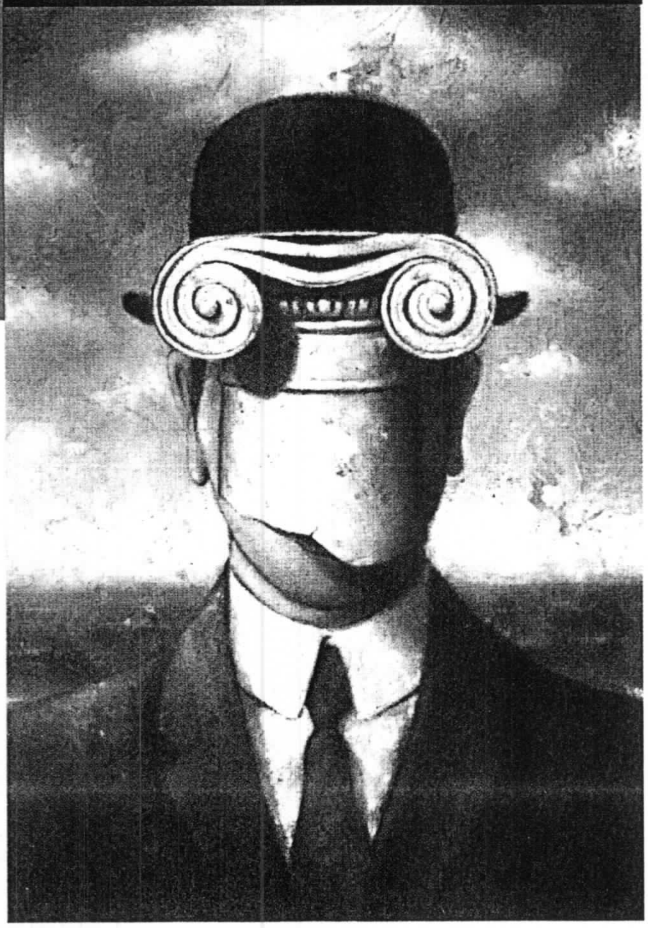
2nd international congress on

"science and technology for the safeguard of cultural heritage in the mediterranean basin"

5–9 July 1999

Paris France

PROCEEDINGS



CENTRE NATIONAL DE LA RECHERCHI SCIENTIFIQUE France

CONSIGLIO NAZIONALE DELLE RICERCHE Italia

Vol. 2

ELSEVIER

PLANT EXPLOITATION DURING THE EARLY AND MIDDLE HOLOCENE IN THE TADRART ACACUS (CENTRAL SAHARA, LIBYA) - POLLEN EVIDENCE OF CHANGES

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Keywords: Pollen, Plant Exploitation, Tadrart Acacus, Uan Afuda, Uan Muhuggiag

1. INTRODUCTION

Palynological investigations carried out so far in the archaeological sites of the Tadrart Acacus[1-4] have provided a great deal of information about Holocene pollen flora, vegetation and palaeoclimatic oscillations in the area, factors which significantly affect human behaviour (see, e.g. note 5, and references therein). Anthropogenic pollen was important for investigating ethnological aspects. In fact it evidenced the exploitation of a variety of plants, testifying or suggesting that humans used them based on cultural knowledge[4].

In this paper, the Uan Afuda Cave and Uan Muhuggiag Rockshelter, two sites of remarkable archaeological and artistic interest[6,7], were selected as examples to discuss the relationships between environmental and cultural changes suggested by pollen spectra obtained from two reference sequences, and studied by archaeologists and various field archaeo-environmentalists. The Uan Afuda cave was occupied by hunter-gatherers groups during the Early Holocene, and the Uan Muhuggiag rockshelter was occupied by pastoralists during the Middle Holocene. On the whole their Holocene deposits dated from 10 to 3.5 kyrs bp[8].

2. MATERIALS AND METHODS

Pollen spectra of sixteen samples (collected by M. Cremaschi, S. diLernia, A. M. Mercuri) were considered there. Six samples came from the Uan Afuda cave and ten samples from the Uan Muhuggiag rockshelter. Sample treatments and detailed pollen data were described elsewhere[2-4].

