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Former and Present Vegetation of Kraman Island, Upper Egypt

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ABSTRACT. The application of Two Way Indicator Species Analysis (TWINSPAN) classified the island into four different habitat types. Each of them comprises different communities with indicator species of their own.

Deterended Canonical Correspondence Analysis (DCCA) was used to study species-environment relationships. Accordingly, the most important environmental factors affecting the distribution and structure of the present communities are: moisture content, depth of water, $CaCO_3$ concentration, organic carbon and soil texture.

The former vegetation of the island was studied through palynological technique. DCA (Deterended Correspondence Analysis) ordination of TWINSPAN pollen assemblage groups clarified the distribution of hydrophytes in the lowermost layer and mesophytes in the uppermost layer of profile dug (60 cm depth) in the island. Amphibious species occupied the middle level reflecting a change from hydric to mesic conditions.

Plant life of the past is investigated partly for their own interest and partly because their study may illuminate the present. This approach underlies attempts to describe vegetation of the past by detailed comparative studies of modern and fossil pollen rains (Birks and West 1973, Zahran *et al.* 1992, 1995, Ayyad *et al.* 1992, Fernandez 1994). Wright (1967) and Kershaw *et al.* (1994) pointed out that the reconstruction of the former vegetation of an area becomes little more than speculation unless the fossil pollen assemblages can be related to vegetation of known structure and composition.

The information derived from pollen spectra and diagrams is a definition of the relevant vegetation. These grains are preserved in geological deposits and can be retrieved, identified and interpreted through various techniques (Faegri *et al.* 1989, Hicks 1994, Janssen and Birks 1994).

This study describes the present vegetation and the environmental factors affecting its distribution and composition in the different habitats. Also, it attempts to reconstruct past vegetation in this island by using the palynological technique.

The Study Area

At Sohag area, the course of the River Nile is interrupted by some islands of varied size and structure, *e.g.,* Kraman, Al-Beida, Al-Shawash, *etc.* Kraman Island is the nearest to Sohag City where the width of the river is about 1.5 km (Fig. 1). It trends in SW-NE direction with length of about 3 km and maximum breadth of about 1 km.

The island is formed mainly of the alluvial deposits carried by the river and eroded from the Nile banks in the recent geological times (Said 1981). It is composed mainly of sand, silt and clay sediments. This island comprises different habitat types: submerged lands, partly submerged land, seasonally submerged land, occasionally (every few years) submerged land and dry land. Variations in the size and shape of these habitats are obviously affected by the annual and over-year policy for the flooding of the island by the Nile water. The ground surface of the island attains an average height of 61 m above sea level (0-2 m above the river water surface). The depth of the subsurface water in the island ranges between 0.3 and 2 m (Abdel-Moneim 1994).

Sohag area lies in the extreme-arid part of Egypt (31° - 32° E, 26° - 27° N). The mean annual maximum and minimum air temperatures are 22.7° C and 11° C, respectively. Rainfall is negligible (mean annual = 2.25 mm) and occurs in winter. However, occasionally short rainy storms may take place anytime (Abdel-Moneim, 1987) on the eastern site of Sohag area.

Materials and Methods

Forty stands were randomly chosen at locations where either dense vegetation cover or change in species composition was encountered. Vegetation analysis was done according to Kershaw and Looney (1985). Plant identification was according to Täckholm (1974), Boulos (1995) and El-Hadidi and Fayed (1995).

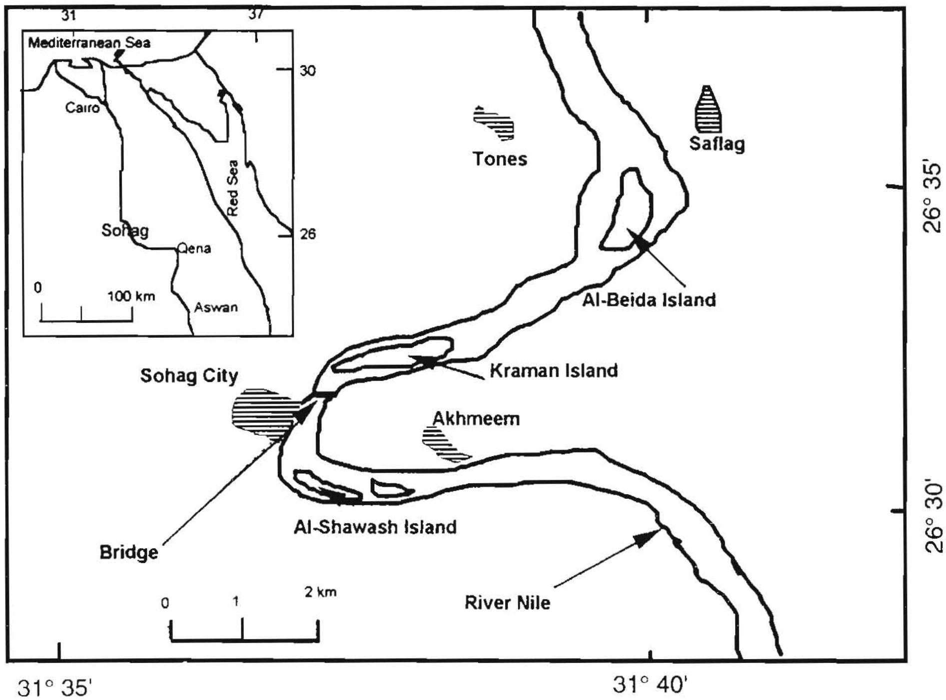

Fig. 1. Location map of Kraman Island in the River Nile, Sohag area, Upper Egypt.

Forty soil samples were collected from profiles dug in the ground supporting the dominant species of each recorded community. All soil analyses were according to The United State Salinity Laboratory Staff (1954).

For the palynological studies, a profile (60 cm deep) was dug in the fallow land (arable non-cultivated land). The samples were taken every 5 cm along the depth of the profile. The extraction methods and identification were done according to Moore *et al.* (1991). Two slides in each sample were prepared and examined (Light and Scanning electron microsope). Approximately 300 pollen grains were counted for each sample.

