Upper Egypt: vegetation at the beginning of the third millennium BC inferred from charcoal analysis at Adaïma and Elkab

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Abstract

Archaeological charcoals from two Predynastic sites located in Upper Egypt are studied to help reconstruct woody vegetation. “Ash-jars” from the cemeteries at Adaïma and Elkab appear to have been filled with domestic hearth residues as offerings. The results show the predominance of Acacias at Elkab and Tamarix at Adaïma. This difference may be due to the influence of more active wadis on the east bank, near Elkab. Adaïma has a more diverse and slightly more widespread vegetation compared to the present. There is some evidence for the tendency in an increase in aridity and/or human impact between the Nagada II period and the first dynasties (3500–2900 BC).

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1. Introduction

Evidence for woody vegetation in the Nile valley during the pharaonic period is scant, due to the dearth of extensive charcoal and wood analyses. However, this state of research is currently changing, with for example ongoing studies in Lower Egypt at Giza and Memphis, and in Middle Egypt at Amarna (Rainer Gerisch, pers. comm.).

One particularity of the research subject explaining in part the lack of data is related to the nature of the Upper Egyptian ecosystems. The natural vegetation of the Nile valley forms a semi-oasian corridor in the midst of the Eastern Sahara; rainfall is irregular and nearly non-existent, and no permanent tributary to the river Nile flows within Egypt’s boundaries. Thus, the vegetation is entirely dependent on the Nile, except in the wadi beds draining the occasional rains falling on the Eastern mountain range bordering the Red Sea [52]. Vegetation composition is therefore linked to temperature, species’ growth habit and ability to withstand flooding several months a year. For instance, in Upper Egypt, high temperatures allow the presence of Sudanian species such as Balanites aegyptiaca or Calotropis procera usually occurring at lower latitudes. The physiognomy of the vegetation varies within the valley according to topography and proximity to the Nile or to the water table.

Charcoal and pollen analyses from central and eastern Sahara [32] point to a final stage of aridification around 5700 BP, while the study of lacustrine sediments from the Gilf Kebir (eastern Sahara) indicates a later date, around 4000 BP [36]. It is generally accepted that the present-day aridity was reached by the fourth millennium BC. As a result, vegetation changes during the middle and late Holocene in the Nile valley do not

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reflect changes in rainfall, but instead are closely related to the impact of local human activities.

Our study aims at reconstructing the woody vegetation in the Upper Egyptian Nile valley, at the beginning of the historical period (Pharaonic period) (~3500–2900 BC). The spatial variability is deduced from the comparison of two sites located in the same area: Adaïma on the West bank, Elkab on the East bank (Fig. 1). The special nature of archaeological remains available allows us to further our investigations. In fact, some of the Adaïma samples and all the Elkab samples come from funerary contexts. A comparison between settlement and cemetery samples at Adaïma was therefore undertaken, in order to assess the possible existence of choices in the funerary contexts.

1.1. The present vegetation

The present woody vegetation of the Nile valley between Isna and Idfu is found in two main habitats: canal and river banks, and cultivated fields [53]. On the canal banks, bank retainers are often planted trees and shrubs: Acacia nilotica, Ficus sycomorus, Melia azaderach, Morus spp., Salix subserata, Tamarix arboerea, Ziziphus spina-christi, Alhagi maurorum and Arthrocneum glaucum. Sand-tolerant and stabilizing plants include Casuarina equisetifolia, Dalbergia sissoo, Eucalyptus spp., Parkinsonia aculeata (four naturalized taxa), Ricinus communis, Salix spp. and Tamarix aphylla. The plants growing within the cultivated plain are T. aphylla, T. nilotica, the palms Phoenix dactylifera and Hyphaene thebaica, D. sissoo, allochtonous Ficus spp., Z. spina-christi and Acacia spp. Near the water pumps grow Salix tetrasperma, S. subserata and R. communis. Many of the taxa are naturalized and/or cultivated, thus rendering the evaluation of the natural vegetation hazardous.

Towards the desert Tamarix spp., Acacia shrubs, Chenopodiaceae, C. procera and Capparis decidua can be found. The wadi beds further into the desert support xerophilous shrubs such as Fagonia indica and Cornulaca monacantha, as well as therophytes when soil water is available.

1.2. The archaeological contexts

Adaïma lies in the Nile valley, about 9 km south of the modern town of Isna, at the present limit between the irrigated plain and the desert, and covers 35 ha. The Eastern and Western cemeteries and a large settlement area have been excavated since 1990 under the direction of Béatrix Midant-Reynes (CNRS, Toulouse, France). The occupation of Adaïma covers over 700 years, spanning from the cultural periods Nagada IC (N IC, Predynastic) to Nagada IIIC/D (N IIIC/D, IIInd dynasty). The settlement area studied concerns the northern terrace (Fig. 2), from which radiocarbon dated charcoal samples gave dates between ca. 3400 and 2900 BC. These dates correspond culturally to the period between the end of Nagada II (N II, Predynastic) and Nagada IIIB/C (N IIIB/C, Protodynastic, dynasties I and II) [30]. The features excavated between 1997 and 2000 are mainly pits dug into the substratum of the terrace, filled with a loose mixture of sand and silt, where no clear vertical stratigraphy can be observed.

