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NUMERICAL ANALYSIS OF CHARRED SEEDS AND FRUITS FROM AN 8000 YEARS OLD SITE AT NABTA PLAYA, WESTERN DESERT, SOUTH EGYPT

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ABSTRACT. Charred seeds and fruits from an early Neolithic site Nabta Playa E-75-6 in south Egypt were studied. Multivariate methods were applied to 113 archaeobotanical samples from one house in order to explain their floristic variability. Correspondence analysis has shown that the east and west sectors of the house differed with respect to the composition of food plants processed. It was suggested that this might reflect the existence of the two activity areas in the house. No difference was found between samples from various types of archaeological contexts, i.e. from hearths, pot-holes, postholes and the rest of house fill.

KEY WORDS: archaeobotany, charred seeds and fruits, hunter-gatherers plant-food economy, correspondence analysis, early Neolithic, Sahara, Egypt

INTRODUCTION

The upper Pleistocene climate of the Western Desert of Egypt, as that of most of central and east Sahara, underwent fluctuations marked by arid or hyperarid and moist episodes. The last period of extremely dry conditions, between 70000 and 11000 yrs bp, was followed by the times of increased humidity which lasted (with oscillations) until about 5000 yrs bp, when the recent dessication of the Sahara began. At the beginning of the Holocene, groups of early Neolithic people entered the Sahara and left their traces in the form of scattered hearths, interpreted as brief stops of nomadic pastoralists (Gabriel 1987), and settlements of longer duration (Wendorf & Schild 1980). Most of the settlements were related to the playas, or similar situations, and the site E-75-6 at Nabta Playa is one of them. Archaeological investigations at Nabta Playa were conducted by the "Combined Prehistoric Expedition" under the leadership of Fred Wendorf and Romuald Schild (Close 1992, Wasylikowa et al. 1993, Wasylikowa et al. 1995, Wendorf & Schild 1980, Wendorf et al. 1991).

The early Neolithic settlement at the site E-75-6 includes several huts with hearths, storage pits and walk-in wells. They were arranged in two rows over an area of ca. 1000 square meters to form a kind of small, well organized village. The complete archaeological record indicates that the site was occupied seasonaly by people who knew pottery and whose food economy was based on wild (and domestic ?) resources (Close 1992, Wasylikowa et al. 1993, Wendorf & Schild 1980, Wendorf et al. 1991). Most features contained charred plant remains.

MATERIAL

Samples for carpological studies were collected by H. Królik and R. Schild, with the assistance of L. Kubiak-Martens, H. Barakat and K. Wasylikowa in 1990, 1991 and 1992. Field description of each sample included: location within the metric grid of the excavation, depth (sometimes), type of archaeological feature, sediment lithology and colour, and sampling date. Volume of the whole sample or subsample taken for botanical analysis was measured. Samples were dry sieved on ca. 1.0 mm mesh sieves and plant remains were

picked up in the tent laboratory by K. W. (in 1990) and L. K.-M. (in 1991 and 1992). Identification was done in the W. Szafer Institute of Botany, Polish Academy of Sciences, Cracow.

All plant remains were charred with the exception of the Boraginaceae family fruits which do not get carbonized in high temperatures due to their wall structure. The presence of charred seeds in a few fruits has proved, however, that they belonged to the subfossil assemblage. Seeds and fruits from the whole settlement have been segregated into 29 taxa, including 21 positive identifications (genus, family) and 8 morphological types of unknown taxonomic affiliation (designation NP followed by a number). To this number, the new identifications of vegetative tissues by J. Hather (Hather 1995) should be added.

In spite of inadequate stage of taxonomic elaboration, the information already available may be an essential contribution to a better understanding of subsistence pattern on the Sahara in the early Neolithic. With this in mind it seemed appropriate to proceed with the analysis of broad groups of taxa in order to evaluate their significance for the inhabitants of the site.

Numerical analyses were applied in order to see if there is any pattern in the distribution of plant remains over the surface of individual houses and the whole settlement. The interpretation of such a conceivable pattern might include two aspects, human actions connected with exploitation of useful plants and plant ecology relevant to the reconstruction of occupation seasons.

The present article concerns only plant material from one house No. F1/90. This was a large oval house (8.3 x 4.5 m) with traces of 6 hearths and over 74 small depressions (ca. 0.1–0.2 m in diameter) called here pot-holes (Fig. 1) (Wasylikowa et al. 1993). Botanical samples from this house represented five categories of archaeological context: hearths, pot-holes, house fill, house fill top and post-holes. In 144 samples a total of 11139 seeds or fruits were found; they belong to 24 taxa (Table 1).

Table 1. List of taxa found in the house F1/90 at Nabta Playa, site E-75-6

Taxa	Number of specimens per sample			Number of samples
	min-max	average	total	
Boraginaceae (*Arnebia*)	1–37	4.8	400	84
Capparidaceae (*Capparis?*)	1–57	4.3	206	48
Caryophyllaceae indet.	1–1	1.0	2	2
Cleome/Gynadropsis type	1–2	1.3	4	3
Cruciferae (*Schouwia?*)	1–1180	40.5	4092	101
Cucurbitaceae indet.	1–3	1.4	21	15
Cyperaceae indet.	1–2	1.3	4	3
Cyperus/Fuirena/Scirpus holoschoenus type	1–16	3.2	41	13
Gramineae indet.	1–3	1.3	9	7
Leguminosae small-seeded	1–83	9.6	989	103
Leguminosae others	1–15	3.4	132	39
Malvaceae type	1	1.0	1	1
Paniceae	1–342	17.3	1967	114
Polygonum type	1–1	1.0	3	3
Schoenoplectus type	1–1	1.0	2	2
Sorghum	1–7	2.1	130	62
Ziziphus sp.	1–53	6.3	320	51
NP-9	1–23	4.8	239	50
NP-18	1–309	10.9	989	91
NP-19	1–8	1.7	68	41
NP-21	1–149	15.0	1202	80
NP-23	1–6	1.6	28	18
NP-24	1–51	4.1	266	65
NP-28	1–10	3.4	24	7
Total	1–1929	77.4	11139	144