Data analysis

Multivariate analysis

TWINSPAN, a two way indicator species analysis was applied for the classification of the stands and species into groups based on presence estimates of 33 species recorded (Hill 1979). Classification of pollen assemblages into groups by using cluster analysis was based on the pollen percentage of the different recorded taxa at different depths of the profile. DCA was used to ordinate pollen assemblage groups in two dimensional space. Therefore, the spatial distribution of classification groups established using TWINSPAN became evident when samples of each group were plotted with a specific symbol. The Deterended Canonical Correspondence Analysis (DCCA) (ter Braak 1987) was applied to relate the different TWINSPAN groups and the individual species to the different environmental factors, and to evaluate the relative importance of the environmental variables. All the uses options of DECORANA was achieved by default options using the CANOCO computer program (ter Braak 1987).

Statistical analysis

One-way analysis of variance was used to check whether any difference between a set of means of soil variables representing TWINSPAN vegetational groups using statgraphics computer program (version 5).

Results

I-Habitats and Present Vegetation Types

The distribution of plant communities in the island is controlled by edaphic and hydrological factors. The use of TWINSPAN was found to be the suitable tool for classification of the studied stands.

At the first level of hierarchical classification, distinct communities of wet habitats are separated on the right side (Fig. 2). They are characterized by the presence of *Eichhornia crassipes, Ceratophyllum demersum, Potamogeton pectinatus, Phragmites australis,* as an indicator species. Left side of the diagram represents communities of dry habitats which have no characteristics species and still very heterogeneous.

a- Wet Habitats

At the second level, stands are separated into two groups, each characterized by presence of its own vegetation. Within group (D), *Eichhornia crassipes* as a dominant indicator species for floating community is separated from *Ceratophyllum*

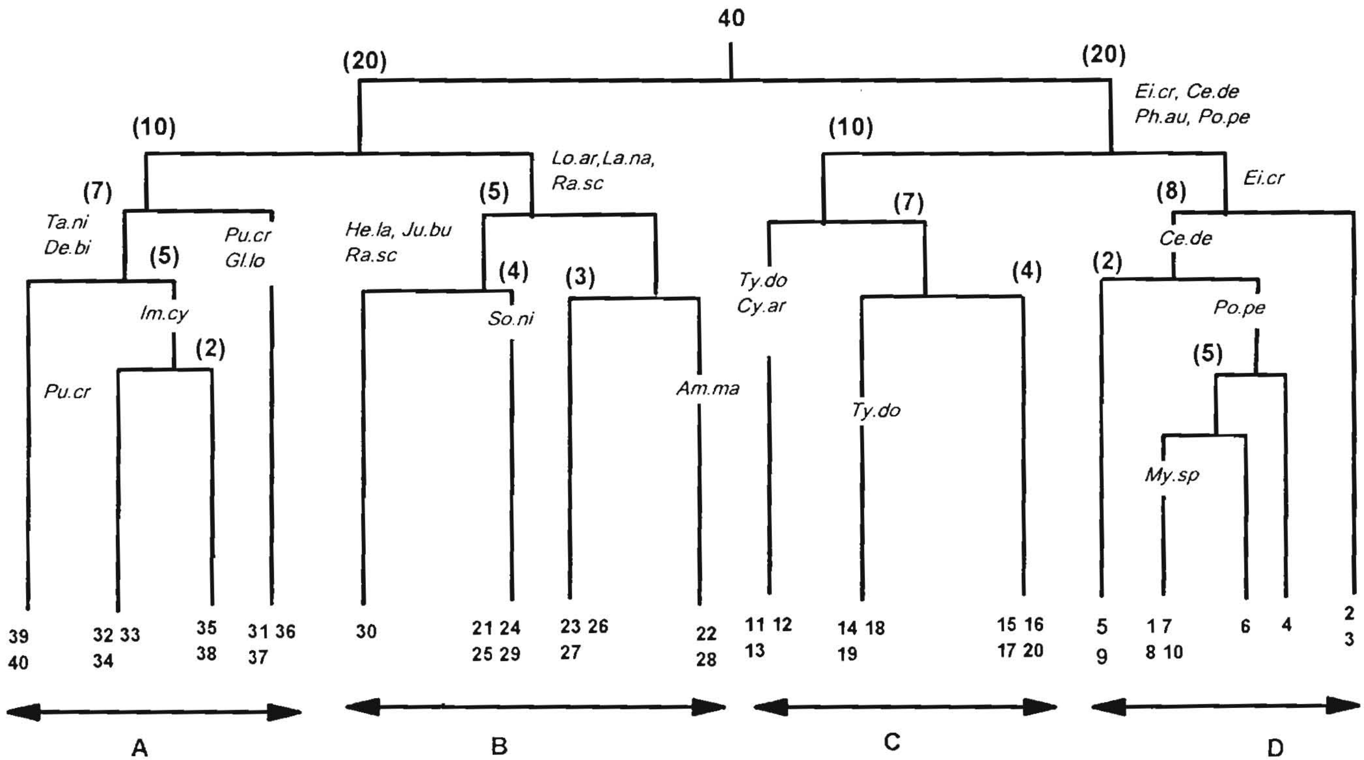

Fig. 2. TWINSPAN dendrogram of 40 stands based on presence value of 33 species in the studied island. Indicator species names are abbreviated to the first two letters of both genus and species names.

demersum which is an assigned as indicator species for submerged community at the third level of the diagram. These aquatic vegetation types prevail along the banks of the river and around the island in the relatively less deep water (40 cm) and deep water (120 cm), respectively. Common associate species are *Potamogeton pectinatus, Potamogeton perfoliatus* and *Myriophyllum spicatum.*

At the left side of the second level, reed vegetation (group C) is separated. *Typha domingensis* and *Cyperus articulatus* are the indicator species. This type of vegetation occurred in parts of the island where water depth fluctuated between 10 and 40 cm.

b- Dry Habitats

All the remaining sample groups were from dry habitats. Table 1 shows that clear differences in plant community structure and composition, as revealed by indicator and preferential species of these groups. However, there are certain feature in common.