The ceramic material from the terrace seems to indicate that the material from the western sector is globally older (N IIC in majority, ~3400 BC) than that from the eastern sector (N III in majority, ~3200–2900 BC) (Buchez, Bavay 2001, unpublished report). The mixed nature of the archaeological material and sediment in square 7001 does not allow us to consider the charcoal from this context as representing a single
period, and can therefore not be compared chronologically with the other sectors.

The cemetery, excavated under the direction of Éric Crubezy (Paul Sabatier University, Toulouse, France), is divided into two main zones. The western area, excavated until 1996, is located on a sandy butte separated from the settlement site by a wadi bed [13]. Its continuous use spans from Nagada IC until Nagada IIIA/B (3500–3100 BC). It comprises tombs of several degrees of richness, including one which could bear a founding role (S55). It attests the existence of an elite group and of complex ritual practices, concerning both the burial of the bodies and the deposit of offerings [9,13]. The Eastern cemetery is located in the wadi bed, and can be divided into two parts. One is mainly the burial site of children aged 0–12 years, and seems to have been in use during the Nagada IIIA/B period (end of the Predynastic, 3200–3100 BC), the other is a later group from Nagada IIIC/D (IInd dynasty, 2900 BC). The graves from the Eastern cemetery were found intact. They are directly comparable with the Eastern children’s cemetery at Adaïma.

2. Material and methods

At Adaïma, charcoal fragments have been recovered from two different deposits: the settlement area and the cemetery area. Organic material from the settlement area was recovered by floatation of sediments; charcoal fragments were sorted out from the larger fraction (>1 mm). Samples come from three squares in the main sectors, i.e. the western sector (1070-80/13), the eastern sector (1040/16), and the isolated square 7001 to the south (each square measures 100 m²). Since no clear stratigraphy could be recognized in the settlement area, results are presented by sector of occupation, as presented on the site map (Fig. 2). Charcoal from the...
cemeteries was collected either by hand during field work (to prevent breakage of bigger fragments included in the sediment fill of the tombs) or by subsequent dry sieving of the ash found in ceramic vessels thereafter called “ash-jars”, placed in the tombs as offerings. These ashes contained many charred macroscopic plant remains (seeds, fruit and charcoal) as well as charred animal dung. Most of the material from Adaı¨ma N IIC tombs and Elkab is from such ash-jars.

The interpretation of our data will take into account previous preliminary results [38] from another sector of the settlement (sector 1001) (Fig. 2) and from several tombs in the western cemetery.

The charcoal fragments were identified following standard procedures: observation, under a high-power microscope, of the three anatomical planes of wood and use of wood anatomy atlases [18,33,41] as well as a reference collection of modern Egyptian woods.

Wood fragments (desiccated) were also examined from all contexts [15,34], and though their study lies beyond the scope of this paper, reference will be made to some of the results.

3. Results

3.1. Adaı¨ma settlement

Thirteen samples were studied from the settlement context: 5 from the western sector, 5 from the eastern sector and 3 from square 7001.

The samples have a high taxonomic diversity; in total 24 taxa are identified (Table 1), with 2–16 per sample. Qualitatively, the spectrum is stable at the scale of the squares (Fig. 4). This good reproductive quality of the assemblage reveals the nature of the wood used, i.e. wood collected non-selectively for domestic fuel. The large number of taxa represented and the stability of the spectrum imply that over the period of occupation, all the major taxa growing in the area were collected for fuel use and apparently with little selection of species. This allows us to interpret the spectra in terms of palaeoecology, as demonstrated previously [11,12]. Indeed, the overall spectrum of taxa identified should reflect a compound picture of the ancient vegetation, through the differential occurrence of the dominant taxa versus the secondary and therefore less used taxa.

*Tamarix* is always the most abundant taxon (Table 1, Fig. 4), followed by *Acacia*, the other taxa never represent more than 10% of the total charcoal fragments. Unidentified Dicotyledones are frequent, in the form of young stems and bark fragments. Only *Tamarix* occurs in all the 13 samples, whereas *Acacia*, *C. decidua* type, *Faidherbia albida*, *Salvadora persica*, *A. nilotica* type, Chenopodiaceae, cf. *Prosopis* sp., *T. aphylla* type and Dicotyledones occur in at least seven of the samples (Table 1). Six taxa were identified in only one sample: *Cupressus /Juniperus*, Plantaginaceae type, cf. *Solanaceae*, *Fagonia /Zygophyllum*, *Suaeda* sp. and *Salix mucronata*. The preliminary results obtained by Pernaud [38] include only the main taxa represented here, as well as one doubtful occurrence of *Fraxinus* sp.; they will not be discussed further.

