Plant Food Economy and Environment during the Epipalaeolithic in southwest Anatolia : an Investigation of the Botanical Macroremains from Öküzini and Karain B

Inauguraldissertation

zur
Erlangung der Würde eines Doktors der Philosophie
vorgelegt der
Philosophisch-Naturwissenschaftlichen Fakultät
der Universität Basel

von

Danièle C. Martinoli
aus Busswil BE

Basel, 2005

Genehmigt von der Pholosphisch-Naturwissenschaftlichen Fakultät auf Antrag von Prof. Dr. Stefanie Jacomet und Dr. Sue Colledge

Basel, den 10. Mai 2005

Prof. Dr. Hans Jakob Wirz

Preface and acknowledgements

Today's hunter-gatherers are not isolated survivors nor the direct descendants of the first humans. But ethnographic reports were always close to my mind and reminded me that hunter-gatherer societies are rich, complex and full of surprises. Vandana Shiva wrote: "Diversity is the characteristic of nature and the basis of ecological stability. Diverse ecosystems give rise to diverse life forms, and to diverse cultures. The co-evolution of cultures, life forms and habitats has conserved the biological diversity on this planet. Cultural diversity and biological diversity go hand in hand." (Shiva, 1993).

The work presented here was an encounter with the Epipalaeolithic hunter-gatherers who lived at the foothills of the Taurus mountains in southwest Turkey by the mediation of the botanical macroremains they left behind, and through important human activities, such as subsistence and fuel use. But this study was also a meeting with a country, a population, a culture, a language, sounds and flavours of great richness. There are many whom I wish to thank for their help and encouragement. First of all I would like to thank Prof. Stefanie Jacomet for her support and confidence when I projected to realise a PhD with Near Eastern plant material, and to accept to be my supervisor together with Dr. Sue Colledge, my co-supervisor. I owe Prof. Gordon Hillman and Dr. Mark Nesbitt to encourage me to undertake the archaeobotanical analyses of Karain and Öküzini. Prof. Isin Yalcinkaya and Prof. Marcel Otte entrusted me with the archaeobotanical material from their sites and I am grateful to them for this. Prof. ass. Harun Taskiran was always of invaluable help with all the administrative tasks involved when doing research in a foreign country. The assistants from the Universities of Ankara and Liège, Kadryie Ceylan, Beray Kösem, Levent Atici, Metin Kartal and Rebecca Miller, as well as the students of the University of Ankara contributed to the good progress of the fieldwork and provided a good atmosphere. The main part of this work was realised in Basel at the Botanical Institute and at the Institute of Prehistory and Natural Sciences from the University Basel. The list of persons I would like to thank is too long to be presented here. However, I would like to thank my closest colleagues with whom I could share on a day to day basis the progress of my work: Örni Akeret, Robert Blatter, Christoph Brombacher, Alexa Dufraisse, Michaela Ernst, Dominique Hecker, Sabine Hosch, Marlies Klee, Marlu Kühn, Lucie Martin, Karin Meier-Riva, Britta Pollman, Angela Schlumbaum, Meral Turgay, Patricia Vandorpe, Lucia Wick and Petra Zibulski. This work involved many travels and stays and I thank Hugh Elton, Michèle Martinoli, Rafael Socias I Company and Stéphanie Thiébault for their welcome. I am also grateful to Ann Butler who checked my Fabaceae identifications, Werner Schoch and Stéphanie Thiébault for their help with the charcoal identifications. This research would not have been possible without the financial support from the Swiss National Science Foundation (grant n° 12-64974.01 and n° 101312-101585/1) and the Freiwillige Akademische Gesellschaft, Uarda Frutiger-Fonds. The support from my friends and my family helped me to go through these years.