On the hierarchical diagram, shore-line habitat (Group B) with saturated soil, which is inundated during summer, is separated from dry one (Group A) at the second level. This group had a diverse set of indicator and preferential species (Table 1), the most important of which (measured by presence value) were *Lotus arabicus, Launaea nudicaulis* and *Ranunculus sceleratus.*

Within the last group (A), three different communities are distinguished. *Pulicaria crispa-Gnaphalium luteo-album* community is separated from the other communities at the third level. Other communities of this group are separated at the fourth level. One of them is indicated by *Tamarix nilotica* and *Desmostachya bipinnata* as indicator species and the second community by *Imperata cylindrica* and further characterized by presence of *Pulicaria crispa.* All of these communities are recorded in fallow land on the well drained areas of the island.

Soil characteristics of each of the four sample groups identified by TWINSPAN are summarized in Table 2. The mean value of the edaphic variables showed significant variations between groups, except soil reaction. Sand fractions, moisture content and depth were significantly higher in group D than in the other groups (significant at $p < 0.05$, 0.01). Also, samples of this group contain low amount of organic carbon (1.1%). Group C is characterized by higher soil salinity (EC = 456 μ mhos/cm) and clay fractions (13.5 %). The minimum value of silt fractions (5.5%) was recorded in samples of group B which represented the shore-line habitat. Group A has a higher value of $CaCO_3$ concentration and silt fractions (12.1%) than other

Table 1. TWINSPAN table for the classification of 33 species and 40 stands in the study area

			343333333332222222221111111112 1	
			9023458167014593672812348956705917806423	
15	Lot	ara	----------4444-44444--------------------	0000
23	Lau	nud	-----------444-44444--------------------	0000
24	Cyp	rot	-----------4----44-4--------------------	0000
18	Sol	nig	-----------4444-4-44--------------------	0001
20	Pla	maj	-----------4-44--444--------------------	0001
22	Sen	des	-----------4444-44-4--------------------	0001
25	Amb	mar	-----------444----44--------------------	0001
16	Jun	buf	----------444-4----4--------------------	0010
17	Ran	sce	----------4444444----------------------	0010
19	Pol	mon	----------44444-44----------------------	0010
21	Con	aeg	-----------4444--4----------------------	0011
26	Hel	las	-----------4444-------------------------	0011
30	Gen	alb	-------4--------------------------------	010
31	Plu	dio	-------4--------------------------------	010
32	Alh	mau	-------4--------------------------------	010
27	Imp	cyl	--4444444--4----------------------------	011
28	Tam	nil	444444-4--------------------------------	011
29	Fra	cri	--444--444------------------------------	011
33	Des	bip	--44------------------------------------	011
4	Pot	per	--------------------------------44444444	1000
2	Eic	cra	------------------------------4444444444	1001
3	Pot	pec	------------------------------4444444444	1001
5	Pot	cri	------------------------------4444444-44	1001
6	Myr	spi	------------------------------444444-444	1001
1	Cer	dem	--------------------4-----4---44444444--	101
10	Cyp	art	--------------------444-----------------	110
11	Rum	den	--------------------4-4-----------------	110
12	Eme	spi	--------------------4-------------------	110
13	Ech	sta	--------------------444-----------------	110
14	Ech	col	--------------------44------------------	110
7	Phr	aus	--------------------4444444444----------	111
8	Typ	dom	--------------------444444--------------	111
9	Pol	sal	--------------------44-4-4--------------	111
			0000000000000000000011111111111111111111	
			0000000000111111111100000000001111111111	
			0000000111000001111100011111110000000011	
			0011111 0111100011 000111100111111	
			00011 000001	
			00001	

Table 2. Mean ± SD, Significance ov variation between 8 soil variables in the 4 groups of stands distinguished by TWINSPAN from Kraman Island

Soil variables	Groups				F ratio
	A	B	C	D	
% Sand	77.1 ± 6.3	84.9 ± 3.4	75.9 ± 3.9	87 ± 5	4.79**
% Silt	12.1 ± 3.3	5.5 ± 2.2	9.2 ± 1.3	7.6 ± 1	3.80**
% Clay	10.8 ± 4.2	9.8 ± 2	13.5 ± 4.8	5.5 ± 1.8	7.53**
pH	8.3 ± 0.4	8.3 ± 0.4	8 ± 0.5	8 ± 0	1.99
E.C. (μmohs/cm)	287 ± 76.8	242.5 ± 40.1	456 ± 115.2	228.5 ± 73.3	4.48**
% $CaCO_3$	13.5 ± 0.5	8.4 ± 0.5	10.5 ± 0.7	5.1 ± 1.5	3.75**
% Organic carbon	2.2 ± 0.9	2.2 ± 0.4	2.2 ± 0.6	1.1 ± 0.3	28.86**
% Moisture content	1.5 ± 0.5	2.2 ± 0.4	2.2 ± 0.6	23.5 ± 2.7	6.74**
Depth (cm)	0	0	18.2 ± 4.5	113.5 ± 8.2	5.13**

** = F ratio significant at 0.05 and 0.01.
E.C. = Electric conductivity.

groups. The soil samples of this group are characterized by low moisture content. The soil reaction in the different groups was alkaline and not significantly different ($p < 0.05$, 0.01).

The DCCA ordination of TWINSPAN groups of the present vegetation with the environmental factors is presented in Figure 3a. Most of these groups are separated along the first axis. The weighted correlations between the environmental factors and the first two axes of DCCA are shown in Table 3. These data indicated that the distribution of the plant species are most closely correlated with depth (r = –0.98), moisture content (r = –0.80), organic carbon (r = 0.66). In addition, the weighted correlations of the first axis with $CaCO_3$ and clay are high. The second axis is significantly correlated with silt fraction (r = 0.66) and sand fraction (r = –0.43). The species-environment correlations for the first and second axes are 0.99 and 0.88, respectively. These two axes accounted for 91.7 % of the variance of the weighted averages of the species with respect to each of the measured variables.