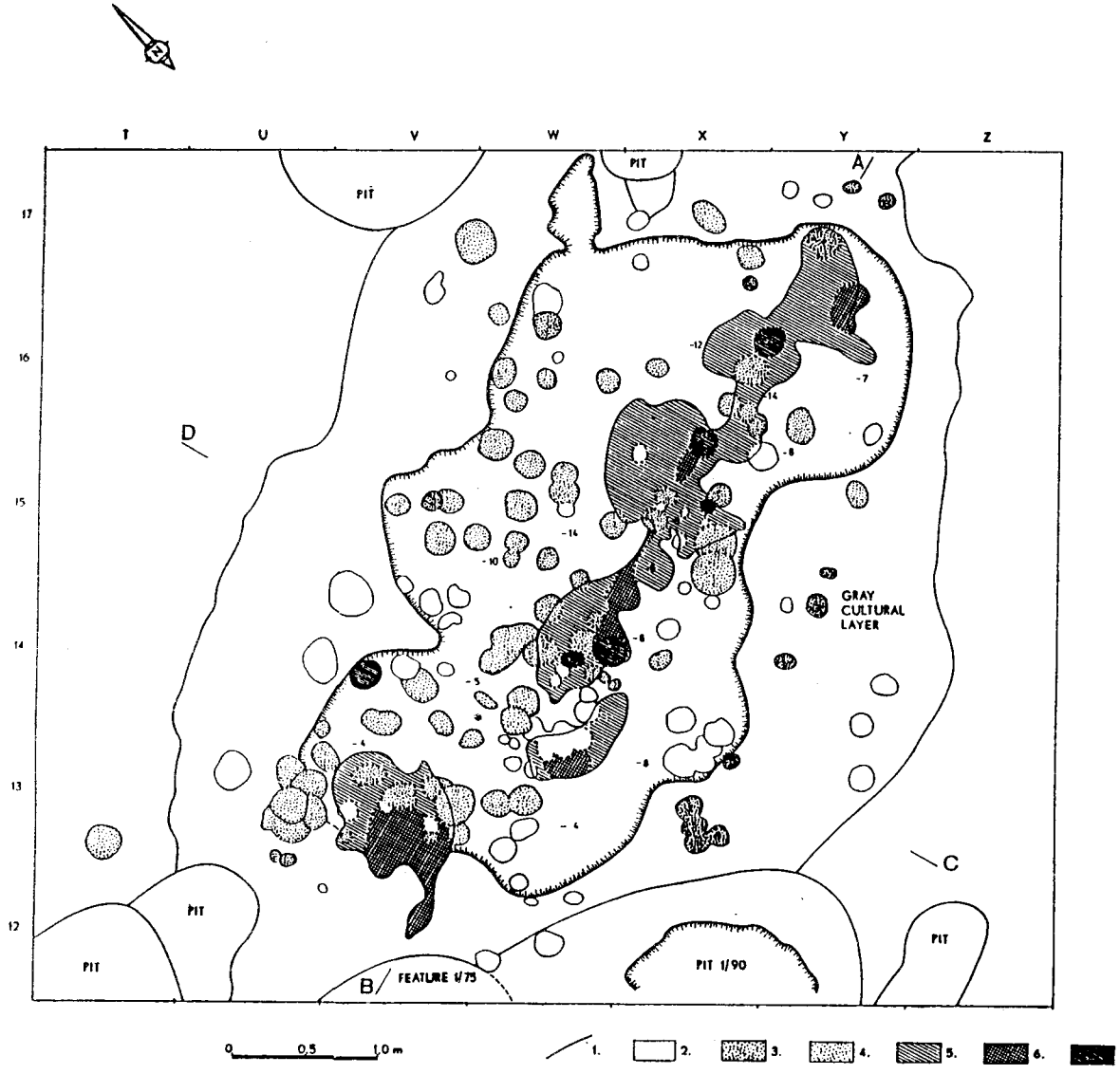

Fig. 1. Plan of the house F1/90 at the site Nabta Playa E-75-6. 1 – outline of a feature or a pit, 2 – pot-hole not excavated, 3 – excavated posthole, 4 – excavated pot-hole filled with grey sand, 5 – brown fill, hearth, 6 – red burned sand (base of a hearth), 7 – excavated pot-hole filled with brown sand. R. Schild, unpubl.

It has been expected that the analyses of samples from one large house might answer the following questions: 1/ were plant remains uniformly distributed over house surface or not, if not 2/ were certain taxa connected with certain archaeological contexts or 3/ were they connected with different house areas.

METHODS

Multivariate methods were applied in order to explain the floristic variability of archaeobotanical samples. The indirect gradient analysis method of correspondence analysis (CA) was used (Hill 1973, Jongman et al. 1987). In effect of an iterative procedure sample scores are derived from taxa scores and conversely, taxa scores are obtained from sample scores. So, the sample scores are weighted averages of taxa scores. While preparing the ordination diagrams these scores are plotted along axis I and axis II. Then, in the effect, groups (clusters) of samples, similar in their floristic composition, are being created. The joint occurrence of taxa and samples denotes a higher role of these taxa in these samples.

The analyses were done at two levels, first separately for the samples from different archaeological contexts, i.e. hearths, pot-holes, house fill and house fill top (number of samples from postholes was too small) and then, jointly for all samples from the whole house.