Table of contents

1. Introduction

1.1. Choice of the subject

The foraging mode of subsistence is very old and lasted for the longest part of human history, but its diversity and evolution through time remains still insufficiently known. The hunting and gathering way of life persisted until recent or historic times in some populations often relegated in remote environments. These modern hunter-gatherer populations give evidence of the multiplicity of subsistence strategies, material cultures, traditions, mobility patterns, etc. and of their deep knowledge and admirable degree of adaptation to their respective environments (Kelly, 1995; Lee & DeVore, 1968; Lee & Daly, 1999; Panter-Brick, Layton & Rowley-Conwy, 2001). While Mesolithic or Epipalaeolithic people were food-gatherers, making their living by hunting, fishing and collecting plants, the different ways they adapted to their natural environment are far from being understood. This lack of information is mainly due to the meagre traces past foraging societies have left. Their material culture represents the most obvious records preserved in the form of stone artefacts and bone tools, wall paintings or carvings, as well as habitation structures (walls, fireplaces, etc.). Much rarer are ecofacts like animal and especially botanical remains. Therefore, very little is known about the economy (vegetal diet, plant based subsistence, overall subsistence strategy, mobility pattern), as well as about the environment in which they lived.

The Epipalaeolithic represents a key period preceding the emergence and the spread of agricultural practices and sedentary mode of living in south eastern Europe and the Near East. Geographically, this period is unequally well investigated, mostly because of political obstructions. Sites in which plant remains have been recovered, and for which plant based economy could be investigated to some extent, are rare (see § 3.3.). Since our knowledge of the Epipalaeolithic of southwest Anatolia is extremely limited, the study of the Late Glacial plant food economy and vegetal environment at Öküzini and Karain B promised to add substantially to our understanding of Anatolia's prehistory.

1.2. Aims of the research

The study of the plant remains recovered in Öküzini and Karain B caves and dated to the Epipalaeolithic had the overall objectives to better understand the use and interaction of these populations with their vegetal environment. Several specific aims were:

- To determine the taxonomic spectrum of plant resources (seeds, fruits, other plant parts and wood) exploited by the inhabitants of the sites, with particular reference to the plants used for food.
- To investigate the plants used for food and their role in the diet, to infer the plant based subsistence strategy and to explore the past patterns of seasonality of wild plant food availability, of resource exploitation and of site occupation.
- To define and trace diachronic changes in the patterns of plant use through the Epipalaeolithic.
- To contribute to the environmental reconstruction of the vegetation in coastal southwest Anatolia.
- To explore the links between environment, subsistence and mobility patterns.

1.3. Limits of the research

One particular problem faced with plant remains from Epipalaeolithic sites in Southwest Asia is the difficulty to identify them on the species level due to the enormous biological diversity existing in this area. Moreover, our knowledge of the range of plants used by prehistoric populations is fragmentary because of the selective preservation of the organic remains in the archaeological deposits and the lack of preservation of soft tissues (for example leaves, soft stems, buds, edible gums, flowers, etc.). In early pre-agrarian sites, the food species which happen to survive in the charred remains represent only a small fraction of those actually available for exploitation within the site catchment's as a whole (Colledge, 2001). In addition, the remains often suffer from poor preservation and high fragmentation (preservation is by charring, more rarely by mineralization).

A major focus of the archaeobotanical research in the last two decades was to distinguish wild from cultivated plants. With this aim in mind, a range of novel anatomical and histological criteria was explored, especially for the cereals and pulses. The investigations included examinations of the micro-morphology of pulses and the bran histology of cereal caryopses (Butler, 1989; Colledge, 1988; Hillman *et al.*, 1993; Kislev, 1984). A study of the morphology of charred remains of the grass species native to Southwest Asia (Nesbitt, 1997) offered the prospect of identifying these taxa more precisely. Hather's work on the micro-morphological identification of charred roots and tubers (Hather, 1991; Hather, 1993) permitted in some cases the identification of such remains recovered in archaeological sites (Hillman, 1989; Kubiak-Martens, 1996; Mason, Hather & Hillman, 1994). But, despite the research, which has been done to date, the identification of some groups of plants and certain types of remains are still problematic.