The species-environment biplot in Figure 3b presents the DCCA ordination of the species showing their relative distribution along the different environmental gradients. Thus, the species of group A *(Eichhornia crasspies, Ceratophyllum*

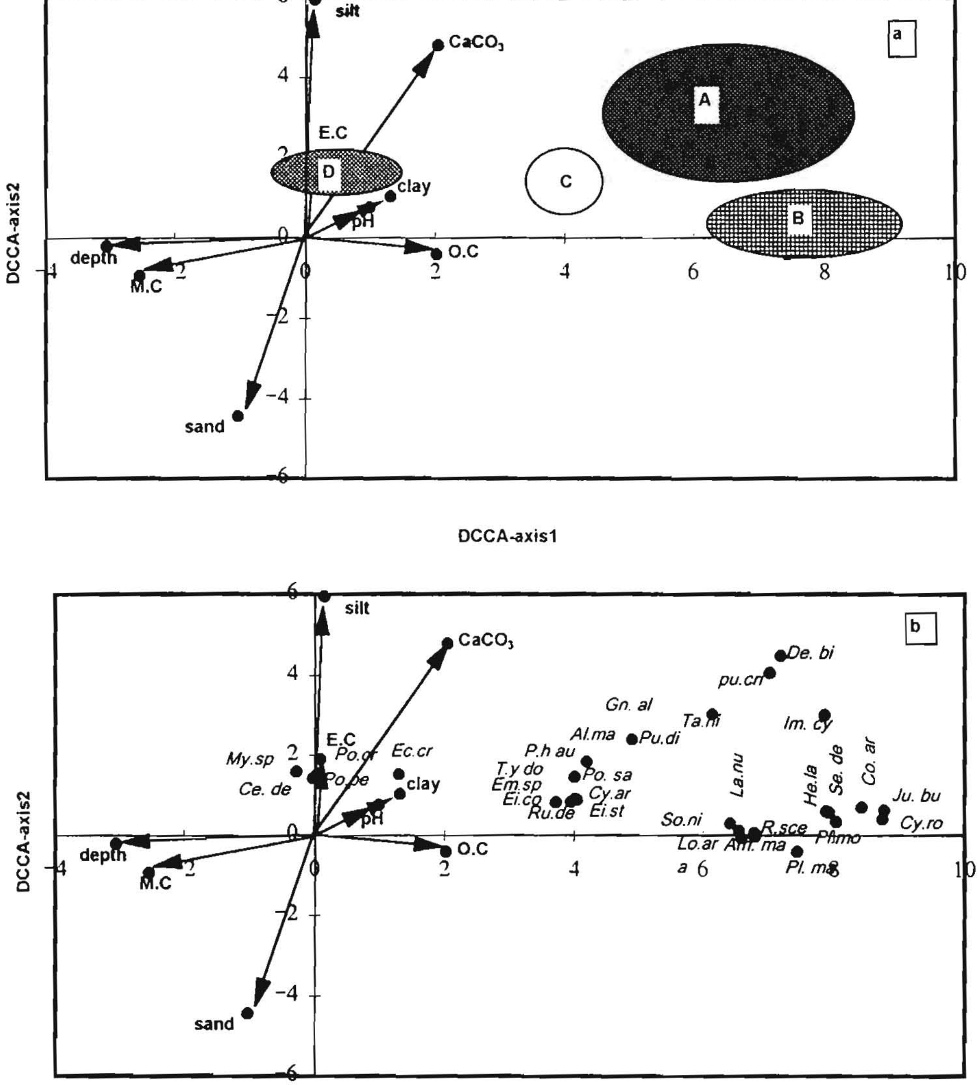

Fig. 3. (a) DCA ordination of 40 stands with TWINSPAN groups superimposed and the environmental factors.
(b) DCA species-environment biplot based on 33 species with arrows and points indicate to the environmental factors and to species, respectively.
O.C. = % Organic carbon, M.C. = % Moisture content, E.C. = Electric conductivity.

Table 3. Weighted correlation matrix of species ordination axes with environmental factors, eignvalues and % variance of species-environment

Variables	DCCA Axes	
	Axis-1	Axis-2
% Sand	–0.227	–0.431
% Silt	–0.087	0.662
% Clay	0.402	0.022
pH	0.301	0.014
E.C. (μmohs/cm)	–0.016	0.297
% $CaCO_3$	0.553	0.397
% Organic carbon	0.664	–0.192
% Moisture content	–0.8	0.072
Depth (cm)	–0.977	0.189
Eigenvalue	0.98	0.46
Spe-env. corre.	0.99	0.88
% variance	34.3	57.4

E.C. = Electric conductivity.

demersum, ...) appear to have soil with high moisture content and deeper water, but showing low contents of organic carbon and calcium carbonates. Extrapolation of the moisture content arrow back through the origin provides an indication of a number of groups having different water demands. According to the relative position of their perpendiculars from the head of the moisture content arrow, they are arranged in the following order: C > B > A.

On calcium carbonates arrow, species of group A (*Tamarix nilotica, Imperata, cylindrica, Pulicaria, crispa,* ......) highly suggesting a strong affinity for soil with high $CaCO_3$ content. Also, they are associated with soil having relatively high content of clay fractions.

Ranunculus sceleratus and other shore-line species (group B) are more closely associated with high soil moisture content than species of group A. Meanwhile, swampy vegetation, which separated near the center of the ordination diagram, appears to associate with high soil salinity and clay fractions.