We now consider the numbers of charcoal specimens identified, excluding unidentifiable fragments. Statistical homogeneity tests were conducted for each 100 m²-square between samples, then between the squares (Table 2). For context 1070-80/13, the samples probably belong to the same initial population; their composition are similar. In squares 1040/16 and 7001, the samples are significantly different, which is probably due to the various contexts of the samples within each large square. At a broader scale, the hypothesis of homogeneity of the populations from the three squares is rejected at a highly significant level; this shows that quantitatively, a variability of the charcoal spectrum does exist. Considering the relatively small size of some of the samples, this variability might be a reflection of random variability of the secondary taxa between samples. Between contexts 1070-80/13 and 1040/16, the differences indeed do not affect the main taxa *Tamarix* and *Acacia*, but only secondary ones; in the first context, the proportions of the Capparaceae and *S. persica* are higher whereas those of *C. procera*, *F. albida*, and *T. aphylla* type are lower.
3.2. Adaı¨ma cemetery

Seven hundred and forty fragments of charcoal were identified from the 20 cemetery samples in Adaı¨ma; 135 in one sample (S 55) dating N IC (early Predynastic, \( \sim 3500 \) BC), 487 in six samples dating N IIC (Predynastic, \( \sim 3400 \) BC) – including 348 from 4 ash-jars –, and 118 in 14 samples dating to N III (late Predynastic until the IInd dynasty, \( 3200–2900 \) BC) – including 12 from one ash-jar.

The charcoal spectra are presented in chronological order (Fig. 4), all types of samples added together – charcoal from the ash-jars and fragments found either in ceramic vessels or in the tombs. Using the same statistical method as for the settlement samples, it was found that no significant difference exists between the spectra dating to N IIC and N III. However, due to the small numbers of charcoal, the variation of the less numerous taxa could not be taken into account. General characteristics of the assemblages are the predominance of Tamarix spp. (about 60% of the fragments), followed by Acacia spp. (over 20%) and S. persica (6%). The other taxa are never represented by more than 5% of the fragments in any sample.

One single exception is identified – tomb S55 – where the charcoal assemblage is dominated by S. persica (68.3%). The second most abundant taxon is Tamarix (22.3%). The context of this material demands special attention: a layer of charcoal and ashes on which the corpses were laid while the ashes were still warm [13] in the oldest dated tomb of Adaı¨ma (N IC). They are

### Table 1
Results of the identification of charcoal fragments from Elkab II. dynasty children’s cemetery, Adaı¨ma settlement and cemeteries, expressed in counts of identified fragments

<table>
<thead>
<tr>
<th>Taxon</th>
<th>Elkab II. dynasty N IC</th>
<th>N IIC</th>
<th>N III</th>
<th>Adaı¨ma settlement total</th>
<th>1040/16</th>
<th>1070-80/13</th>
<th>7001</th>
<th>1043</th>
<th>13</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acacia sp.</td>
<td>141/11</td>
<td>105/5</td>
<td>20/5</td>
<td>180/136</td>
<td>403/12</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acacia nilotica type</td>
<td>34/5</td>
<td>13/4</td>
<td>4/2</td>
<td>14/10</td>
<td>9/29</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Faidherbia albida</td>
<td>18/4</td>
<td>27/5</td>
<td>1/1</td>
<td>15/8</td>
<td>10/33</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>cf. Prosopis sp.</td>
<td>2/1</td>
<td>1/1</td>
<td></td>
<td>9/11</td>
<td>9/29</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>cf. Leguminosae type</td>
<td>1/1</td>
<td>1/1</td>
<td>2/1</td>
<td>6/2</td>
<td>8/16</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Capparaceae type</td>
<td>3/2</td>
<td>1/1</td>
<td>1/1</td>
<td>5/3</td>
<td>2/2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tamarix sp.</td>
<td>55/10</td>
<td>33/1</td>
<td>256/6</td>
<td>75/9</td>
<td>367/13</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tamarix aphylla type</td>
<td>14/7</td>
<td>13/1</td>
<td></td>
<td>24/7</td>
<td>3/29</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>cf. Balanites aegyptiaca</td>
<td>1/1</td>
<td></td>
<td></td>
<td>1/3</td>
<td>8/16</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Salvadora persica</td>
<td>101/1</td>
<td>32/4</td>
<td>5/3</td>
<td>16/30</td>
<td>40/86</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ziziphus sp.</td>
<td>2/2</td>
<td>4/3</td>
<td>1/1</td>
<td>8/5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calotropis procer</td>
<td>7/1</td>
<td>1/1</td>
<td></td>
<td>9/4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ficus sp.</td>
<td>1/1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Suaeda sp.</td>
<td>1/1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chenopodiaceae</td>
<td>9/7</td>
<td>5/1</td>
<td></td>
<td>21/8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Asteraceae type</td>
<td>2/2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Brassicaceae type</td>
<td>1/1</td>
<td>7/2</td>
<td>3/1</td>
<td>12/4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plantaginaceae type</td>
<td>2/1</td>
<td>1/1</td>
<td></td>
<td>1/1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Solanaceae type</td>
<td>2/2</td>
<td></td>
<td></td>
<td>2/2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fagonia/Zygophyllum</td>
<td>1/1</td>
<td></td>
<td></td>
<td>1/1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cupressus-Juniperus</td>
<td>1/1</td>
<td></td>
<td></td>
<td>1/1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unidentified Angiosperm</td>
<td>16/6</td>
<td>24/4</td>
<td>2/2</td>
<td>12/24</td>
<td>20/56</td>
<td>7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Monocoltodelone</td>
<td>1/1</td>
<td>1/1</td>
<td>2/2</td>
<td>4/3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unidentified Dicotyledone</td>
<td>19/2</td>
<td>1/1</td>
<td>4/5</td>
<td>3/5</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total except unidentifiable</td>
<td>305/20</td>
<td>135/1</td>
<td>487/6</td>
<td>118/14</td>
<td>689/56</td>
<td>1862/13</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The Adaı¨ma settlement results are presented by sector (100 m² square), the cemetery samples by archaeological datation. Comparison for each taxon between the total number of fragments identified and the number of samples in which they were identified (occurrence). nf, number of fragments, occ: occurrence = number of samples in which the taxon was identified. Note: In Fig. 4 Chenopodiaceae include Suaeda sp.

