to investigate associations of ant species and sites with environmental variables using data for all 14 sites. It is an ordination technique that connects ordination with multiple regression. The magnitude and direction of the vectors in the species-environment biplots represent the degree of correlation between species and environmental variables (Baxter, 2014).

Indicator Species Analysis:

Indicator values are calculated by means of the Dufrene & Legendre method (1997). Analysis of indicator species is a divisive polythetic process of numerical classification that can be applied to large groups of quantitative or qualitative data. This process provides an easy and intuitive solution to the problem of species evaluation associated with sets of sample units. It combines information about the concentration of species abundance in a particular group and the constancy of occurrence of a species in a certain group. This process provides indicator values for each species in each group. These are examined for statistical significance using a Monte Carlo technique. It requires data from two or more sample units. Indicator values (range from 0 for no indication to 100 for perfect indication) are displayed for each species. The statistical significance of the maximum recorded indicator value for a given species is generated by a Monte Carlo test. There are many kinds of indicator species ranging from individual species (Dufrene & Legendre, 1997).

RESULTS

The Overall Pattern of Diversity:

Over the four seasons of collection, a total number of 121,488 individuals representing 43 ant species in 16 genera and 5 subfamilies which belong to the family Formicidae were sampled in the pitfall traps. 95% of the total individuals were recorded in the forested sites, whereas 5% of the total individuals have recorded in the control deserted sites.

There were 28 ant species recorded in both the desert (control) and the forested habitats. 14 ants species were recorded in the forest habitat only with three species that were common in all the studied forested canopies (*Cerapachys longitarsus*, *Nylanderia jaegerskioeldi*, and *Trichomyrmex destructor*). There was only one species recorded in the control sites and disappeared from the forest habitat (*Camponotus* sp.3). The most species-rich subfamilies were Myrmicinae (23 species) followed by Formicinae (15 species), then Dolichoderinae (3 species), and finally Dorylinae and Ponerinae (1 species for each).

Trends in Richness, Abundance and Diversity*:*

Trends in Richness and Abundance:

A total of 43 ant species was recorded from the 14 sites (12 forested sites and two control sites) of the study area, with the minimum number of ant species richness and mean abundance (20 species and 61 individuals) were recorded in the two control sites C2 and C1 respectively. The maximum number of ant species richness and mean abundance (34 species and 439 individuals) were recorded in the two forested sites ECD2 and CS2 respectively. The one-way ANOVA's showed a highly significant difference between the different forested and control sites ($F_{(1, 12)}$ =11.90 and P<0.01) in terms of species richness, while the one-way ANOVA's showed no significant difference between the forested sites and control sites in terms of species abundance.

Trends In Diversity and Evenness:

The two diversity indices for the ant species were as follows; the (H) value ranged from 1.04 in the control site (C2) to 1.95 in the forested site KS2 and ranged from 0.45 in the control site (C2) to 0.83 in the PH1 forested site for (D) across all sites. The evenness value ranged from 0.35 in the C2 control site to 0.60 in the PH1 site. The one-way ANOVA's showed no significant difference between all groups of sites for the species diversity index H and evenness, while for the species diversity, D, showed a highly significant difference between the different studied sites ($F_{(1, 12)}$= 7.41 and P<0.02). (Table 2).

Table 2. Summary of diversity parameters for ants sampled across the 14 studied sites. Species number (S), evenness (E), Shannon diversity (H'), and Simpson diversity (D').