II- Former Vegetation

The pollen percentages at the different soil levels in the profile are shown in Fig. 4. Pollen spectra of families Haloragaceae, Pontederiaceae, Potamogetonaceae,

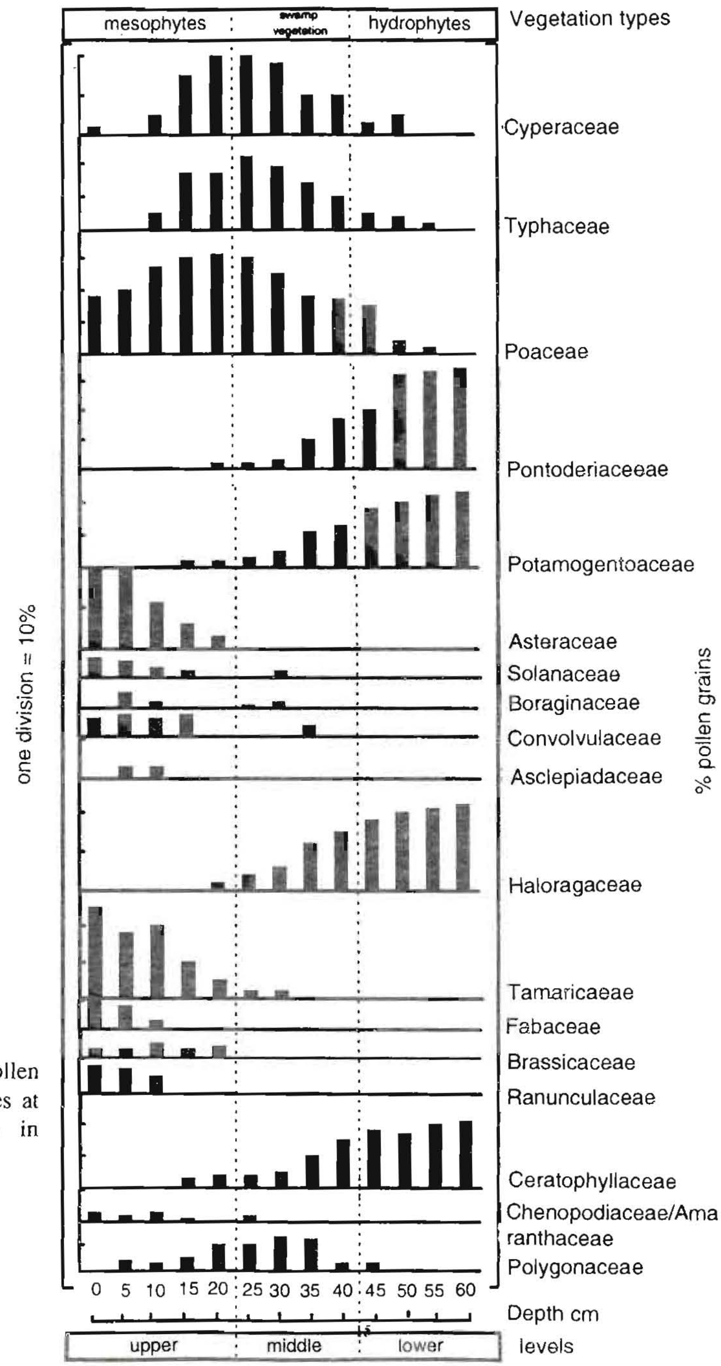

Fig. 4. Percentage of pollen grain assemblages at different depths in Kraman Island.

Ceratophyllaceae, Cyperaceae, Typhaceae, Polygonaceae, Poaceae, Tamaricaceae, Asteraceae and Fabaceae are very well represented.

Cluster analysis (Fig. 5) of Pollen grain percentages at different levels of the profiles shows that pollen assemblages separated into three distinct groups. Group A comprises familes of aquatic habitat (Haloragaceae, Pontederiaceae, Potamogetonceae and Ceratophyllaceae). These families were not represented palynologically in the upper strata (0-10 cm) and have considerable percentages in the middle one (15-40 cm). Whereas, in the lower strata (45-60 cm), their pollen assemblages attain their highest values: 22%, 34%, 23%, and 21%, respectively (Table 4, Fig. 4). Group B includes the pollen assemblages of families Cyperaceae, Typhaceae, Polygonaceae and Poaceae. The dominance of these assemblages is the main character of the middle level of the profile. Their pollen percentages ranged between 10% - 20%, 10% - 22%, 3% - 13%, and 17% - 31%, respectively. Group C is represented by families Asteraceae, Tamaricaceae, Fabaceae and Brassicaceae. The pollen assemblages of these families increase upward the profile reaching in the upper level 20%, 25%, 10% and 8%, respectively. In the lower level, their pollen grains disappear.

The deposit pollen grains of families Ranunculaceae, Solanaceae, Convolvulaceae, Chenopodiaceae/Amaranthaceae, Boraginaceae and Asclepiadaceae contribute only to a small part of the pollen assemblages especially in the upper level of the profile (Table 4, Fig. 4).

DCA ordination of TWINSPAN groups match well the spatial distribution of different habitats along its two axes (Fig. 6a). Scores of different pollen assemblages on the ordination diagram (Fig. 6b) reflect their distribution pattern in the taken samples. Pollen assemblage groups are different in their occurrences in the ordination diagram. Families of group A are separated in the right side, while those of group B and C are separated near the center and left side of the diagram, respectively.

Different pollen assemblages are correlated well with the moisture content and soil salinity (Fig. 7). Pontederiaceae, Potamogetonaceae, Ceratophyllaceae and Haloragaceae are positively correlated with moisture content, while Tamaricaceae, Asclepiadaceae and Asteraceae are negatively correlated with the same variable. Cyperaceae, Typhaceae and Poaceae are highly correlated with soil salinity at different depths of the profile..