<table>
<thead>
<tr>
<th>Number of taxon categories</th>
<th>Number of observations</th>
<th>Number of degrees of freedom</th>
<th>Z</th>
<th>H₀ retained at:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1040/16</td>
<td>4</td>
<td>4</td>
<td>9</td>
<td>20.8 1%</td>
</tr>
<tr>
<td>1070-80/13</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>4 10%</td>
</tr>
<tr>
<td>7001</td>
<td>4</td>
<td>3</td>
<td>6</td>
<td>19 0.10%</td>
</tr>
<tr>
<td>Between the 3 squares</td>
<td>5</td>
<td>3</td>
<td>8</td>
<td>35.3 0.1%</td>
</tr>
</tbody>
</table>

Homogeneity tests conducted on charcoal samples from squares 1040/16, 1070–1080/13 and 7001, and between these three squares: presentation of the statistical criteria and results.
### Elkab Cemetery
- IInd Dynasty (~2900 BC)
  - 305 identifiable fragments

### Adaïma Cemetery
- N III (~3200-2900 BC)
  - 118 identifiable fragments
- N IIC (~3400 BC)
  - 487 identifiable fragments
- N IC (~3500 BC)
  - 135 identifiable fragments

### Adaïma East
- 1040/16
  - 689 identifiable fragments

### Adaïma West
- 1070-80/13
  - 612 identifiable fragments

### Adaïma South
- 7001
  - 561 identifiable fragments

### Taxa Identified in Small Numbers
- Acacia sp.
  - 20% of fragments
- Tamarix sp.
  - 5% of fragments
- Salvadora persica
  - 5% of fragments
- Capparaceae (1)
- Leguminosae (1)
- Ficus sp. (1)
- cf. Balanites aegyptiaca (1)
- cf. Prosopis (1)
- Capparaceae (2)
- Ziziphus sp. (2)
- Asteraceae
  - (2)
- Brassicaceae (1)
- Plantaginaceae (2)
- Monocotyledone (1)
- Leguminosae (2)
- Capparaceae (5)
- Plantaginaceae (5)
- Monocotyledone (1)
- cf. Prosopis (9)
- Leguminosae (6)
- Capparaceae (1)
- cf. Balanites aegyptiaca (3)
- Ziziphus sp. (4)
- Brassicaceae (7)
- Cupressus/Juniperus (1)

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**Fig. 4. Anthracological diagram, summarizing charcoal identification results from Adaïma settlement and cemetery samples, and Elkab IInd dynasty cemetery samples.**

Unidentifiable fragments are not taken into account in the percentages.

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therefore probably the remains of a ritual combustion structure in situ. For the moment its significance is still unknown.

The number of taxa is inferior for the cemetery than for the settlement (18 against 23), which can be explained by the smaller size of each of the samples: 148 fragments at most (S55, including 13 unidentifiable fragments), and by the type of deposit: fragments in heterogeneous sediment filling in pots. However, the taxonomical diversity is sufficient to permit a general comparison with the settlement. If we exclude results from tomb S55, the settlement and cemetery spectra are similar.