Site	Mean abundance	S	E	H'	D'
AS1	221.35	30	0.464	1.579	0.665
AS2	305.88	29	0.470	1.584	0.728
CS1	155.23	31	0.554	1.902	0.807
CS2	438.74	26	0.364	1.187	0.508
PH1	179.58	31	0.601	2.065	0.832
PH2	222.95	31	0.391	1.343	0.637
KS1	114.07	29	0.509	1.713	0.760
KS2	121.47	28	0.585	1.948	0.819
ECM1	158.30	31	0.381	1.307	0.624
ECM2	145.65	26	0.473	1.541	0.687
ECD1	309.47	29	0.528	1.777	0.797
ECD2	313.95	34	0.480	1.694	0.722
C1	61.186	26	0.422	1.375	0.580
C2	77.465	20	0.347	1.041	0.453
Total Average	**201.81**	**28.6**	**0.469**	**1.575**	**0.687**

Multivariate Analysis:

Cluster Analysis:

The cluster dendrogram carried out for the 14 sites resulted in three clusters or groups (G1, G2 and G3). In the first group (G1) the two control sites (C1 and C2) were separated together from all the other forested sites by the ant species *Temnothorax* sp., which was common in the control sites (C1 and C2). The second and third cluster divisions; separated the seven forested canopy sites (CS1, CS2, KS1, KS2, ECM1, ECM2 and PH1) in group two (G2) from group three which represented by the five forested sites (ECD1, ECD2, PH2, AS1 and AS2). The characteristic ant species for (G2) were the five species; *Camponotus* sp.1, *Plagiolepis pallescens maura*, *Tetramorium lanuginosum*, *Tetramorium* sp. and *Trichomyrmex destructor* while the four ants' species, *Cataglyphis holgerseni*, *Cataglyphis* sp.2, *Messor* sp.2, and *Tapinoma simrothi* were common in group three.

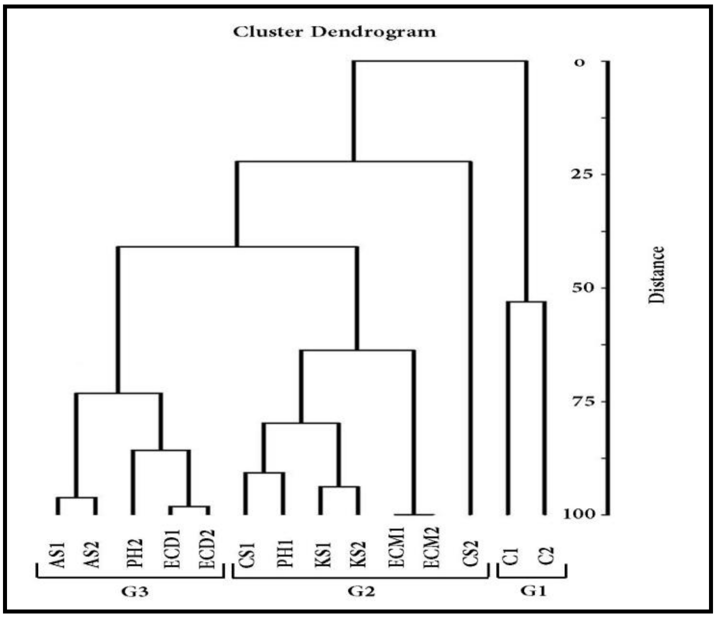

Fig. 2: Cluster dendrogram of the ants' species for all the sites of the study area (12 forested and 2 control sites).

Principal Component Analysis (PCA):

Figure (3) shows the two control sites C1 and C2 as (G1) were clustered near each other in the upper right quarter between axis 1 and axis 2 with their characteristic ants' species *Temnothorax* sp. The second cluster (G2) includes CS2 and ECM2 were separated at the lower right quarter from the rest of the sites. The third cluster (G3) includes KS1, KS2, ECM1, CS1, and PH1. The last fourth cluster (G4) includes the remaining five forested sites, AS1, AS2, ECD1, ECD2, and (PH2) which were grouped separately from the rest of the sites at the upper left quarter with their own four preferential ants' species, *Cataglyphis holgerseni*, *Cataglyphis* sp.2, *Messor* sp.2, and *Tapinoma simrothi*. The first two axis contributed 88% of the total variation.