2.1 Chronology

Samples belonged to different cultural and chronological phases (archaeological and radiocarbon dates : see notes 8 and 9), as reported below:

Uan Afuda Cave - hunter-gatherers - Early Holocene
a) Early Acacus; 9765±105-9260±290 years bp; colluvial deposits;
b) Late Acacus; 8935±100-8330±100 years bp; organic layers;
Uan Muhuggiag - pastoralists - Middle Holocene
c) Early Pastoral; 6900±220, 6690±130 years bp; humified organic material;
d) Middle Pastoral; 6035±100 years bp; straw and ash, soluble salt and carbonates;
e) Late Pastoral; 3370±200 years bp; organic layers and coprolites.

2.2 Tables

Selected data from pollen spectra were presented in tab.I and II. They concerned total Grass pollen, Large-sized Grass pollen (i.e., ≥ 40 μm[4]) and other pollen types which characterised the spectra. Pollen percentage sums and ratios useful to evaluate Dry/Wet conditions[10,11] were calculated: a) D (dryer) sum: % Compositae undiff. + % Chenopodiaceae; it suggested a dry type of vegetation, namely a steppe and desert vegetation; *Artemisia* was excluded due to its over-representation in some spectra of both sites due to human disturbance[2,4]; b) W (wetter) sum: % Gramineae + % Cyperaceae; it suggested a Saharan-Sahelian savannah vegetation; c) the ratio sum D/ sum W indicates either a dryer or wetter vegetation prevailed; d) the ratio between % Chenopodiaceae (Ch) and % Gramineae (Gr) followed the distinction proposed by Hooghiemstra (see note 10 and references therein) between Saharan pollen = Chenopodiaceae and Sahelian pollen = Gramineae; it was useful to reconstruct latitudinal oscillation of the southern boundary of the Sahara.

The sum of total Anthropogenic pollen Indicators (AI) was reported, according to the categories described by Mercuri[4] as well as one individual AI category, i.e. grazing indicators (gz). Note that the 'gz' category does not include great part of grasses (only *Panicum* is included), and is a more suitable index of ovicaprine herding than cattle breeding. The Human Influence on Flora Index (HIFI = number of taxa of AI *100 / total number of pollen types[12]) was reported too. It indicates how much the flora was affected by human influence.

3. RESULTS AND DISCUSSION

In the two sites, a total of 9425 pollen grains were counted. Pollen was generally well-preserved. Concentrations ranged between 15,000 and 186,000 pollen grains/gram; only two samples had < 7000 p/g. Pollen spectra were characterised by Gramineae, Compositae, *Typha,* Cyperaceae, Chenopodiaceae. The main features of pollen spectra are reported below.

3.1 Uan Afuda ([9, 4]; 24°52'07"N 10°30'02"E; tab.I)

The cave is located along the wadi Kessan, a left branch of the wadi Teshuinat. The Early Holocene occupation dated between 10 and 8 kyrs bp. It was referred to as a 'pre-pastoral' period with hunter-gatherers of Early and Late Acacus cultural phases.

Pollen flora was quite varied (160 pollen types). The vegetal landscape was characterised by wooded grassland alternated with savannah (mean Gramineae plus Cyperaceae > 30%; fig.1b), and wet environments with *Typha.* Desert vegetation was not widespread (sums D/W <1.4 and Ch/Gr always ≤ 0.1). Climate was, in general, considerably wetter than today's.

As for the relationship between humans and plants, the pollen sequence showed high variety, concentrations and percentages of anthropogenic pollen indicators, particularly abundant during the Late Acacus phase (fig.1d). Pollen showed plants to be useful for food, fodder, fibre and drugs, and suggested that humans had a great capacity for discriminating plant properties such as chemical principles, colours and scent. A very high amount of pollen of *Echium plantagineum* type and *E.* cf *humile* (up to 2,000,000 pollen/gram), herbaceous plants which contain toxins of the