3.3. Elkab cemetery

The material from the IIInd dynasty cemetery at Elkab comprises 305 fragments of charcoal from 20 samples; these include 164 fragments from two ash-jars. Altogether, 12 taxa were identified. The general spectrum is different from those of Adaıma; *Acacia* spp. are the most frequent taxa with 57% of the fragments, followed by *Tamarix* spp. (23%) and *F. albida* (6%). The other six taxa are not present in more than 3 fragments, whereas unidentified bark and twig fragments are numerous; they have been identified as Dicotyledones (5%) or Angiosperms (6%). Similar results are obtained if only ash-jar samples are considered: *Acacia* spp. (47%) and *Tamarix* spp. (18%).

4. Discussion

4.1. Where do the ashes from the “ash-jars” come from?

The ash-jar contents in both Adaıma N IIC tombs and Elkab IIInd dynasty tombs included charcoal fragments, seed and fruit remains. Remains identified are similar to those from domestic refuse, such as the ones found at Adaıma settlement: cereal processing debris (chaff and straw), sheep/goat pellets, seeds from wild and weed species [34].

Taxa diversity in the ash-jars from Adaıma is very similar to that identified in the settlement and may indicate a similar provenience, i.e. domestic fires. This hypothesis is confirmed by the nature of the other plant remains. Although we do not have direct data on Elkab domestic fires, the similarity of composition in plant remains other than charcoal to the samples of Adaıma and the taxonomic diversity of the charcoal samples allow us to extrapolate the results of Adaıma to Elkab: the ashes contained in the ceramic vessels might also be remains from domestic fires.

The presence of such ash-jars was also recorded in other predynastic and early dynastic cemeteries from both Lower and Upper Egypt: early dynastic Minshat Abu Omar [44], N II cemetery HK 43 in Hierakonpolis [20], cemetery H in Diospolis parva [39] and Nagada [40]. The plant remains in some ash-jars from Minshat Abu Omar and Hierakonpolis were studied. The charcoal was not studied, but the general assemblages, which include seed, fruit and dung remains, bones and charcoal, are similar to hearth refuse assemblages. The ritual involving the placing of pots filled with hearth refuse in the tomb during the burial is thus certainly common to these sites, confirming the results from Adaıma and following Nathalie Buchez’ suggestion from the study of the ceramic material (1998).

4.2. A more diverse and more extended woody vegetation

Linking identified taxa to plant communities according to modern knowledge in ecology proves to be difficult. One reason for this is that many species have a large ecological amplitude. In the case of the most frequent taxa, their abundance and large ecological amplitude may be interpreted as their simultaneous presence in a variety of plant communities. Another reason is the level of identification reached; the geni *Acacia* and *Tamarix* could not be identified to the level of the species. Although anatomical types were sometimes distinguished (types *A. nilotica* and *T. aphylla*), these cannot be treated as identified species. Indeed, *T. aphylla* type comprises species *T. aphylla* and *T. passerinoides* ([33], p. 415). Identification of *Tamarix* encompasses 6 species in Egypt, and *Acacia* 10 species [5].

The 24 taxa identified in the charcoal plus one identified as desiccated wood (*Ficus* sp.) may belong to three types of habitat: the river banks, Nile valley communities on deep soil including ruderal vegetation, and plant communities in wadi beds and on poorly developed soils.

Possible riparian species like *A. nilotica*, *Acacia* spp., *F. albida* and *Tamarix nilotica* are ubiquitous in the samples, and constitute the greater part of the charcoal fragments. *S. mucronata* and *Ficus* spp. are rare (one charcoal fragment for the former, two desiccated wood fragments for the latter). The woody taxa that can grow in riverine habitats [53], in partly submerged lands or that can withstand seasonal flooding, may have composed part of the floodplain vegetation, in or between fields and on uncultivated land; *A. nilotica*, *Acacia* spp. (*A. raddiana*, *A. seyal*), *C. procera*, *F. albida*, *Ficus* spp., *T. nilotica* and *S. mucronata*.

An open vegetation composed of *Tamarix* spp., Chenopodiaceae including *Suaeda* spp., Capparaceae, *C. procera*, *Prosopis* sp. and *S. persica* could have grown on the sandy plain south of the settlement, separated by the terrace from the floodplain, provided that the water table was sufficiently high. Observations leading to the
last hypothesis concern the Eastern cemetery located in a wadi bed; many tombs seem to have been flooded one or several times, either when the wadi was active or when the water table rose due to high floods. It is moreover acknowledged that the water table in the Nile valley has been lowered consequently to the building of the dams on the river, in particular the High Dam south of Aswan.