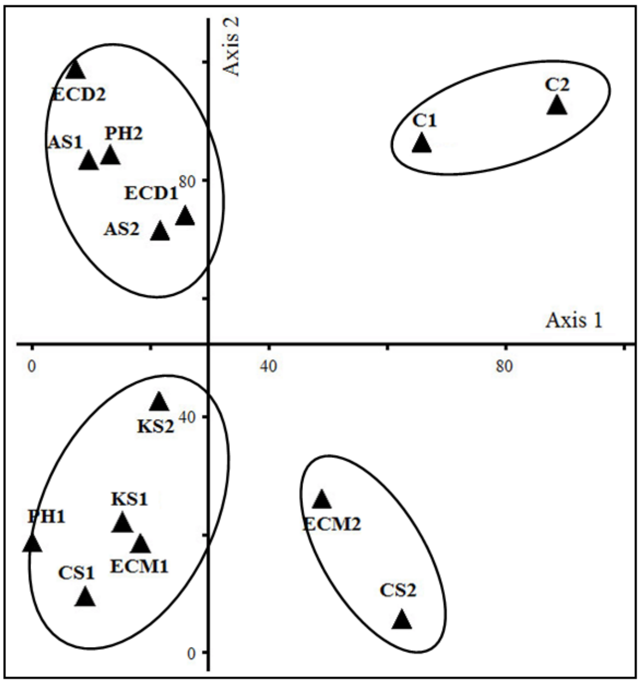

Fig. 3: Principal component analysis (PCA) of ants' species for all the studied sites (12 forested and 2 control sites).

Environmental Variables and Diversity:

The canonical correspondence analysis (CCA) was conducted to measure the correlation between the environmental variables (chemical and physical properties of soil, land cover, flora and all the environmental variables combined) and the sampled ants' species composition.

1- Chemical and Physical Properties of Soil:

A total number of 18 variables (13 chemicals and 5 physical) were used during this analysis. Chemical variables were tested separately with the most important variables of them. From the 13 variables, only six showed a high correlation coefficient affecting the scattering shape of the studied sites. These variables are located between the first and the second axes which had the highest eigenvalues (0.20 and 0.16) respectively.

Figure (4) shows the relationship between the Chemical properties of soil and the ants. Forested sites AS1 and ECD2 respectively were strongly correlated with Ca^{+2}. AS2 forested site shows the maximum correlation with both TSS, EC and Na^{+} than any other sites. PH2 site is closely located between two arrows (N and Ca^{+2}) and therefore, a perpendicular line can be dropped on both arrows to determine the most influential factor. The PH2 site is located close to N and is more affected by this variable. Furthermore, CS2 site shows a high correlation with the P variable followed by ECD1. Both the control sites (C1 and C2) were clustered close to each other at the positive end of axis 1 separated from the forested sites.

On the other hand, figure (5) showed the different correlations between the most important soil, physical variables (3 of 5) and the 14 studied sites. These physical variables are clay, sand and WHC respectively. The two forested sites AS1 and ECD1 were strongly correlated with the clay variable, whereas ECM1 and CS2 are more influenced by WHC vector. The nearest site to sand variable was ECD2 and therefore, it was the most affected one by this factor. The control sites (C1 and C2) are located at the upper-right quarter of the two main axes (1 and 2) and showed a negative correlation with the physical soil factor (WHC).