Holocene phase	Early Holocene					
Culture	Late Acacus					Early Acacus
^{14}C ages	8,330 ±100				8,765 ± 105	9,765±105 9,245±270
Pollen Samples	UAF-PS1	UAF-PS2	UAF-PS3	UAF-PS4	UAF-PS5	UAF-PS6
Pollen Zones	UAF2					UAF1
% Gramineae Total	52.4	39.8	25.5	27.9	18.3	31.1
% Large-sized Gram.	25.9	2.5	14.8	10.5	14.5	16.7
% Cyperaceae	4.3	9.1	7.1	6.7	0.1	3.3
% Typha	3.3	5.3	0.8	1.5	0.2	4.4
%Compositae undiff.	23.1	23.0	33.7	5.5	4.8	46.1
% Artemisia	1.0	0.9	0.4	0.6	43.6	2.1
% Chenopodiaceae	1.0	2.5	0.5	0.4	0.2	2.3
Pollen Counts	**511**	**319**	**744**	**717**	**1224**	**821**
conc. Total Pollen	60833	1921	186000	135795	21983	6274
conc. Tot.Gramineae	31876	765	47538	37900	4032	1951
D: %Com u.+Chen	24.1	25.5	34.2	5.9	5.0	48.4
W: %Gr+Cyp	56.7	48.9	32.6	34.6	18.4	34.4
D/W	0.4	0.5	1.0	0.1	0.2	1.4
%Ch /Gr	0.02	0.1	0.02	0.01	0.01	0.1
% AI	31.7	30.1	42.3	57.6	69.8	24.0
% gz	22.1	15.7	18.7	11.0	7.9	12.1
HIFI	31	43	45	37	37	44

conc. = number of pollen grains per gram; D = % Compositae undifferentiated (excl.Artemisia) + Chenopodiaceae; W = % Gramineae + Cyperaceae; %Ch/Gram = %Chenopodiaceae / %Gramineae; AI = Anthropogenic pollen indicators; gz = grazing indicators; HIFI = Human Influence on Flora Index

Tab. I - Uan Afuda cave – selected pollen data and sums.

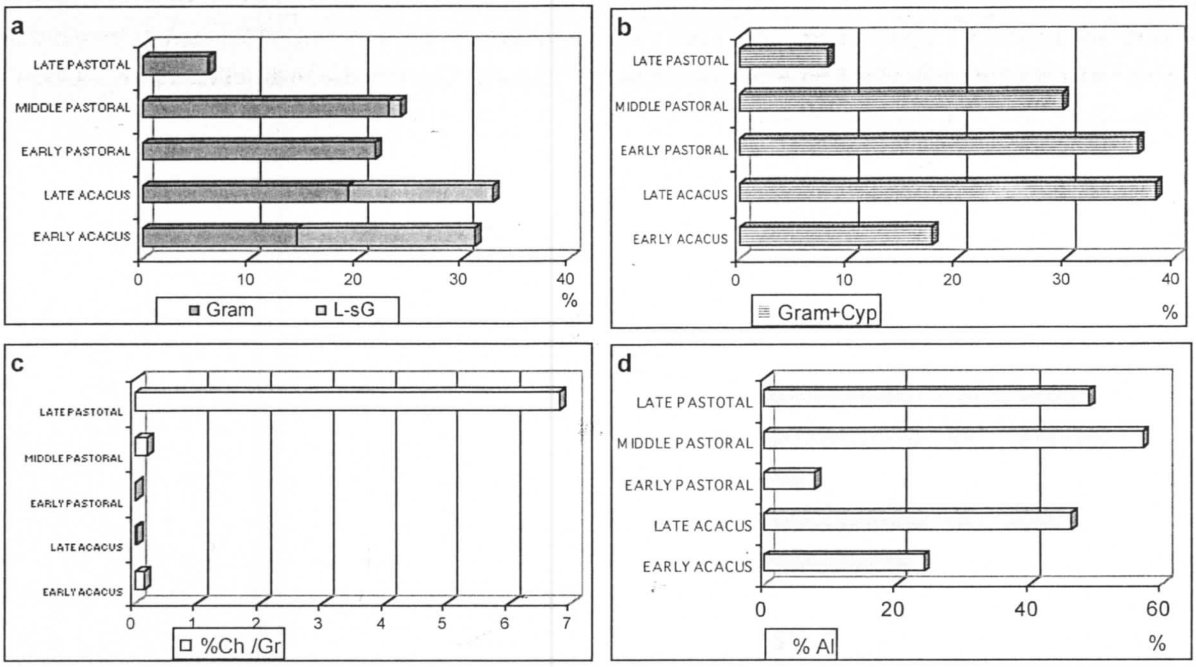

Fig. 1 - Mean percentages of selected pollen data per cultural phase: a- Gramineae (including Large-sized Grass pollen); b- Gramineae plus Cyperaceae; c- ratio Chenopodiaceae / Gramineae; d- Anthropogenic pollen indicators.