It has been attempted to use principal component analysis (PCA), however, the lack of negative correlations between occurrences of species makes the method, with underlying assumption of a linear model, less useful compared to that of a unimodal response model (as in CA – Jongman et al. 1987).

Multivariate analyses were made with the program

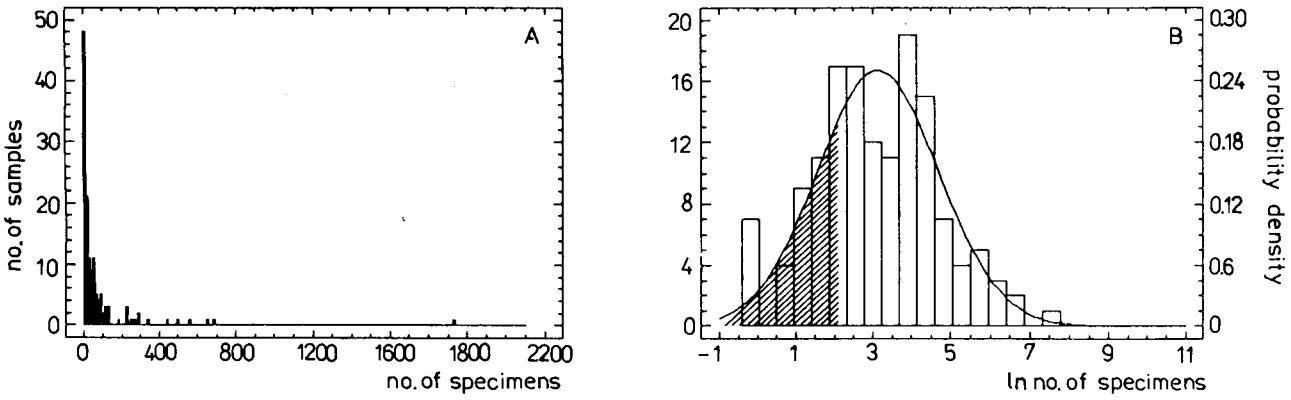

Fig. 2. Distribution of samples from the house F1/90 according to the total number of seeds and fruits. A – frequency histogram of specimen numbers in the samples, B – frequency histogram of ln number of specimens. Normal distribution curve (chi-square test for goodness of fit=9.18, d.f.=9, p=0.42) enabled the probability of occurrence of samples with a given no. of specimens to be assessed. The lower tail area (hatched) shows p≤0.20, an arbitrally chosen criterion of rarity, which gives no. of specimens 6

CANOCO (ter Braak 1988). The data were not transformed prior to analysis.

In order to remove the "noise" in the data the program was run after the samples having six or less specimens had been rejected. This decision was taken after plotting the probability density function of log-transformed data for all samples, which follows normal distribution (Fig. 2). It enabled the probability of occurrence of samples with a given number of specimens to be assessed. Inspection of the lower tail area of the distribution helped to choose the critical value of specimen density, which was finally established at $p \leq 0.20$.

Statistical calculations were carried out with program package STATGRAPHICS v.5 (STSC Inc.).

RESULTS

Hearths

All 22 samples that have been collected from the hearths were used for CA. They fall into 3 categories, two of them form distinct clusters associated with certain plant taxa, the third one includes scattered samples (Fig. 3).

1. The largest cluster of samples is characterized by taxa called here Paniceae group which includes significant numbers of Paniceae, NP-19, NP-21, Leguminosae small-seeded and some *Sorghum*. Boraginaceae, unknown types NP-18 and NP-24 occur in smaller numbers, other taxa are present in negligible amount. It includes 11 samples situated in the eastern part of the hut (Fig. 4).

2. The *Ziziphus* group includes 3 samples situated in the western sector. They have the highest number of *Ziziphus* fruit stones among all samples from the hearths, Cruciferae seeds are abundant in two of them.

3. Scattered samples are characterized by high numbers of seeds of Cruciferae, Capparidaceae and Leguminosae other than small seeded ones, less by the type NP-9 (possibly also from Leguminosae family). Five of these samples come from the eastern part of the house and are distributed at the periphery of the area of samples from the 1st group. Three samples come from the central part of the hut; they have the highest number of Boraginaceae, Capparidaceae and NP-18 among samples from the hearths.

Pot-holes

Number of collected samples was 41 but only 27 were used for CA analysis. They form three clusters, two of them similar to those from the hearths (Fig. 5).

1. The Paniceae group includes 16 samples. It differs from the same group in the hearths by closer association with Capparidaceae and the type NP-18 and lesser significance of Boraginaceae. All but one samples of this group are located in the eastern and central sector of the hut (Fig. 6). Their distribution overlaps the area taken by Paniceae cluster and scattered samples in the hearths.

2. Three samples of the *Ziziphus* group come from the western house end as in the hearths.

3. The samples characterized by Cruciferae, Leguminosae other than small-seeded ones and the type NP-9 form a distinct cluster, un-