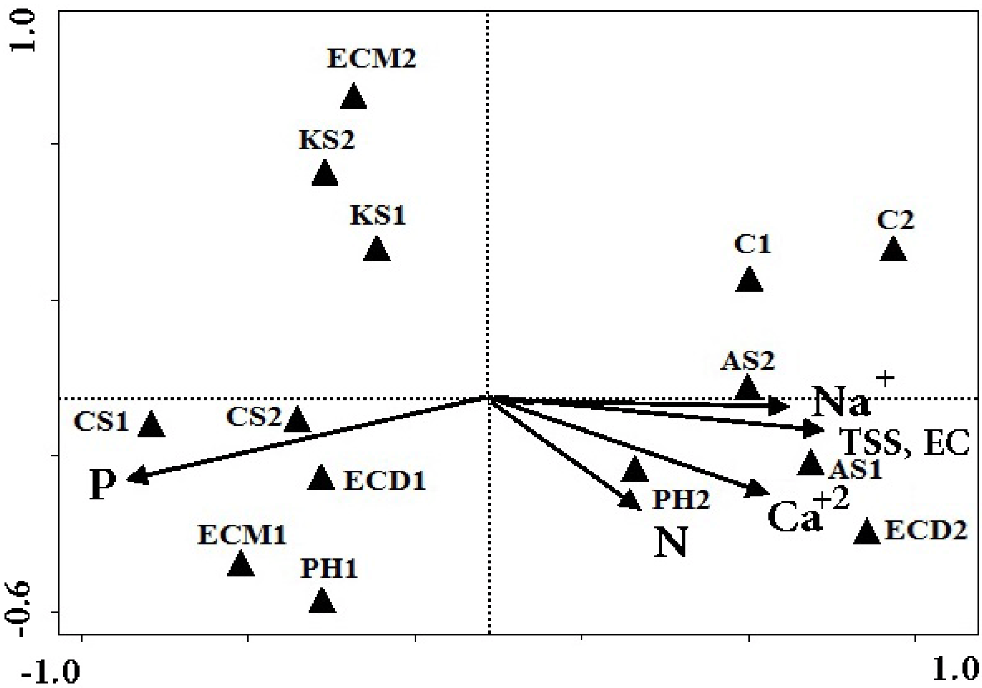

Fig.4: CCA Ordination diagram for axes 1 and 2 of the most important chemical soil variables (6 of 13) represented by arrows and different studied sites represented by triangles**.**

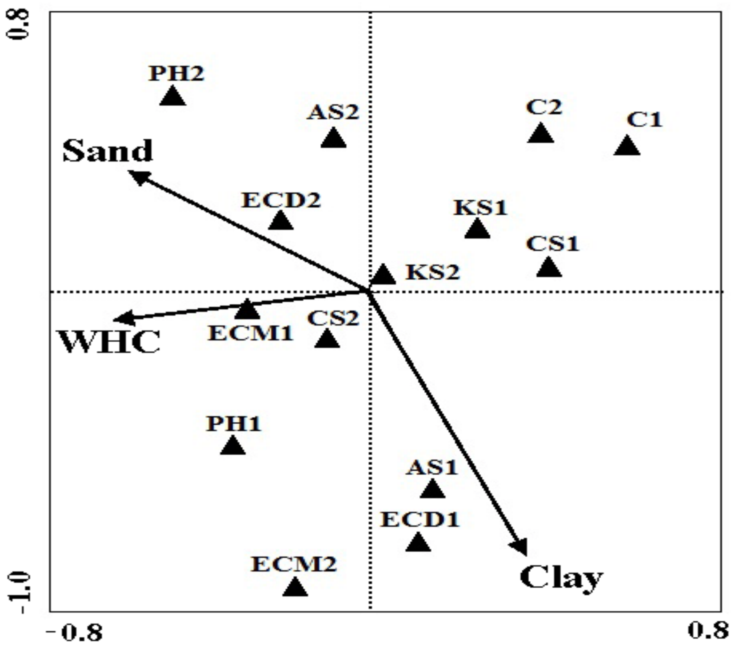

Fig. 5: CCA Ordination diagram for axes 1 and 2 of the most important physical soil variables (3 of 5) represented by arrows and different studied sites represented by triangles.

Land Cover:

Figure 6 shows the CCA ordination graph using the land-cover variables. The first two axes accounted for 94.1% of the total variation. In general, there was a strong correlation between the bare ground variable and ECM1. On the other hand, KS1, KS2 and PH1 possess a high positive correlation with the litter depth variable. ECD2 site was slightly correlated with two variables (log and plant cover). There is also a positive correlation between the litter cover variable and PH1 site followed by KS1 and KS2 sites respectively. Both control sites (C1 and C2) have a slight correlation with both plant cover and log variables.