1.4. Structure of the thesis

In chapter 2, we considered briefly the state of the archaeological research in Anatolia for the Epipalaeolithic period. Chapter 3 brings together the four research papers, which build the main part of the thesis. In 3.1, special attention was given to a very important category of remains recovered in the Epipalaeolithic levels: the „1 mm thick nutshell" remains. The use of morphological and anatomical features, connected with the examination of reference material from various collections and the present distribution areas of the potential species, enabled us to better circle the identification. This study, completed with a review of the possible uses and the properties of the fruits identified, gave birth to the paper "Identifying endocarp remains and exploring their use at Epipalaeolithic Öküzini in South-West Anatolia, Turkey". In chapter 3.2, the results of the analysis of the complete Epipalaeolithic plant assemblages from Öküzini and Karain B caves, wood charcoals excluded, was outlined. The results brought about a discussion on diet, plant based subsistence strategy and seasonality of use of the caves. The knowledge about the palaeoenvironmental conditions during the Late Glacial in southwest Anatolia, and especially in the coastal area, is extremely poor. In chapter 3.3, the charcoal remains recovered in both caves were studied, and the results were combined to other proxy data from regional and local studies in order to reconstruct the local vegetation and to better understand the resource procurement zones exploited by the Epipalaeolithic populations. This was achieved with "Reconstruction of the local woodland vegetation and use of firewood at two Epipalaeolithic cave sites in southwest Anatolia (Turkey)." In chapter 3.4, the results from the analyses of the Epipalaeolithic plant assemblages were compared to other contemporaneous sites in "Plant food subsistence in context: an example from Epipalaeolithic southwest Anatolia" and the particularity of the southwest Anatolian sites were outlined. We have then used the Optimal Foraging Theory to test its explanatory capacity for the understanding of the observed patterning. Finally, in chapter 4, the main results and interpretations were synthesized and future research directions suggested.

2. Archaeological context: The Anatolian Epipalaeolithic

Anatolia is a peninsula that extends like a bridge between the Near East and Europe. Most of the territory consists of plateaux and high valleys ranging from 800 to 1200m in elevation, which are occasionally cut by sunken basins, intermountain plains or by hills of volcanic origin. The coastal topography is also extremely diverse; while steep-sided ranges of mountains block access both to the Mediterranean as well as to the Black Sea from the central plateau, there are fluvial plains penetrating inland, and deltaic formations along the other coastal regions from the littoral areas of the Aegean. In considering the distances as well as the diversity of habitats, it is clear that Anatolia cannot be taken as a single entity between the Near East and Balkans.

A combination of technological and environmental factors presumably confined Epipalaeolithic groups to areas where wild animals and food plants were abundant (Yakar, 1991). A model proposed for hunter-gatherers of Epipalaeolithic times envisages small mobile groups exploiting small ecological niches with rich fauna and edible flora and maintaining a balance between their numbers and the capacity of their environment to support such numbers. This presumes more or less egalitarian groups. Another model figures a non-food producing community living in a permanent settlement situated in a very rich ecological zone. This form is likely to induce, in short or long term, the need to manipulate the resources towards a conservation, what can be considered as a first step towards food production (Yakar, 1991).

In Anatolia, our knowledge of the cultural development preceding the initial stages of the Neolithic period is extremely limited. A reason involved is that „(...) the main focus of archaeological research in the Near East was the Levantino-Mesopotamian regions and Anatolia was considered a marginal area, where peripheral cultures resided only during later prehistory“ (Özdogan, 1997). The advanced technology of the Epipalaeolithic period produced very refined composite tools such as reaping knives used for wild plant harvesting or reed cutting for building shelters or for making baskets and mats. However, the sequence of lithic industries of the Epipalaeolithic is known only from a few sites and the ancient investigations (roughly before 1980) suffer from poor documentation and inaccurate dating and enable only limited observations, even after re-evaluation (Kartal, 2003). The lack of modern systematic surveys and excavations makes it difficult to get an accurate image of the Anatolian Epipalaeolithic. Almost all the sites attributed to the Epipalaeolithic have revealed significant microlithic assemblages, some with geometric components. However, as the dating of these sites mainly depend on typological similarities, and as there was very little or no information on the non-artefactual assemblages, these were considered with a degree of scepticism (Kartal, 2003; Özdogan, 1998). Nevertheless, different cultural areas seem to compose the Anatolian Epipalaeolithic: i.e. the Pontic area, central Anatolia, south eastern Anatolia and southern Anatolia. In his review of the Anatolian Epipalaeolithic assemblages, Kartal (Kartal, 2003) comes to the conclusion that Öküzini and Karain B offer at present the only true Epipalaeolithic assemblages found in stratigraphic position. According to the characteristics of the lithic industry studied in detail in Öküzini cave, it appears that the assemblage possessed its own characteristic with influences from the Levant and Zagros (Bar-Yosef, 2002; Kartal, 2003), but this is still debated. With more than 50 radiocarbon dates at Öküzini and ca. 20 at Karain B, the sequences are among the best-dated in Southwest Asia.