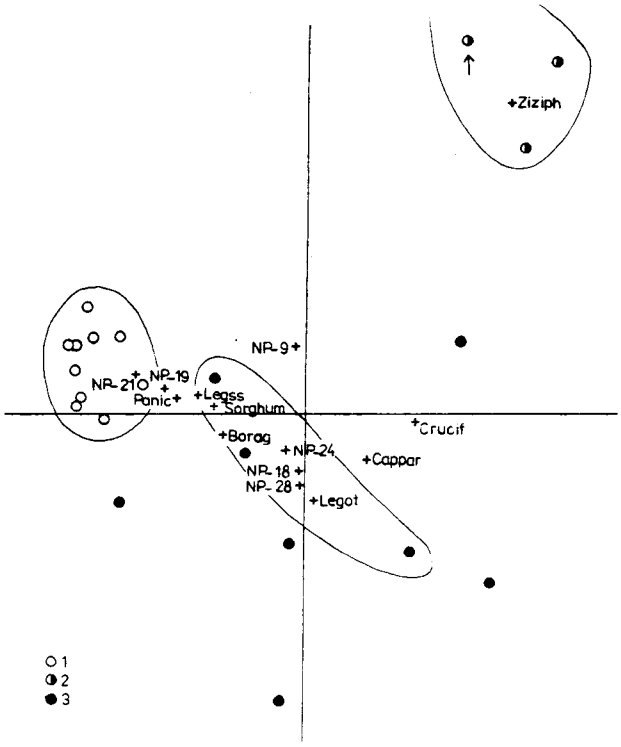

Fig. 3. Correspondence analysis of archaeobotanical samples from the hearths in the house F1/90, Nabta Playa E-75-6. 1 – Paniceae cluster, 2 – *Ziziphus* cluster, 3 – scattered samples. Continuous lines encirle samples situated in the same part of the house. Abbreviations of plant names: Borag – Boraginaceae, Cappar – Capparidaceae, Crucif – Cruciferae, Cyp-Fu – *Cyperus/Fuirena/Scirpus holoschoenus* type, Legot – Leguminosae others, Legss – Leguminosae small-seeded, Panic – Paniceae, Ziziph – *Ziziphus*

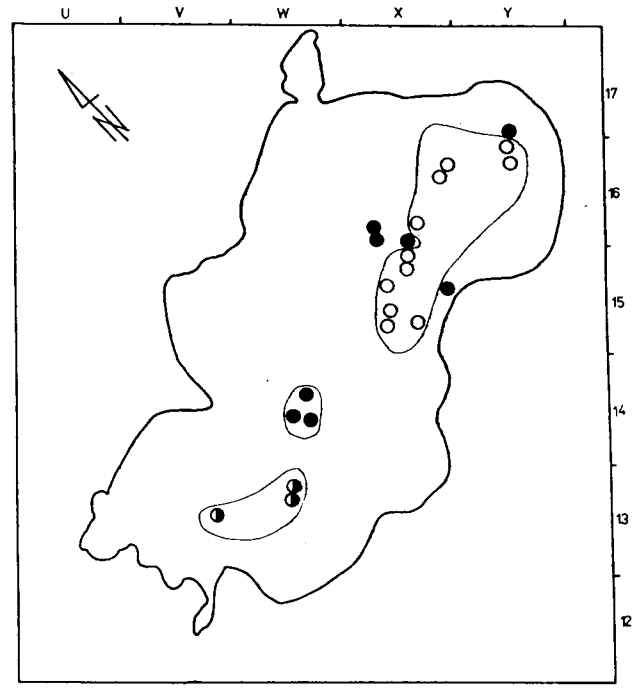

Fig. 4. Distribution of archaeobotanical samples from the hearths in the house F1/90. Sample symbols as in Fig. 3

like in the hearths. Here they are not linked with Capparidaceae. Samples are scattered in the western and central sectors of the hut.

House fill

Total number of samples was 51, 40 of them were used for CA analysis. Samples fall into two groups, with 2 outliers (Fig. 7).

1. The Paniceae group includes 28 samples, all from the eastern sector of the house (Fig. 8). Combination of taxa is closer to that in the hearths than in pot-holes, because Capparidaceae do not belong to this group.

2. The *Ziziphus* group includes 10 samples characterized by *Ziziphus* and Cruciferae; 8 are located in the western part of the house, 2 in the eastern. The association of *Ziziphus* with Cruciferae differs house fill samples from the hearths and pot-holes.

The absence of the third group of samples may be due to the fact that no samples were analyzed from the house fill in the central sector of the house (Fig. 8). The distinction of the two sectors, however, is real because none of the samples from Paniceae group come from the western part.

House fill top

From among 21 samples collected, 20 were used for CA analysis. Almost all samples come from the broad area in the central part of the house, which means that we have no information about plant assemblages in the western and eastern sectors. The samples form two clusters, poorly separated (Fig. 9).

1. The Paniceae group is characterized by Paniceae, Boraginaceae, *Sorghum*, NP-21, Leguminosae small-seeded, Capparidaceae and NP-9. It includes 11 samples, 9 of them located in the south-central sector of the house, two in the eastern house end (Fig. 10).

2. The *Ziziphus* group is characterized by *Ziziphus,* Cruciferae, Leguminosae other than small-seeded ones and *Cyperus/Fuirena* type. This is the only context in which the last-mentioned taxon occurs fairly abundantly. The *Ziziphus* cluster is made of 8 samples which come from the area adjoining the distribution area of the former group from north and east.

The one outlier is a sample very poor in plant remains, situated in the western house end.