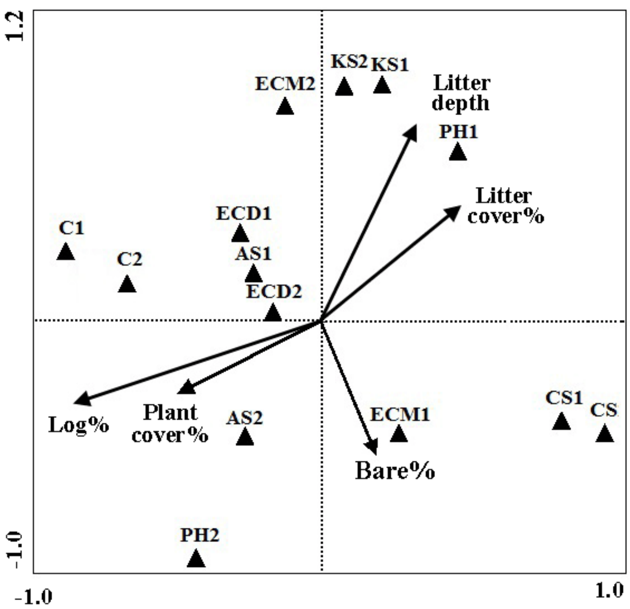

Fig. 6: CCA Ordination diagram for axes 1 and 2 of the five land cover variables represented by arrows and different studied sites represented by triangles.

3- Flora:

The CCA for the ants' species composition and the flora variables is shown in **figure 7.** The forward selection procedure of CCA resulted in the retention of five of 11 environmental variables.

These variables according to the strength of the correlation coefficients between these variables and the study sites are (*Eucalyptus citriodora*, *Agave sisalana*, *Cupressus sempervirens*, *Zygophyllum album*, and *Phragmites australis*) respectively. Axis 1 has the highest eigenvalue (0.50), followed by axis 3 with an eigenvalue (0.14). A high positive correlation was displayed towards the right end of axis 1, between *Cupressus sempervirens* and the two sites CS1 and CS2. On the other hand, both AS1 and AS2 were located near each other at the lower end of axis 3 showing a strong correlation with *Agave sisalana*. In addition, ECD1 and ECD2 sites were clustered at the negative end of axis 1 showing a very strong correlation with *Eucalyptus citriodora* variable, which was highly significant ($p<0.05$). With respect to control sites (C1 and C2), both were strongly correlated with *Phragmites australis*. Furthermore, C1 and C2 together have a more correlation with *Zygophyllum album* than AS1 and AS2.