Holocene phase	Middle Holocene									
Culture	Late Pastoral			Middle Pastoral				Early Pastoral		
^{14}C ages	3770±200			6035±100				6690±130; 6900±220		
Pollen Samples	UM-PS1	UM-PS2	UM-PS3	UM-PS4	UM-PS5	UM-PS6	UM-PS8	UM-PS9	UM-PS10	UM-PS11
Pollen Zones	UM3			UM2				UM1		
% Gramineae Total	2.0	8.8	8.0	25.4	10.1	20.1	40.7	16.4	14.8	33.9
% Large-sized Gram.	0.2	0.2	0.4	4.1		0.3	0.2			0.1
% Cyperaceae		3.4	2.1	5.1	0.3	9.4	7.7	20.6	13.5	10.5
% Typha		0.2	0.4	0.6	0.3	1.3	15.7	48.6	53.8	33.1
%Compositae undiff.	4.2	13.8	11.7	10.4	6.2	11.2	10.5	6.6	8.3	13.7
% Artemisia	0.3	4.8	3.2	5.5	71.1	37.2	15.1	1.6	4.6	3.6
% Chenopodiaceae	26.7	24.5	34.2	10.0	3.4	0.6	0.4	0.2	0.8	
Pollen Counts	**626**	**522**	**532**	**511**	**705**	**627**	**504**	**509**	**519**	**504**
conc. Total Pollen	47584	42709	84494	14853	22758	24895	28444	36057	27541	45562
conc. Tot.Gramineae	952	3758	6760	3773	2299	5004	11577	36057	27541	45562
D: %Com u.+Chen	30.8	38.3	45.9	20.4	9.6	11.8	10.9	6.8	9.1	13.7
W: %Gr+Cyp	2.0	12.2	10.1	30.5	10.4	29.5	48.4	37.0	28.3	44.4
D/W	15.3	3.0	4.5	0.6	0.8	0.4	0.2	0.2	0.2	0.2
%Ch /Gr	13.3	2.8	4.3	0.4	0.3	0.03	0.01	0.01	0.05	
% AI	41.2	50.2	55.3	52.1	81.6	55.3	38.9	7.2	6.7	8.9
% gz	27.2	32.4	31.8	18.4	7.0	8.1	20.0	2.8	1.0	3.4
HIFI	66	44	30	42	45	28	33	34	33	32

conc. = concentration of pollen per gram; D = % Compositae undifferentiated (excl.Artemisia) + Chenopodiaceae; W = % Gramineae + Cyperaceae; %Ch/Gram = %Chenopodiaceae / %Gramineae; AI = Anthropogenic pollen indicators; gz = grazing indicators; HIFI = Human Influence on Flora Index

Tab. II - Uan Muhuggiag rockshelter – selected pollen data and sums.

pyrrolizidine alkaloid class, was recorded in the dung layer found in the inner part of cave (60 m from the entrance). The hypothesis formulated to explain such an accumulation was that humans deliberately selected these plants to induce a slow poisoning in wild animals (*Ammotragus lervia*[9]) kept into the cave. *Artemisia* flowers were selected too and swallowed as shown by the over-representation of its pollen in one sample (UAF-PS5) and by the pollen from human coprolites found in the cave. Wild cereals were certainly selected for human food, and grasses characterised by Large-sized pollen were extensively harvested. According to pollen analysis in progress (Mercuri et al, manuscript in prep.), some of these grasses were probably species requiring fresh-water environments, e.g. *Echinochloa*, and their availability in the area was favoured the wet ecological and climatic conditions which characterised the area in the Early Holocene.