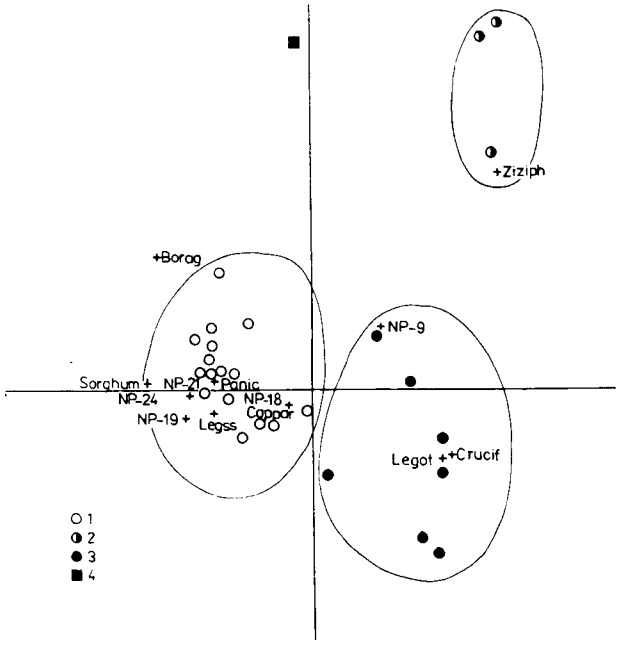

Fig. 5. Correspondence analysis of archaeobotanical samples from the pot-holes in the house F1/90, Nabta Playa E-75-6. 1 – Paniceae cluster, 2 – *Ziziphus* cluster, 3 – Cruciferae cluster, 4 – outlier. Continuous lines encirle samples situated in the same part of the house. Abbreviations of plant names as in Fig. 3

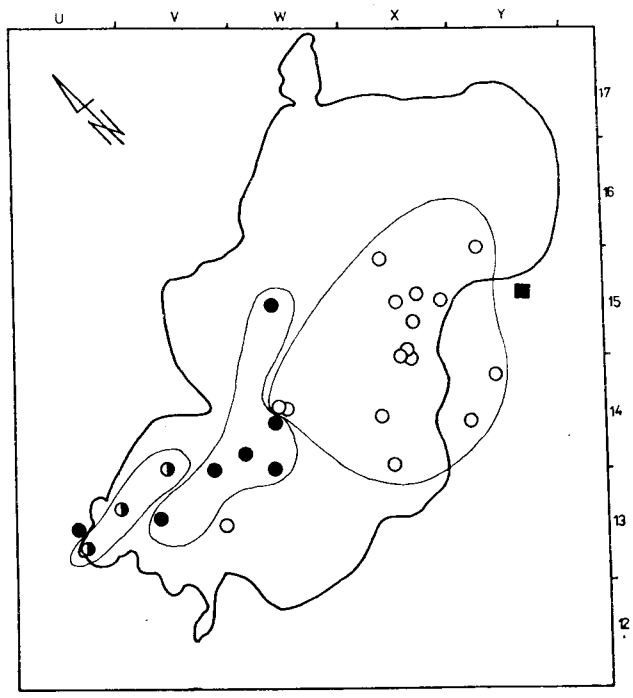

Fig. 6. Distribution of archaeobotanical samples from the pot-holes in the house F1/90. Sample symbols as in Fig. 5

The samples from house fill top fill the gap between the two groups of samples from the house fill.

All samples from the house F1/90 together

Total of samples collected was 144, 113 were used for CA analysis. In addition to the samples discused above 4 samples from postholes were included in the total analysis.

Two main sample clusters are formed (Fig. 11). The one on the left side of axis II is characterized by the Paniceae group of taxa, that on the right by the *Ziziphus* group. This pattern is also reflected in the plots for individual taxa, e.g. the distribution of sorghum shows its greater significance in the samples of the first group (Fig. 12). Samples of the Paniceae group come mostly from the eastern sector (82% of samples), those of *Ziziphus* group are dispersed over the house surface but more than half of them (55%) comes from its western part (Table 2).

The western sector of the house is very different from the east and central ones in that almost all samples (95%, Table 3) belong to the *Ziziphus* cluster characterized by the occurrence of *Ziziphus*, Cruciferae, Capparidaceae, Leguminosae other than small-seeded ones, *Cyperus/Fuirena* type and NP-9. Samples from the eastern part are slightly less homogenous, 83% of them belong to the Paniceae but 17% to the *Ziziphus* cluster (Table 3). The central portion of the house has intermediate

Table 2. Location of samples from Paniceae and *Ziziphus* clusters in the house F1/90 based on the correspondence analysis of samples. Number of samples is given

	Paniceae cluster		*Ziziphus* cluster	
	sum	%	sum	%
West sector	1	1.4	21	55
East sector	59	82	12	32
Central sector	12	17	5	13
Total in clusters	72	100	38	100

Table 3. Floristic differences between the west, east and central sectors of the house F1/90 based on correspondence analysis of all samples. Number of samples is given

Sample groups	Sectors					
	West		East		Central	
	sum	%	sum	%	sum	%
Paniceae	1	4	59	83	12	71
Ziziphus	21	95	12	17	5	29
Total in sectors	22	100	71	100	17	100

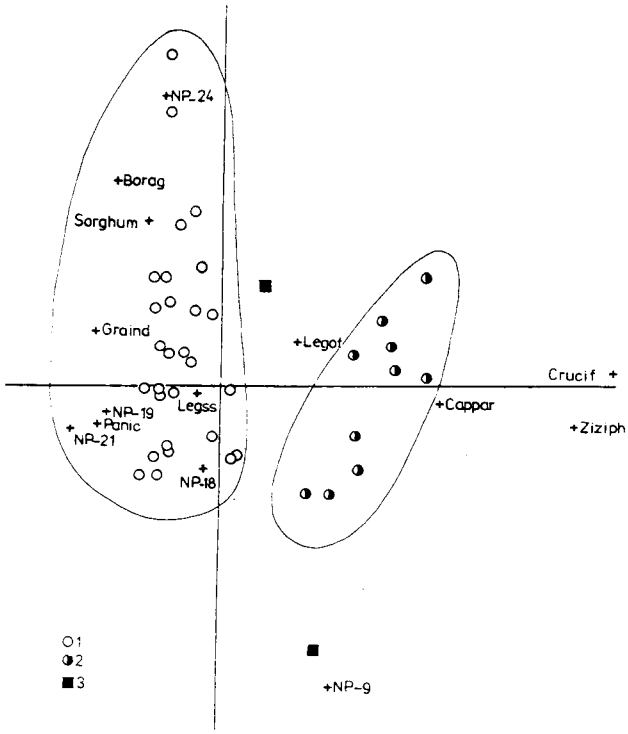

Fig. 7. Correspondence analysis of archaeobotanical samples from the house fill in the house F1/90, Nabta Playa E-75-6. 1 – Paniceae cluster, 2 – *Ziziphus* cluster, 3 – outliers. Continuous lines encirle samples situated in the same part of the house. Abbreviations of plant names as in Fig. 3