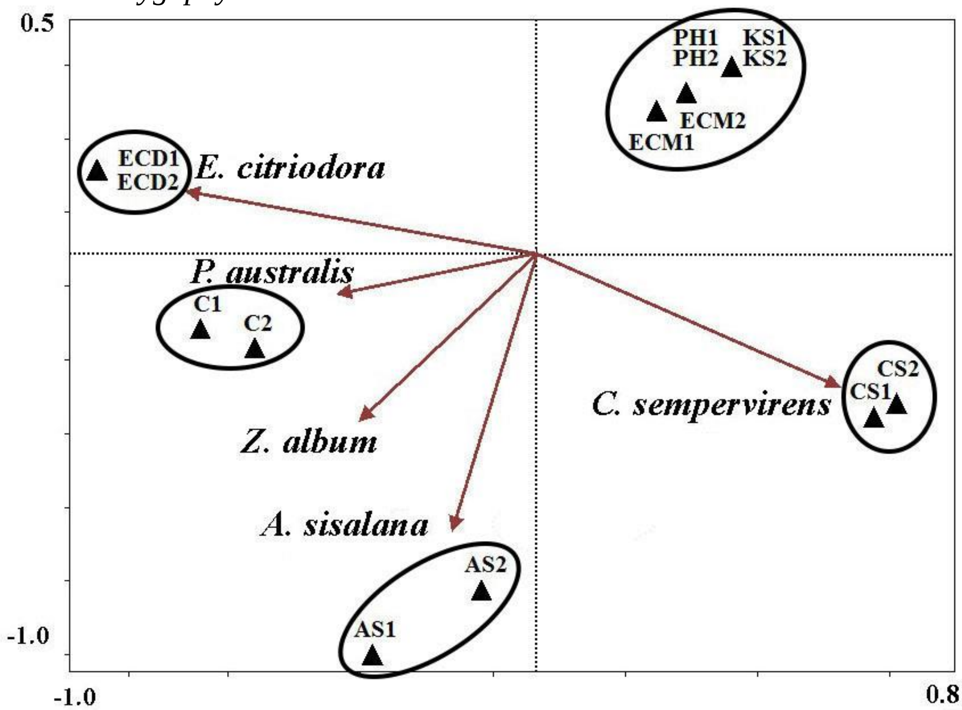

Fig.7: Canonical correspondence analyses (CCA) ordination biplots for axes 1 and 3 of the most effective flora variables (5 of 11) represented by arrows and different studied sites represented by triangles.

4- The Environmental Variables Combined Together:

The CCA for the 14 sites and all the environmental variables combined is shown in figure 8. The forward selection procedure of CCA resulted in the retention of 8 out of 34 environmental variables. Ca^{+2}, *Eucalyptus citriodora*, log, *Cupressus sempervirens*, *Agave sisalana*, sand, *Phragmites australis*, and clay, were the most important factors in the analysis and were important on both CCA axes. Eigenvalues for the two CCA axes were 0.52 and 0.20. The CCA shows the two control sites were clearly separated from the rest of the forested ones. They showed an association with the log variable. There is also a strong correlation between control sites (C1 and C2) with both *Phragmites australis* and Ca^{+2} variables. Control site C1 is more correlated with

Phragmites australis, whereas C2 is more correlated with Ca^{+2} factor. *Cupressus sempervirens* plant species showed a strong positive correlation with the second CCA axis. The arrow divided CS1 and CS2 with an almost equal positive correlation. Furthermore, the arrow of the *Agave sisalana* factor goes between AS1 and AS2 showing high correlations with this variable. ECD1 and ECD2 are correlated in the same manner by *Eucalyptus citriodora* variable. Clay variable showed a strong correlation with a group of forested sites clustered at the upper end of axis 2.