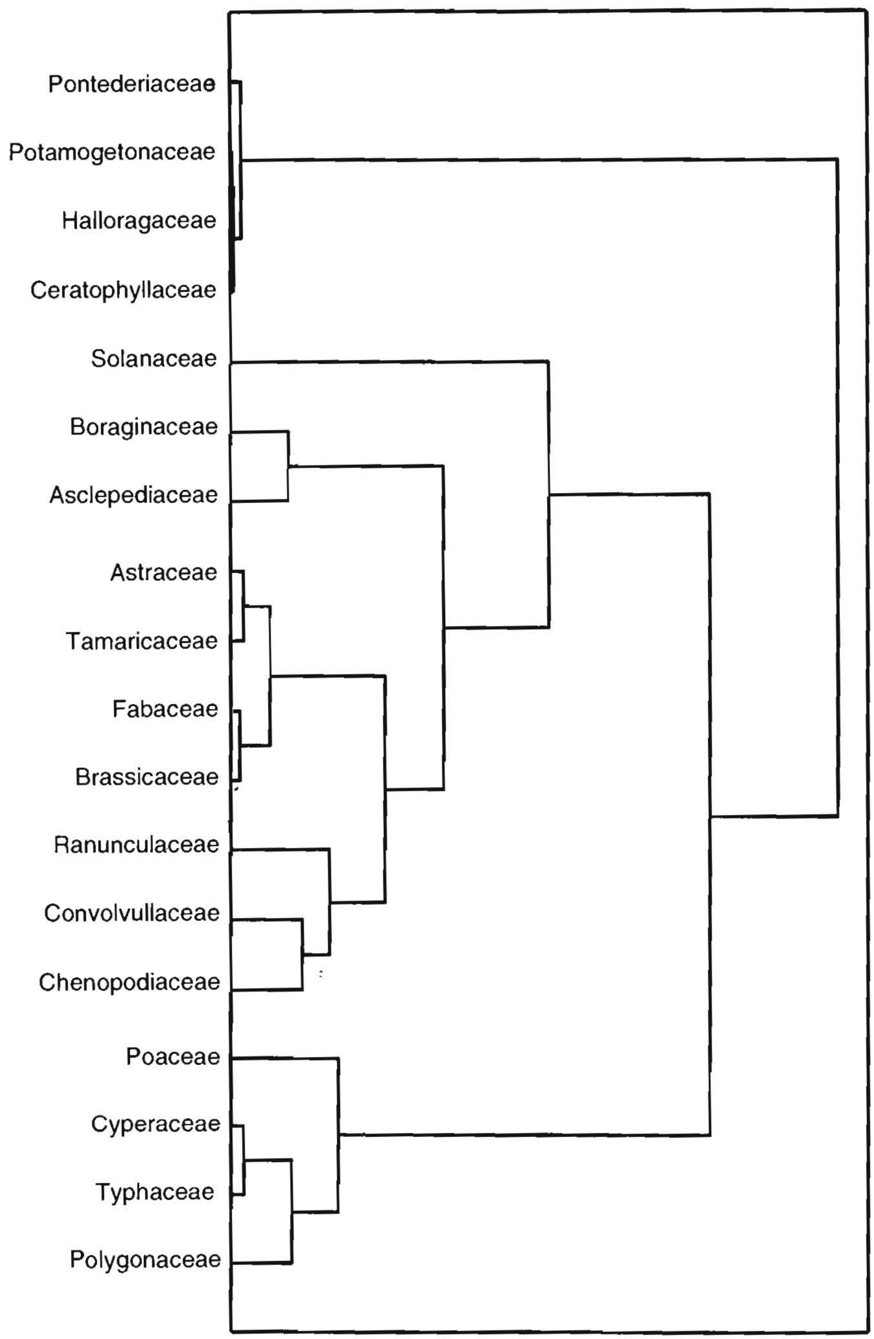

Fig. 5. Cluster analysis of 18 pollen assemblages at different depths in the profile of Kraman Island.

Table 4. Percentage of pollen grain assemblages at different depths (cm) in the profile of fallow land; recorded environmental factors. EC = Electric conductivity, M.C. = Moisture content

Pollen assemblages	**Different depths of the profile**												
	0 cm	**6 cm**	**10 cm**	**15 cm**	**20 cm**	**25 cm**	**30 cm**	**35 cm**	**40 cm**	**45 cm**	**50 cm**	**55 cm**	**60 cm**
Polygonaceae	–	4	3	5	10	10	13	12	3	3	–	–	–
Chenop/Amaran	3	2	3	1	–	2	–	–	–	–	–	–	–
Ceratophyllaceae	-	–	–	3	4	4	5	10	15	18	17	20	21
Ranunculaceae	3	3	5	3	4	–	–	–	–	–	–	–	–
Brassicaceae	8	7	5	–	–	–	–	–	–	–	–	–	–
Fabaceae	10	8	3	–	–	–	–	–	–	–	–	–	–
Tamaricaceae	25	18	20	10	5	2	2	–	–	–	–	–	–
Haloragaceae	–	–	–	–	2	4	6	12	15	18	20	21	22
Asclepiadaceae	–	3	3	–	–	–	–	–	–	–	–	–	–
Convolvulaceae	5	6	5	6	–	–	–	3	–	–	–	–	–
Boraginaceae	–	5	2	–	–	1	2	–	–	–	–	–	–
Solanaceae	6	5	3	2	–	–	2	–	–	–	–	–	–
Asteraceae	20	19	11	6	3	–	–	–	–	–	–	–	–
Potamogetonaceae	–	–	–	2	2	3	5	11	13	18	20	22	23
Pontederiaceae	–	–	–	–	2	2	3	10	17	20	32	33	34
Poaceae	18	20	27	30	31	30	25	18	17	15	4	2	–
Typhaceae	–	–	5	17	17	22	19	14	10	5	4	2	–
Cyperaceae	2	–	5	15	20	20	28	10	10	3	5	–	–
E.C. μmhos/cm	275	275	275	270	270	265	260	260	260	210	200	200	175
% M.C.	3	5	5	8	8	10	15	15	25	30	33	35	38