3. Research papers

3.1. Martinoli Danièle and Stefanie Jacomet (2004). “Identifying endocarp remains and exploring their use at Epipalaeolithic Öküzini in southwest Anatolia, Turkey”. Vegetation History and Archaeobotany 13: 45-54.

Veget Hist Archaeobot (2004) 13:45–54
DOI 10.1007/s00334-003-0029-0

ORIGINAL ARTICLE

Danièle Martinoli · Stefanie Jacomet

Identifying endocarp remains and exploring their use at Epipalaeolithic Öküzini in southwest Anatolia, Turkey

Received: 10 July 2003 / Accepted: 28 November 2003 / Published online: 5 February 2004

Abstract Excavation of the Epipalaeolithic levels of the cave site Öküzini in southwest Anatolia produced many "nutshell" remains, mainly endocarp fragments belonging either to *Prunus* or *Amygdalus*. Morphological comparison with the range of potential species and present geographical distribution made it possible to refine the determination to either of two species of wild almond, *Amygdalus orientalis* or *A. graeca* . These plants could grow in the surroundings of the site on rocky slopes or sandy hills and had to be collected during late summer. All wild *Amygdalus* seeds are toxic, so that their use as food is disputed. This paper explores the detoxification possibilities, nutritional properties and ethnographic analogies for the use of wild almonds. It comes to the conclusion that the seeds probably played a notable role in the diet of the Epipalaeolithic population of southwest Anatolia, complementing meat and other plant food. An examination of further prehistoric "nutshell" finds from Anatolia supports a long and widely distributed tradition of almond use.

Keywords Amygdalus · Prunus · Endocarp identification · Wild-food gathering · Detoxification · Epipalaeolithic · Turkey

Introduction

During the excavations of the small Öküzini cave (37°05′N, 30°32′E), a remarkable assemblage of carbonised plant macroremains has been recovered (Martinoli 2002). The cave is set in southwest Anatolia some 300 m above sea level (Fig. 1). Located at the foot of the Katran Mountains with summits reaching more than 2,000 m, it opens onto an alluvial plain overlooking Antalya. The site was discovered and first excavated in the 1950s and an additional excavation led by Prof. Yalçınkaya (Ankara University) and Prof. Otte (Liège University) lasted from 1989 to 1999 (Yalçınkaya et al. 2002). The 3.5 m thick deposits contain an archaeological sequence starting with the final Palaeolithic, followed by thick Epipalaeolithic layers (Otte et al. 2003). Several Neolithic and Chalcolithic burials were present at the top of the sequence, cut into the underlying deposits. The sequence is interrupted by three sedimentary gaps (Otte et al. 2003). The cave bears traces of intense human activity: hearth stones, combustion zones filled with ash deposits, extremely abundant lithic material (including grinding stones) and faunal debris are found throughout the stratigraphic sequence. The site was often reused, probably as a seasonal campsite (Atıcı and Stutz 2002). Based on the archaeological assemblages, six occupation phases (also called anthropological phases) have been distinguished: units I to IV belong to the Epipalaeolithic industry, V and VI have Neolithic and Chalcolithic components (Otte et al. 2003). The dates range from 16,560±180 uncal B.P. (18,200–17,400 cal B.C.) to 12,130±100 uncal B.P. (14,400–11,800 cal B.C.) for the

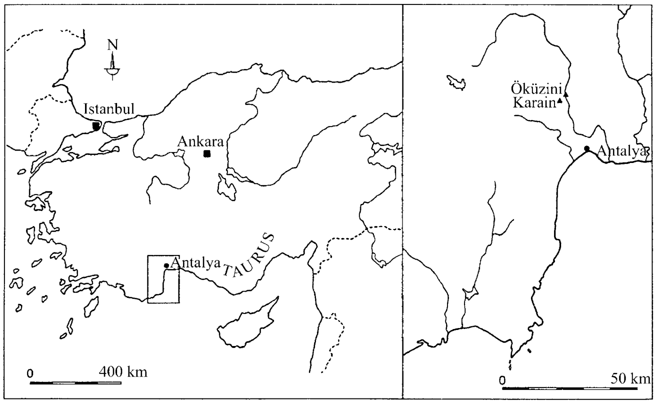


Fig. 1 Location map of Öküzini Cave

D. Martinoli (✉) · S. Jacomet
Institut für Prähistorische
und Naturwissenschaftliche Archäologie IPNA, Archäobotanik,
Universität Basel,
Spalenring 145, 4055 Basel, Switzerland
e-mail: dmartinoli@arso.org

Epipalaeolithic levels. The upper deposits gave a date of 7,880±80 uncal B.P. (6,840–6,640 cal B.C.).