The Nile valley/ruderal formation and the more xerophilous formation on sandy soil may represent a contracted desert vegetation, at the limit of the Nile floodplain: *Tamarix* would predominate on sandy soils and *Acacia* on coarser alluvial soils [54]. Indeed, genus *Tamarix* comprises a whole range of xerophilous and halophilous species, but the ecological amplitude of *T. nilotica* is even larger. *Tamarix* spp. can form riverine gallery forests along wadis on sandy soil, like in the central Sahara [52]; they resist aridity, salinity and seasonal flooding. *Prosopis* and many Chenopodiaceae, in particular *Suaeda* sp., also comprise xerophilous and/or halophilous species. Noteworthy is the characteristically low diversity of the *Tamarix* wadi formations. The *Acacia* formation could be composed of the species belonging to the *Acacieata tortilis sub sudanica* community, comprising *Acacia tortilis*, *A. raddiana*, *A. gerardii*, *B. aegyptiaca*, *C. procer*, *D. decidua*, *C. cartilaginea*, *C. sinensis*, *S. persica* and *Z. spina-christi* [54]. According to local geomorphological studies [14] the main substrata outside the present floodplain, within and around the site, are sandy near the river, clayey to the west towards the desert. They correspond to the predynastic substrata since the archaeological structures observed are posterior to them, and all are covered with eolian sand. The wadi on the border of and in which the Eastern cemetery was established is composed of reddish cemented pebbles and sand, where an *Acacia* formation could have grown. A similar vegetation could also have developed in adjacent wadis.

Terraces and levees within and at the border of the floodplain could have supported a mixture of this vegetation and protected or exploited trees, such as fruit trees (*Z. spina-christi*, *Ficus* spp., *B. aegyptiaca*), and a ruderal vegetation associated with human presence (housing and/or horticulture).

The results from the settlement show that all habitats were exploited; the riverine vegetation (the most important), plants growing on levees and terraces in the floodplain, the partly cultivated floodplain, and the more xerophilous vegetation, south of the terrace and in the wadis near the site. This relative importance of exploited habitats could be due to their relative spatial extension or to their relative proximity to the site, located at the border of the floodplain. The two main taxa, *Acacia* and *Tamarix*, correspond to dominant woody taxa of several plant communities. *Acacia* is dominant on coarse alluvial soil, in the Nile valley and in wadi beds, whereas *Tamarix* is dominant on sandy soil, in the Nile valley and in more arid conditions. The overall predominance of *Tamarix* may thus be related to extensive tamarisk formations both on the riverbanks and within the floodplain in uncultivated areas, and on the sandy plain south of the inhabited terrace. The collection of acacia and tamarisk branches for animal feed — young shoots are eaten by caprines and bovines — and the subsequent use of unpalatable wood remains for fuel may provide additional explanation for their frequency.

A comparison between the total number of fragments of the taxa and their occurrence in the samples (Table 2) shows that some taxa occur in many samples, but always in small numbers; *F. albida*, *C. decidua*, *S. persica*, *A. nilotica* type, Chenopodiaceae, cf. *Prosopis* sp. and *T. aphylia* type are present in at least 7 of the 13 samples. Their recurrence in small numbers of fragments could indicate that they were present as secondary taxa in the identified plant communities, this interpretation being consistent with ecological data. *F. albida* would belong to the *Acacia* communities in the floodplain, whereas the other taxa would be associated to the *Tamarix* and/or *Acacia* formations in dry conditions, i.e. the sandy plain south of the terrace and the wadis. The alternative explanation relative to their negative selection due to unfit burning properties does not hold here, since some of these species are still used today for charcoal production: *F. albida*, *Prosopis* [1].

A major difference between the present vegetation and that of the Predynastic period is the absence of any vegetation in the sandy plain south of the settlement terrace today, and its presence near the wadi, only in the form of ruderals around the artificially irrigated fields. Charcoal analysis and geomorphological data point to a higher water table during the Predynastic period.

Concerning the distribution of the identified species, some are now rare or absent from the region. *S. persica*’s distribution zone includes the Nile valley [6], but it was not seen in the vicinity of the site by the author, and its presence in the valley is not recorded by Zahran and Willis [53]; its distribution seems to have shrunk consequently to its exploitation for multiple purposes (fodder, salt, handicrafts, toothbrushes, medicine). It is known from ancient Egypt only in the form of charcoal, and was identified previously only at Makhadma in Middle Egypt, in Predynastic fireplaces [51]. Its abundance in Adaı́ma samples could indicate that its distribution was more extensive at the time. Its presence afterwards is attested neither as wood nor as charcoal during the pharaonic period, because its wood is not often used for the manufacture of objects and because Egyptian charcoal analyses are scarce.

At present, *B. aegyptiaca* grows in the Nile valley, restricted to isolated individuals, but none was noted by
the author around the site. *Prosopis farcta* is a bush mainly found on sandy soil in the Western desert and on the Mediterranean coast, and as a ruderal on cultivated lands of the oases [53], whereas the tree *P. africana* is a savannah species which does not belong to Egypt’s present flora [5]. The charcoal type resembles *P. africana* most. It may have disappeared from the Nile valley consequently to over-exploitation for many uses [1] or to shrinking habitat. *Prosopis* is also known in several cases in the form of seeds in Early dynastic [45], New kingdom [50] and Second intermediate period [46] sites; *Prosopis* and *Acacia* type seeds are however difficult to distinguish.