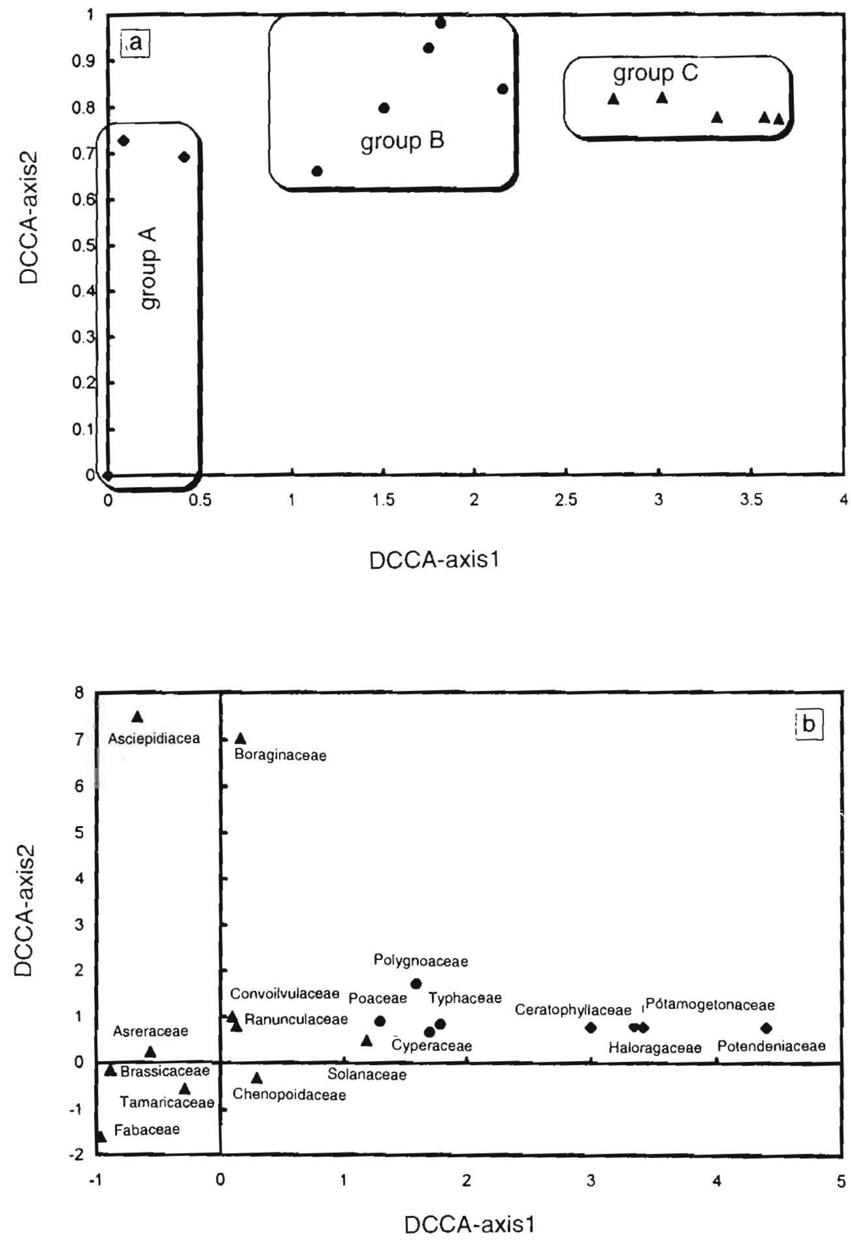

Fig. 6. (a) DCA ordination of 13 soil samples collected at different depths in the profile.
(b) DCA ordination of the different pollen grain assemblages at different depths in the profile.

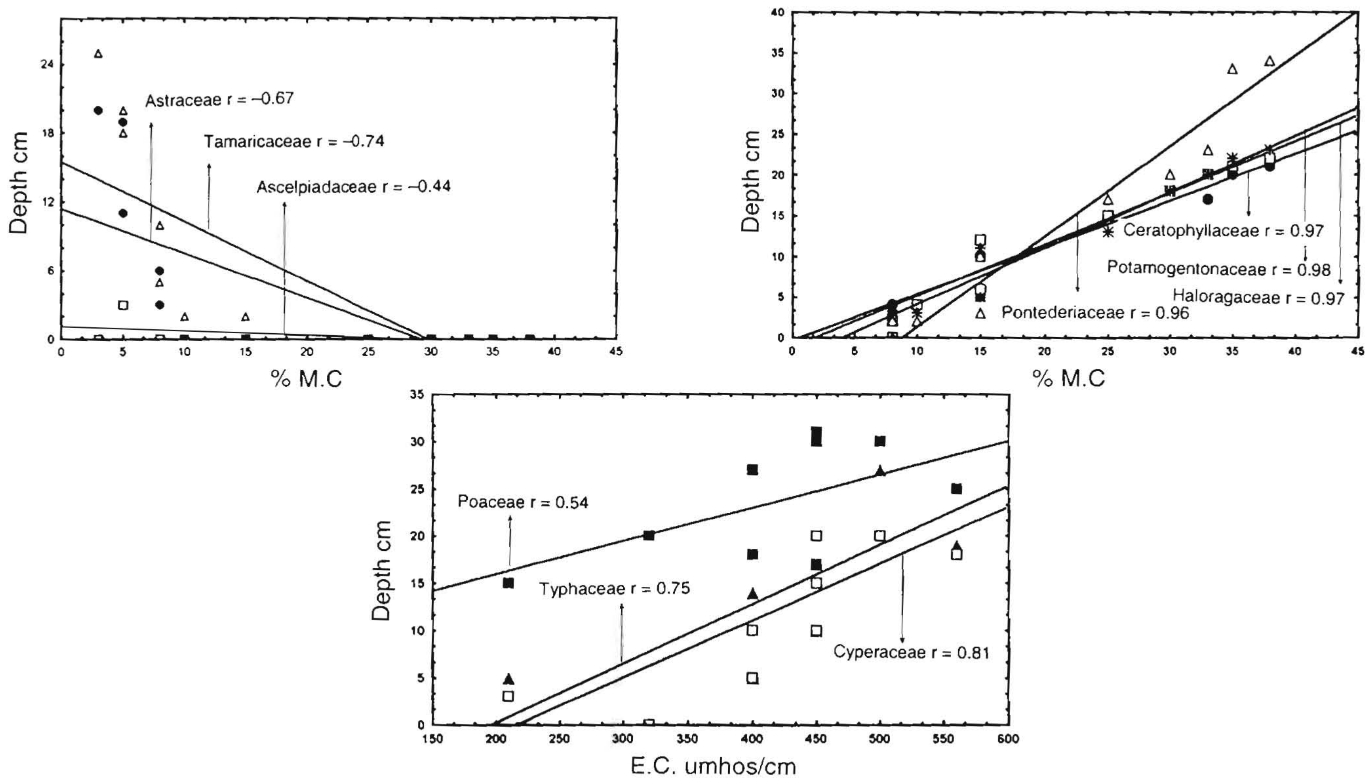

Fig. 7. Scatterplots of moisture content and electric conductivity with different pollen assemblages showing the correlation coefficient.