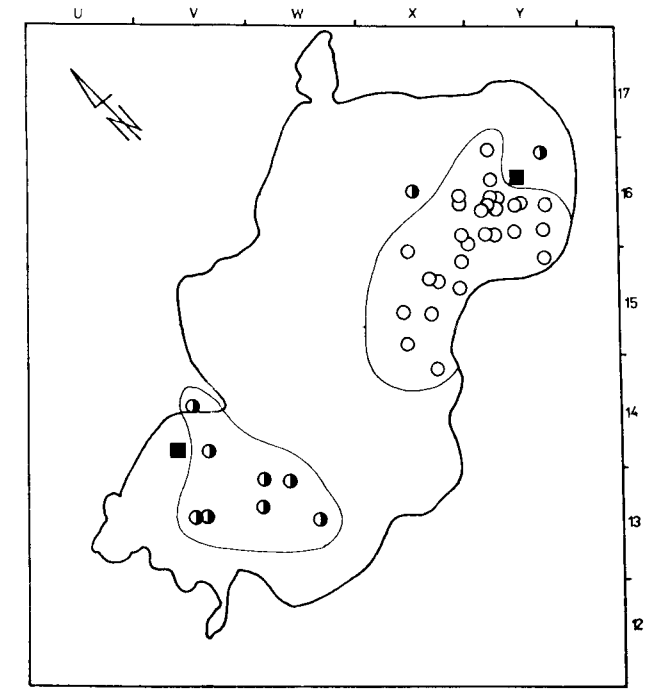

Fig. 8. Distribution of archaeobotanical samples from the house fill in the house F1/90. Sample symbols as in Fig. 7

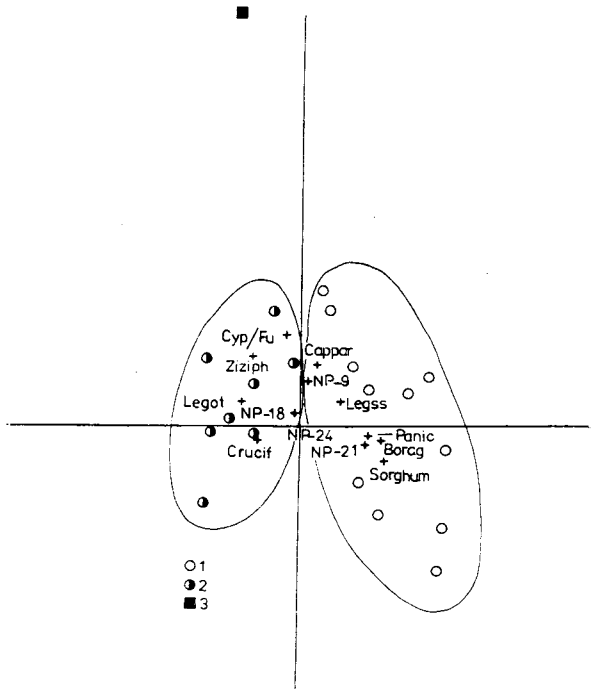

Fig. 9. Correspondence analysis of archaeobotanical samples from the house fill top in the house F1/90, Nabta Playa E-75-6. 1 – Paniceae cluster, 2 – *Ziziphus* cluster, 3 – outlier. Continuous lines encirle samples situated in the same part of the house. Abbreviations of plant names as in Fig. 3

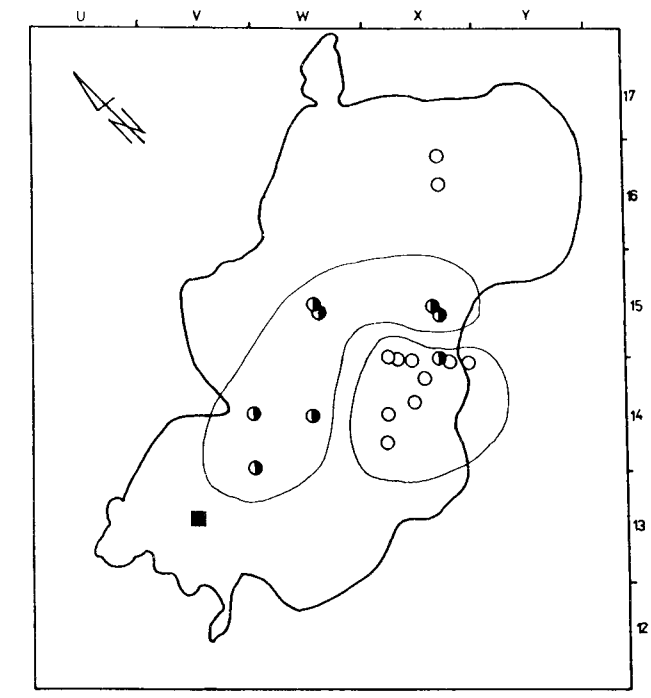

Fig. 10. Distribution of archaeobotanical samples from the house fill top in the house F1/90. Sample symbols as in Fig. 9