Only one taxon raises the question of its provenience: *Cupressus-Juniperus* type (probably *Cupressus* sp.). The allochtonous origin of the wood is very likely, since on the one hand it does not grow locally and one the other hand the import of wood is already known from Predynastic sites and grew in importance during pharaonic times [2,3]. It could have been imported from the north of Egypt, for example the Sinai peninsula, where *Juniperus phoenicea* is attested today [7]. Its presence in Adaima is identified as desiccated wood in another sector of the settlement [15], in square 1050/16 and as charcoal in square 1040/16 on the terrace [34]. *Cupressus-Juniperus* was only identified once in Egypt as wood for the Predynastic period: in Badari [8]. *Juniperus* sp. was also identified as wood in Maadi, Lower Egypt [49].

4.3. A vegetation change through time?

Slight but statistically significant differences were observed between the charcoal spectra from the western and the eastern sectors of the settlement. If these differences are related to chronological phases, following ceramic studies, vegetation changes seem to have occurred.

In the western sector (dating to ~3400 BC according to the ceramic material), the proportions of Capparaceae (including *C. decidua*) and *S. persica* are higher than in the eastern sector (dating to ~3200–2900 BC), whereas those of *C. procer*, *F. albida*, and *T. aphylla* type are lower (Fig. 4). *F. albida* is a riparian species, whereas *C. procer* is at once ruderal and xerophilous. The observed differences in the spectra could be due to a change of the vegetation, either through the desiccation through over-exploitation of the wadis and the sandy plain south of the terrace, or the ruderalisation of the vegetation under human influence, or both. These observed tendencies of change through time are blurred by the archaeological context, i.e. by the fact that both sectors were occupied during overlapping periods of time. Better defined Nagada II contexts recently excavated will be analysed and compared to these first results.

The desiccation of the wadis and of the southern plain, or their over-exploitation and subsequent depletion of woody plants, may contribute to the explanation of observations of settlement shifts during N III in the Nile valley, such as at Adaima, at Hierakonpolis [25], in the Nagada-Khattara region [23], at Abydos-Thinis ([37] in [30]) and of sedimentological studies by Karl Butzer [10]. A contraction of the settlements near the floodplain seems to have occurred, which may have been partly due to ecological reasons and to economical reasons. A shift toward the Nile may indeed be linked to the latter’s role as the major communication route, and therefore the place and starting point for trade [29].

4.4. A differential regional distribution of the vegetation

It is difficult to compare our qualitative data with those from other Predynastic sites in Egypt (Table 3), for the simple fact that not many data are available; when analyses were carried out they concern very small amounts of material per site; the charcoal assemblages thus identified vary very little from site to site, with only major taxa being identified. This study is an exception, since the sampling procedures allowed the identification of a wide range of taxa, and thus made possible the interpretation of the results in palaeoecological terms. Therefore, if regional differences occur, they may be due more to a lack of data and differences in precision of the identifications, than to biogeographical variations. The fact that *Tamarix* and *Acacia* are quantitatively predominant in all cases is not surprising, as even today these two taxa are still selected, especially for the manufacture of charcoal. *Tamarix* in particular is appreciated for its rapid regrowth that allows its long-term exploitation. The associated taxa seem to vary little, an observation that would have to be confirmed by further anthracological studies. For instance, *C. procer* is known from charcoal analysis only at two sites: in the Libyan desert around 7000 uncal. BP (Abu Ballas/Mudpans, [31]) and in the Arabic desert during the Roman period (Mons Claudianus, [47]) and as a single fruit remain prior to the Roman period, at Helwan (I. dynasty, [22]).

The main difference between the charcoal spectra from Adaima and Elkab is the predominance of genus *Tamarix* in the first, of *Acacia* in the second. The secondary taxa are more abundant in Adaima, and include in particular *S. persica*, a species not observed from the Elkab samples. This is an effect of the larger size of the samples from Adaima.

The importance of *Acacia* spp. and *F. albida* in Elkab may testify to the existence of extensive open Acacia savanna close to the site, in particular in the bed of the wadi reaching the foot of the cemetery (Wadi Hiliâl, Fig. 3), and/or to a more extended riparian vegetation.
However, the Nile floodplain at Elkab is narrow because of the nearby mountains, and it is unlikely that the sole provenience of the Acacia wood was the floodplain, because part of it must already have been cleared for agricultural purposes. Today, the wadis in the Eastern desert are still regularly active, whereas in the Western desert those ending in the Nile valley hardly ever carry any water. This implies that the latter do not allow the growth of tree formations, unlike the Eastern desert wadis. The anthracological data suggest that the environment was similar during the early pharaonic period, although maybe less advanced in its desertification on the Western side: a woody vegetation probably grew in the mouth of the wadis near Adaima.