Discussion

The climate of Sohag area is extreme-arid. This may be an explanation of the presence of perennial species in the current vegetation of the island. Human manipulation influences the current vegetation of this island. Also, selectivity in grazing and foraging by domestic animals have its effect on the cover and distribution of plant species (El-Khatib 1995).

In addition to the possible role of the above mentioned meteorological and biotic factors, a number of edaphic factors seem to play a part in the distribution of plant species. This is clear from the results of the DCCA ordination, where calcium carbonates, moisture content, soil salinity, soil texture and organic carbon are the most important factors. Community and soil characteristics show patterns in relation to the pattern of habitats. Species diversity (heterogeneity) decreases from high elevations (2m above the river water surface) to low, hence from dry toward the moist habitats. The amount of calcium carbonates in the soil decreases from high elevations to low in lower ground. Plant zonations are clear along the ordination axes and reflect that competition does not usually produce sharp boundaries (acute changes in the demands of the species from different environmental factors) between species; centers and boundaries of species population are scattered along the environmental gradient. This is in agreement with results of Whittaker (1970) who reported that the environmental factors act together on plants and animals, and it may be difficult without experiment to judge what are the most important factors for a given population, and may be termed a complex-gradient.

The present vegetation of the island is organized into four types, each of them has distinct communities and occupies a specific habitat. These communities were dominated by *Eichhornia crassipes, Ceratophyllum demersum, Phragmites australis-Typha domingensis* and *Lotus arabicus-Ranunculus sceleratus* in the wet habitats, and *Francoeuria crispa-Gnaphalium luteo-album, Tamarix nilotica-Desmostachya bipinnata* and *Imperata cylindrica* in the dry habitat. The common character of these communities is the limited number of the associate species which are often with low presence and weak performance.

The course of successional processes in this island can be established with some degree of precision using the palynological technique. There are certain notes which must be made on the basis of the results presented here. Some plant communities can be distinguished easily on the basis of their pollen data, other cannot. It may be noted that the short core from this island that was used in this exercise probably cover only the very recent past. Also, the impact of man in recent times may have led to the restructuring of current vegetation and some assemblages of the past may have no modern counterpart for comparison. Within these limits, this approach has a considerable potential for setting the palynological reconstruction of the recent vegetation of Kraman Island.

DCA ordination of the different pollen assemblage groups clarified the gradual increase of pollen assemblages of families Haloragaceae, Pontederiaceae, Potamogetonaceae and Ceratophyllaceae with depth which suggest that the site was once (last years), a hydric habitat, as the representive species of these families are mainly hydrophytes. On the other hand, the disappearance of the pollen assemblages of these four families in the upper level of the profile; the increase of pollen assemblages of families Asteraceae, Tamaricaceae, Fabaceae and Brassicacease in the uppermost layer reflects a change from hydric to mesic conditions. This may be attributed to the fact that most species of the latter families in the Egyptian flora are mesophytes.

The percentages of pollen assemblages of families Cyperaceae, Typhaceae, Polygonaceae and Poaceae are well represented in the middle level reflecting the swampy conditions. It is known that, the majority of species of these families (few of poaceae) are amphibious. This in accordance with results of Ritchie (1987) who reported that *Typha* frequencies might be regarded as indicator of changing hydroloical conditions with decrease in freshwater towards the top of the section. Therefore, the swampy vegetation represents a transitional stage between the hydric and mesic conditions in the hydrosere succession.

The pollen spectra of the other families (Ranunculaceae, Solanaceae, Convolvulaceae, Chenopodiaceae/Amaranthaceae, Boraginaceae and Asclepiadaceae) appear only in the upper level. Their representative species are mesophytes growing in mesic habitat.

As revealed from the soil analysis at different depths in the profile, the most important edaphic factors on the distribution of pollen assemblages found to be moisture content and soil salinity. This was proven by the values of correlation coefficient, between these families and these two factors.

On the basis of pollen assemblages, one may conclude that the area under investigation was under different changes in the habitat conditions, strong fluctuation and change in overflooding of the island by the Nile within the last years. As a result of these changes and in the largest part of this island, plants of medium water requirements (mesophytes) which being in harmony with the environment have finally replaced the hydrophytes in the current vegetation. This supports the finding of Weaver and Clements (1938) who reported that, as vegetation develops the same area become successively occupied by different communities, where the final or climax stage results from this series.

Analysing of deeper profiles in this island is then required in order to understand the history of vegetation in the past. Also, radiocarbon dating is important to know the rate of such change.

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الغطاء النباتي القديم والحالي لجزيرة قرامان ، مصر العليا

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قسمت الجزيرة بواسطة "Two Way Indicator Species Analysis (TWINSPAN)" إلى أربعة أنواع من البيئات المختلفة . يضم كل من هذه البيئات الحالية مجتمعات نباتية مختلفة لها أنواع مميزة تبعاً للظروف البيئية السائدة .

تمت دراسة العلاقات ما بين الأنواع النباتية الحالية والظروف البيئية المؤثرة عليها وذلك باستخدام "Deterended Canonical Correspondence Analysis (DCCA)" . أوضحت الدراسة أن المحتوى المائي للتربة ، عمق الماء ، محتوى التربة من كربونات الكالسيوم ، الكربون العضوي وكذلك قوام التربة هي أكثر العوامل البيئية المؤثرة على تركيب وتوزيع المجتمعات النباتية الحالية .

تمت دراسة الغطاء النباتي القديم للجزيرة وذلك من خلال دراسة حبوب اللقاح المتحفرة بعمل قطاع رأسي في الجزيرة على مقاطع وصلت إلى بعد ٦٠ سم من سطح الأرض . أوضح تنسيق مجموعات حبوب اللقاح بواسطة "Deterended Correspondence Analysis (DCA)" إنتشار الأنواع الوعائية المائية في الطبقة السفلى بينما احتلت الأنواع الوسيطة الطبقة العليا من القطاع . شغلت الأنواع النباتية المترددة الطبقة الوسطى من القطاع مظهرةً بذلك تغير الظروف في الجزيرة من ظروف البيئة المائية إلى ظروف البيئة الوسيطة .