3.2 Uan Muhuggiag ([7]; [2]; 24°50'32"N-10°30'47"E; tab.II)

The rockshelter is located in the Wadi Teshuinat, the largest water course of the Tadrart Acacus, a few km away from the Uan Afuda Cave. The Middle Holocene occupation dated between 7 and 3.5 kyrs bp. It was attributed to a pastoral period with pastoralists of Early, Middle and Late Pastoral cultural phases.

Pollen flora was less varied than the Early Holocene flora of Uan Afuda (118 pollen types) but still more varied than today's. Nevertheless it gradually became impoverished and changed along the sequence. Around 7 kyrs bp, i.e. in the Early and Middle Pastoral phases, the vegetal landscape was characterised by an open vegetation, namely a Saharan-Sahelian savannah (mean Gramineae plus Cyperaceae still > 25 %, fig.1b; and Ch/Gr < 1). In particular, the Early Pastoral phase developed in a wet phase (*Typha* was highly abundant, always > 33 %). Later, around 4 kyr bp, i.e. during the Late Pastoral phase, the spreading of desert savannah testified to very arid environmental conditions (D/W ratio = 3-15), and the onset of the present hyperarid climatic phase (mean Gramineae plus Cyperaceae < 10 %, fig.1b; Ch/Gr 3-13).

As for the relationship between humans and plants, the pollen sequence showed that at the beginning of this period the vegetation surrounding the rockshelter provided a good quantity and variety of plant resources more than sufficient to support life of humans and their animals. The low value of anthropogenic pollen indicators during the wet Early Pastoral (fig.1d) agreed with the low frequentation of the area highlighted by archaeological studies[13] suggesting that during the wet phases the occupation of mountain sites was less intense than in the dryer ones. Among the AI pollen some records showed a cultural heritage in plant uses: e.g. the over-representation of *Artemisia* in one sample (UM-PS5) suggested that Uan Muhuggiah pastoralists swallowed mugwort flowers like the hunter-gatherers of Uan Afuda had done thousands of years before. Other records instead showed differences, probably due to the different environment and culture. For example, medical/toxic plants decreased while ruderal/nitrophilous plants and grazing indicators increased compared with Uan Afuda. With regards to Grass pollen, they still had high values (mean percentages in Early and Middle Pastoral phases were > 20 %; fig.1a), but Large-sized pollen drastically fell and the largest-sized, > 60 μm, disappeared. This suggested that the availability of the wild cereals widespread in the Early Holocene was decreasing, and subsequently the exploitation of wild cereals changes forced them to move towards dry resistant cereals, e.g. *Panicum*. Finally, the Late Pastoral phase greatly differed from the previous phases showing the highest values of grazing indicators which reflected ovicaprine herding (gz = 27-32 %). The aforementioned drying of the climate reduced grasses, and more generally plant resources of the area.

CONCLUSIONS

In the Tadrart Acacus, unambiguous interactions between humans and plants date back to at least the Early Holocene, when gathering was a basic subsistence strategy for humans and at the same time management of vegetal resources increased cultural knowledge of plants. The latter, in turn, advanced culture.

Pollen data from the two considered sites showed changes in plant exploitation; some important changes are worth pointing out: 1) during the Early Holocene specific wild cereals, which had the largest-sized pollen observed in the Holocene of the Tadrart Acacus, were selectively harvested by hunter-gatherers among a relatively wide range of wild cereals available; these species disappeared in the Middle Holocene. Moreover, a number of plants were collected, for a number of uses concerning biological and spiritual needs[4]; 2) at the end of the Middle Holocene, and namely during the Late Pastoral phase, a high increase in some grazing plants reflected the spreading of specialised form of pastoralism, with ovicaprines. Moreover evidence of the exploitation of wild cereals and other plants lessened. Pollen suggested that these cultural changes were forced by the drying of the climate, and humans adapted to the changing environment, maintaining however some cultural heritage in their interaction with plants. Considering the impressive number of archaeological sites discovered in the Tadrart Acacus[13] and the diversified relationships between humans and both plants and vegetation testified to by pollen data, we came to the conclusion that the evolution of the vegetal landscape was also influenced by human exploitation of plant resources besides climate.

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