**Table 3**

Summary of charcoal and wood analyses on Predynastic Egyptian archaeological sites, from both Lower and Upper Egypt, including previous published studies and results from Adaima and Elkab

<table>
<thead>
<tr>
<th>Ecology</th>
<th>Site</th>
<th>Lower Egypt</th>
<th>Upper Egypt</th>
<th>Number of identified fragments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Egypt</td>
<td>Egypt</td>
<td></td>
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<td></td>
<td></td>
<td>El-Omari</td>
<td>Maadi</td>
<td>Tell el Far‘in-Battu</td>
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<td></td>
<td></td>
<td>Mekhädna</td>
<td>Mahgar</td>
<td>Arment</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Abydos (tomb Uj)</td>
<td>Herakleopolis (localities 29, 11C, cemeteries 6 &amp; 11)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Adaima</td>
<td>Elk II, Dynasty</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>10, 11 C/12</td>
<td>1917</td>
<td>305 number of sites</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Taxa</th>
<th>Presence</th>
<th>Location</th>
<th>Provenience</th>
<th>Egypt</th>
<th>Upper Egypt</th>
<th>Number of identified fragments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Balanites aegyptiaca type</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Salvadora persica*</td>
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<tr>
<td>Syzygium sp.*</td>
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<tr>
<td>Acacia sp.</td>
<td>(incl. poles)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Retama retama</td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>Genisteae sp.</td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

**Legend:**
- *: halophilous
- nitrophilous/ruderal
- CHARCOAL
- C: charcoal
- D: desiccated wood
- Coloured cells indicate presence of the taxon.
- /x: identified according to ref. 8, /x: identified according to ref. 9.

For each site, only the presence of the taxa is given. References: 1: Barakat [4]; 2: Kroll [27]; 3: Van Zeist and De Roller [49]; 4: Thanheiser [43]; 5: Vermeersch et al. [51] (analyst: Neumann); 6: Litynska [28]; 7: Feindt and Fischer [19]; 8: El Hadidi [16]; 9: Fahmy and Barakat [17]; 10: Pernaud [38] (charcoal); 11: Dietrich [15] (wood).
4.5. Wood selection for a funerary ritual?

The high percentage of *S. persica* in the remains of a ritual combustion structure (S55) may be interpreted in several manners. Firstly, taphonomically: the charcoal fragments represent a single burning episode. For any single fireplace, be it domestic or not, the taxonomic variety is low, for the remains may be from the last (few) log(s) used as fuel [12]. It is therefore not representative of the whole range of firewood available in the vicinity. The presence of *S. persica* may therefore be fortuitous: it happened that the last branches or logs put into the fire were from such a tree. Secondly, we cannot exclude a special selection of the tree for the exceptional purpose of the fire as part of a funerary ritual, in what may be interpreted as the founding tomb of the cemetery. The reason for this possible selection is unknown to us who do not have the same cultural references as predynastic people living in the region of Adaima. Fruit of *S. persica* are edible [26], its leaves used as a herb in cooking [1]. Different parts of the tree (fruit, leaves, bark, roots, roots’ bark) are known for their medicinal applications (against syphilis, headaches, rheumatisms and blennorrhagitis, as an expectorant, a purgative, a vermifuge and a febrifuge) [21,42,35,1] and the ashes of its wood and leaves are precious for their richness in salt [1]. But were these qualities particularly searched for? For the time being, nothing allows us to conclude.

5. Conclusion

At the end of the Predynastic period, ca. 3000 BC, the woody vegetation at Adaima was more diverse than at present, excluding recently naturalized taxa, and possibly more extended towards the desert. Three main plant formations were exploited: (1) riparian formations along the Nile, (2) a ruderal vegetation in the floodplain, (3) xerophilous formations on the sandy plain south of the terrace and at the mouth of the wadis, perhaps with more halophilous affinities on low grounds with poor drainage. The overall abundance of charcoal remains on the site compared to other kinds of fuel and the taxa richness of the samples, may point to a woody vegetation more extended than today, including within the floodplain, in areas not yet turned into cultivated fields. These uncultivated areas of the floodplain may have been exploited as pasture land for the domestic animals [48], hunting land, as well as a source of building materials. The nature and extent of human impact on the natural habitats therefore needs to be assessed more precisely.

The vegetation’s transformation on the site during its occupation is slight: only an indication of a change between Nagada II and the first dynasties, where there is evidence for aridification and/or human impact.

The reconstructed vegetation is differentiated according to the river bank, although less than today. The Acacia communities were more developed relatively to other plant communities on the east side of the river, where large wadis draining orographic rainfall run into the narrow Nile valley. The taxonomic spectrum identified in the charcoal from funerary contexts allows to consider the hypothesis that the ashy contents of the vessels placed in the tombs as offerings are of domestic provenience. This hypothesis renders the palaeoenvironmental interpretation of this charcoal possible. A unique case of wood selection in the context of a funerary ritual (S55) was brought to light and contrasts with the qualitative uniformity of the assemblages at Adaima.

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References


[47] M. Van der Veen, The food and fodder supply to Roman quarry settlements in the eastern desert of Egypt, in: M. Van