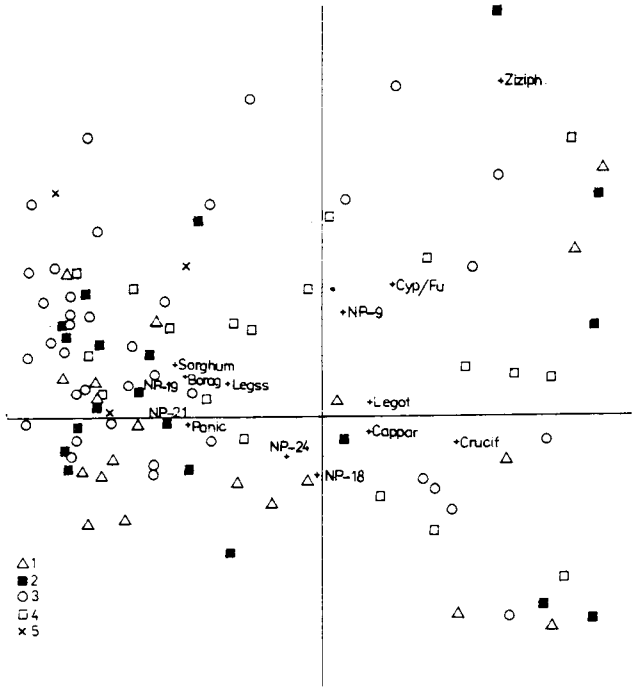

Fig. 11. Correspondence analysis of all archaeobotanical samples treated together from the house F1/90, Nabta Playa E-75-6. 1 – hearths, 2 – pot-holes, 3 – house fill, 4 – house fill top, 5 – postholes. Abbreviations of plant names as in Fig. 3

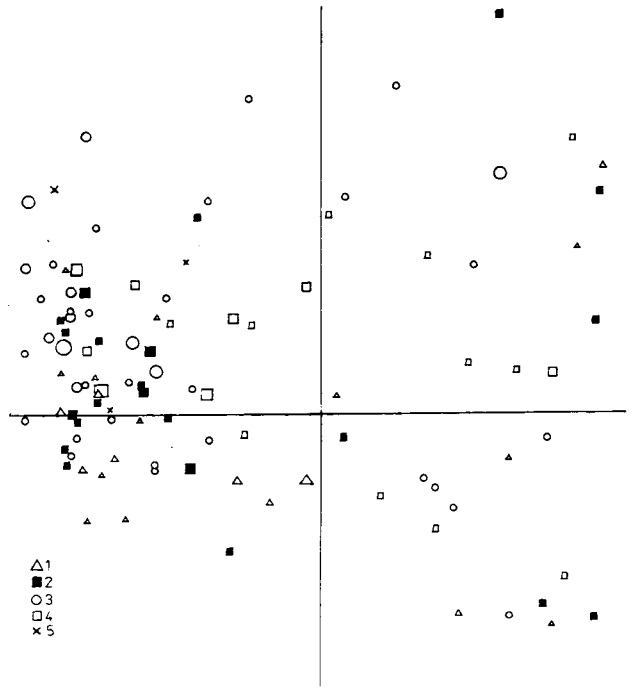

Fig. 12. Distribution of sorghum grains in the samples from the house F1/90 shown by correspondence analysis of all archaeobotanical samples from this house. The larger the symbol the greater the relative number of grains in a sample. 1–5 as in Fig. 11.

character, with 71% of samples of Paniceae group and 29% of that of *Ziziphus*.

It should be emphasized that the sectors discussed above are differentiated solely on the basis of the results of CA analysis of archaeobotanical samples.

No correlation was observed between the category of archaeological context and the composition of plant remains in the samples (Fig. 11).

DISCUSSION

Most plant taxa, that occurred in at least a few samples, were present in different types of archaeological contexts and different parts of the house. Neither the type of archaeological feature (hearth, pot-hole, house fill, house fill top, posthole) nor the house area could have been characterized by a taxon. This evidence is contrary to the opinion, expressed after preliminary examination of the material (Wendorf et al. 1991), that the content of pot-holes was dominated by a single species (the suggestion based on this opinion that plants in pot-holes represent one meal will not be discussed here, because it is not relevant to our main subject). The mixed character of samples was expressed in PCA by the lack of negative correlations between the occurrences of plant taxa. However, the distribution of plant remains in the house was not uniform over the whole house area and this was shown by correspondence analysis.

Two main groups of samples were separated, one characterized by Paniceae, *Sorghum*, Leguminosae small-seeded and NP-21 and the other with *Ziziphus*, Cruciferae and Leguminosae-others type. In hearths and pot-holes the second group split in the separate *Ziziphus* and Cruciferae groups.

The distribution of samples on the house surface divides it into two areas having different combinations of plant taxa and separated by an intermediate zone. The eastern and central sectors of the house belong to the area of Paniceae group dominance, the western sector is dominated by the *Ziziphus* group. The area of the Cruciferae group samples overlaps partly with the two others (Fig. 13). This division suggests the existence of the two activity areas, the larger eastern area and the smaller western one, separated by an intermediate