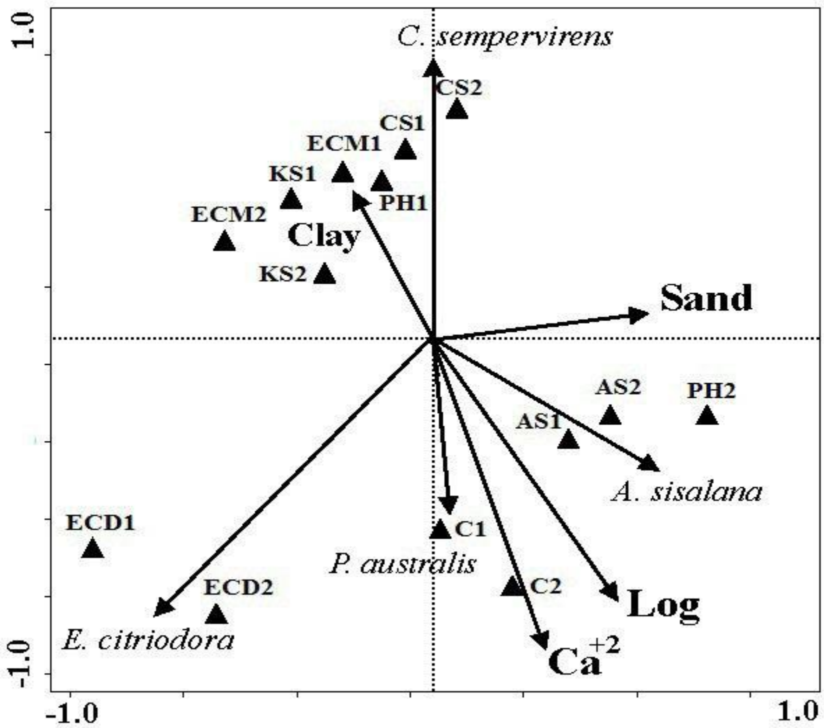

Fig. 8: Canonical correspondence analyses (CCA) ordination biplots for axes 1 and 2 of the most effective environmental variables combined represented by arrows and different studied sites represented by triangles.

Ants Indicator Species:

The indicator species analysis showed that ten ant species were significantly correlated with the studied sites (Table 3). According to the cluster dendrogram, the 14 studied sites are divided into 3 groups as shown in figure (2). The two control sites (C1 & C2) are characterized both by one species, *Temnothorax* sp. with (P<0.047).

There were five ant species that prefer CS1, CS2, PH1, KS1, KS2, ECM1 and ECM2 canopy sites, which were represented by *Plagiolepis pallescens maura* (P<0.01), *Camponotus* sp.1 (P<0.01), *Tetramorium* sp. (P<0.01), *Tetramorium lanuginosum* (P<0.01), and *Trichomyrmex destructor* (P<0.01). On the other hand, AS1, AS2, PH2, ECD1 and ECD2 canopy sites were characteristics by the four ant species, *Cataglyphis holgerseni* (P<0.01), *Cataglyphis* sp.2 (P<0.01), *Messor* sp.2 (P<0.01), and *Tapinoma simrothi* (P<0.01).

Table 3: Ants species that were shown to be statistically significant indicators of the grouping produced.

SP.	Indicator species	Indicator value	*P-value*	Group code
SP 37	*Temnothorax* sp.	51.2	0.047	0
SP 3	*Camponotus* sp.1	53.3	0.012	1
SP 32	*Plagiolepis pallescens maura*	55.4	0.038	1
SP 39	*Tetramorium lanuginosum*	75.1	0.001	1
SP 41	*Tetramorium* sp.	85.8	0.002	1
SP 42	*Trichomyrmex destructor*	96.9	0.001	1
SP 7	*Cataglyphis holgerseni*	49.9	0.002	2
SP 10	*Cataglyphis* sp.2	71.9	0.014	2
SP 18	*Messor* sp.2	66.7	0.026	2
SP 34	*Tapinoma simrothi*	61.4	0.004	2

Sites	C1	C2	CS1	CS2	PH1	KS1	KS2	ECM1	ECM2	AS1	AS2	PH2	ECD1	ECD2
Group Code	0	0	1	1	1	1	1	1	1	2	2	2	2	2

DISCUSSION

Biological invasions are in fact one of the significant drivers of biodiversity changes (Sala *et al*., 2000). The use of exotic tree species for plantation of woody forests in the Serabium region significantly does alter assemblage patterns, species richness and diversity of ants native to this habitat as each habitat supports distinct ants' assemblages that reflect major differences in both the environmental conditions and management (Campos *et al*., 2006)

The current work shows that both the sampling periods and the pitfall trap numbers are adequate for obtaining a complete picture of the ants' fauna at the study sites. Pitfall trapping is likely the most widely utilized method for sampling ground-dwelling arthropods (Cheli & Corley, 2010) because of its simplicity, efficiency and low costs.

In fact, the use of exotic tree species for plantation of woody forest in the Serabium region significantly does alter assemblage patterns, species richness and diversity of ants native to this habitat. Despite the similarities and differences between the forest and desert habitat in terms of univariate analysis, the multivariate analysis showed a clear differentiation between them as many studies have focused on changes in species composition rather than changes in diversity indices. Alien plant species can change the physical properties of the soil environment directly, leading to changes in environmental variables that may control the composition and function of the soil community (Duda *et al*., 2003). According to Lach *et al*. (2010), the abiotic environment affects so many aspects of ant ecology and can strongly limit the activity and local abundance of invasive ants.

Ants are one of the most important groups of terrestrial arthropods that have been commonly used as bioindicators in land management (Andersen, *et al*., 2002, Jiménez-Carmona *et. al.,* 2020 and Zina, V *et. al.,* 2021). They are widely used to evaluate landscape disturbance, ecological functioning and species diversity of habitats. In many terrestrial ecosystems, ants are an important taxonomic group with regard to their size, numerical abundance, and species richness. This, and the fact that ants occupy higher trophic levels and often specialised niches, indicates that they may be good bioindicators for several environmental parameters. They occur all over the world, are easily collected, are well known taxonomically, and constitute an important fraction of the faunal groups in terrestrial ecosystems (Andersen & Majer, 2004; Paknia & Pfeiffer, 2011).

Some environmental variables were measured in this study to investigate their effects on species composition. These variables are land cover, flora composition and soil analysis. Exotic plant species can change the physical properties of the soil environment directly, causing alterations in environmental variables that may control the function and composition of soil communities (Duda *et al*., 2003).

In the current assessment, PCA, cluster analysis and CCA analysis were carried out between the different studied sites that reveal a significant difference in species composition especially between all the forested sites on the one hand and between the control sites (open desert habitat) on the other hand. This could be due to the relationship between ants and the degree of habitat alteration.

As a result of human activities, plant species are introduced continuously into new habitats, where they often flourish and significantly change the properties of native ecosystems. However, as exotic plant invasions continue, an integrated understanding of ecosystems is necessary for clarifying basic principles of community ecology and for the successful management and restoration of communities that have been invaded.

Finally, intensive global trade and transportation have been blamed to be the main cause of biological invasions (Meyerson & Mooney, 2007). The introduction of non-indigenous species is well accepted to cause both economic and ecological effects on ecosystem services worldwide through their influences on biodiversity and ecosystem processes (Simberloff *et al.,* 2013). It is therefore necessary to better understand the impacts of the increased introduction of invasive species: important in terms of not only biodiversity loss but also regarding effects these invasions have on our lives (Vila & Hulme, 2017).

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ARABIC SUMMARY

أنماط مجتمع النمل في البيئيات الطبيعية والغازية الصحراوية.

جمال م .عرابي*[1] ، عبد الرحمن العجمي[2] ، وفايز م صميدا[1]
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على مدى الفصول الأربعة، تم جمع ما مجموعه 121488 فردا يمثلون 43 نوعا من النمل في 16 جنسا و 5أسر فرعية تنتمي إلى عائلة Formicidae بواسطة المصائد الارضية. ووجد أن اختبار فرق المعنوية ANOVAلم يظهر فرقا كبيرا بين جميع المجموعات من المواقع المختلفة بالنسبة لوفرة الأنواع، ومؤشر التنوع شانون H والوفرة النسبية، في حين أن تنوع الأنواع سيمبسون D والثراء أظهرت فرقا كبيرا .وعلى الرغم من أوجه التشابه بين الغابات والموائل الصحراوية من حيث التحليل الأحادي المتغير، أظهر التحليل المتعدد المتغيرات وجود تمايز واضح بينهما .ويكشف كل من ال PCA وتحليل المجموعات و CCAعن اختلاف كبير في تكوين الأنواع خاصة بين جميع المزارع التشجيرية في المنطقة الصحراوية. إن استخدام أنواع الأشجار الغريبة لزراعة الغابات الخشبية في منطقة سيرابيوم قد غير بشكل كبير أنماط التجميع وثراء الأنواع وتنوع النمل الأصلي لهذا الموئل.