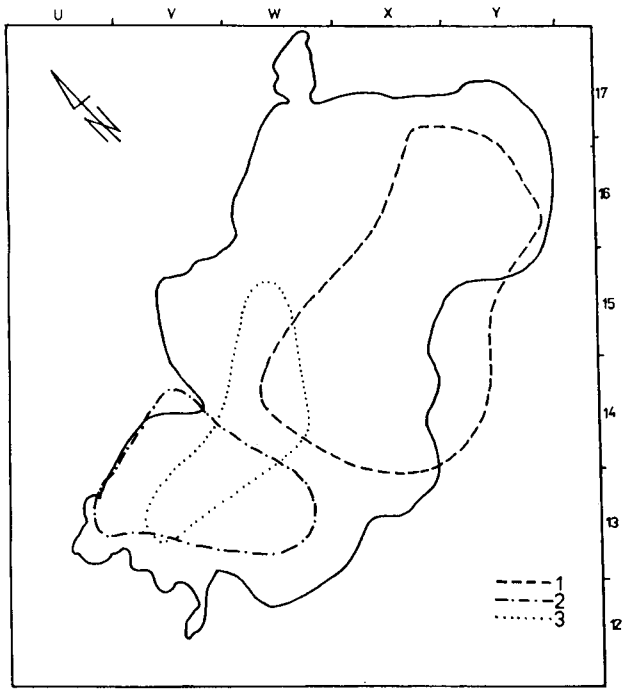

Fig. 13. Division of the house F1/90 into sectors based on plant content of samples from hearths, pot-holes and house fill. 1 – area of Paniceae group, 2 – area of *Ziziphus* group, 3 – area of Cruciferae group

zone. The areas are reflected best in the samples from hearths, pot-holes and house fill but are obliterated in samples from the top of house fill (Fig. 10).

The existing pattern may reflect the way plants were handled by people, i.e. how and when they were brought to the hut and the purpose they were used for. Plants could have been brought to the hut for various purposes, mostly for fuel and food. Theoretically they could have also been introduced in animal dung but the occurrence of dung is not confirmed. The largest portion of plant material must have been burnt in or near the hearths because no traces of a conflagration were discovered in the house. A smaller fraction could also have gotten charred in the so called pot-holes. These were small depressions in the earth in which containers with food were probably placed for cooking in hot ash piled around them. All the charred material present in the lower and upper layers of the house fill must have originated from hearths and pot-holes; it has been scattered over the house surface during the habitation time or just after the house was abandoned. This means that the primary pattern should be recorded best in the samples from the hearths, and this was confirmed by correspondence analysis.

Food prepared in the eastern sector included Paniceae and *Sorghum* grains, seeds of unknown Leguminosae from the Trifolieae tribe (Butler, pers. com.) and possibly seeds of an unknown genus of Cyperaceae (NP-21). *Sorghum* remains were less abundant than the others; either the supply of this grass was more limited or it was more valued by people and they handled it more carefully. We should remember, however, that the number of sorghum grains compared to that of the other taxa is not a good basis for the evaluation of sorghum significance in people's diet because of the difference in size. Sorghum caryopses are larger than those of millets as well as seeds of legumes and of the sedge family. Exactly how the food was prepared we do not know. Grass grains were probably cooked, together or separately, as a kind of gruel or groats, or they have been roasted. Seeds (not nutlets) of Cyperaceae could have been parched or ground and cooked separately or mixed with grasses (see discussion on the use of *Scirpus* seeds in Hillman et al. 1989, p.196). This kind of food was not cooked in the western sector at all or, if so, it occurred less frequently there.

The western end of the house was particularly rich in *Ziziphus* fruit stones. Today, fruits of *Ziziphus* are eaten raw and stones may be collected in order to get seeds which are ground to flour (Tubiana & Tubiana 1977). Perhaps the inhabitants of the hut under study were seating in the western end and eating *Ziziphus* fruits or this could have been the place where stones were crushed by women.

In the area between western and eastern parts of the house samples of different composition occur side by side. Few species occur here in quite large numbers, including plants having edible fruits (Paniceae, Leguminosae, Capparidaceae, NP-21) and plants of unknown or uncertain useful qualities. These are Boraginaceae of *Arnebia* type and Cruciferae, probably *Schouwia thebaica*. Fruits of *Arnebia* have very hard pericarps, no ethnobotanical information about their use was found. *Schouwia thebaica* (the identification needs to be confirmed) is an annual with edible leaves but no data about the useful properties of seeds are available. It is listed by Ozenda (1983) among alimentary plants, Schulz and Adamou (1992) state that it is a good forage for camels and cattle in Niger. Perhaps dry plants of *Ar-*

nebia and *Schouwia* were added to the fuel, or *Schouwia* was gathered for leaves and the rest was thrown into the hearth. In our analyses they do not fall into the same groups. This may be explained by the difference in their habitats; *Arnebia* grows on higher elevated grounds and *Schouwia* in depressions (Bornkamm & Kehl 1990).

No ecological interpretation of the material was attempted because the authors feel that more precise identifications are needed for this purpose.

CONCLUSIONS

The results of correspondence analysis show that plant remains were not uniformly distributed over the house surface. It may indicate that different plants were used by people in the different parts of the house. In its eastern sector food was prepared mainly from grains of Paniceae and *Sorghum*, seeds of unknown plant from Cyperaceae family and probably seeds of some Leguminosae. The western end was the place where *Ziziphus* fruits were consumed or its seeds were prepared for consumption.

No relation was found between sample contents, i.e. their taxonomic composition and quantitative representation of taxa, and the type of archaeological context. Possible explanation is that fresh plant material was first charred in the hearths and then, secondarily, was incorporated into the deposit preserved as the fill of pot-holes, postholes and the rest of the house area.

The whole house F1/90 was excavated and all the preserved archaeological deposit was collected, as far as possible. The samples were not evenly distributed over the hut surface and this is the serious drawback of our study. We think, however, that the picture would not be changed drastically with more complete material. One should realize that the sample collection from Nabta Playa, as for one house and short duration of habitation, is an extensive one. The results have shown that sufficiently rich plant material, properly collected, may reveal inner differentiation of an individual archaelogical feature, one house in our case, and thus, may contribute to the reconstruction of everyday life in prehistoric time.

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