Only a limited number of Epipalaeolithic sites in the southeast Mediterranean and southwest Asia have yielded botanical remains. These are Hallan Cemi in Turkey (Rosenberg et al. 1995, 1998), Franchthi and Theopetra caves in Greece (Hansen 1991; Kyparissi-Apostolika 1999), Abu Hureyra and Mureybit in Syria (van Zeist and Bakker-Heeres 1984/1986; Hillman 2000), Ohalo II, Nahal Oren and Hayonim caves in Israel (Noy et al. 1973; Hopf and Bar-Yosef 1987; Kislev et al. 1992), Wadi Hammeh 27 and Wadi Jilat 6 in Jordan (Colledge 2001). While the concentration of seeds and fruits found at Öküzini is modest, the tough fragments of fruitstones are well represented, in particular endocarp fragments belonging either to *Amygdalus* or *Prunus*. Studies on morphological identification of *Amygdalus* and *Prunus* endocarps in southwest Asia are scarce. The rarity of large and well-preserved finds might be one reason. The high diversity and great variability of this taxonomic group could be another. The latter makes a secure identification, sometimes even of the whole plant, difficult. An attempt to use chemical analysis on similar kinds of fossil remains has given promising results, but has not been further explored (McLaren 1995). Although the genera *Prunus* and *Amygdalus* have been identified among the wood charcoals and pollen recovered in the Epipalaeolithic levels in Öküzini (Thiébault 2002; Emery-Barbier 2002), the identification to a group of species, or to a species, was impossible. A more accurate determination of the endocarps recovered will enhance the comprehension of their role (in *Prunus*, the fleshy fruits and nutty seeds within the fruitstones can be consumed, in *Amygdalus* only the nutty seeds), the season of availability and the ecology of this resource. The wild nuts and fruits uncovered in archaeological layers have usually been considered as food resources. In the case of wild plants which are somewhat toxic, as is the case with the *Prunus* and *Amygdalus* seeds, their past use as food is a controversial point (Ladizinsky 1999). Direct proof for consumption of the seeds of the fossil endocarps is seldom found and their presence on a site can be the result, for example, of their accidental gathering with wood for fuel. In this paper we will use indirect paths to argue in favour of an important role, as a complement to meat, of the *Amygdalus* and/or *Prunus* seeds in the diet of the Epipalaeolithic dwellers of Öküzini, by exploring the nutritional properties of the endocarps identified and ethnographic analogies. A close examination of similar "nutshell" remains and their recovery context in other pre-agrarian and agrarian sites in Anatolia will also support our hypothesis.

Materials and methods

The excavation area was dug with 10 cm thick arbitrary spits in 50×50 cm squares. In order to maximise retrieval of plant remains, all the deposits were processed by bucket flotation and sieved on a 0.5 mm sieve (Martinoli 2002). The inorganic sediments left as residues after flotation were sieved and split in 4, 2 and 1 mm size fractions and sorted with the naked eye. As a result of the excavation strategy, mixed spits, especially in the upper levels, occur and had to be eliminated from this study. Fortunately, because of the more or less horizontal deposition of the sediments,

Table 1 Provenances and collection numbers of the *Amygdalus* and *Prunus* specimens examined

Species	Collection	Provenance
Amygdalus fenzliana (Fritsch) Lipsky	Felipe and Grasselly, Zaragoza	Iran
Amygdalus webbii Spach	Felipe and Grasselly, Zaragoza	Toledo, Spain
Amygdalus webbii Spach	Felipe and Grasselly, Zaragoza	Sicily, Italy
Amygdalus zabulica Searf.	Felipe and Grasselly, Zaragoza	Kabul province, Afghanistan
Amygdalus kuramica Korsch.	Felipe and Grasselly, Zaragoza	Salang, North Afghanistan
Amygdalus kuramica Korsch.	Felipe and Grasselly, Zaragoza	Tcharatou Ghazmir, Afghanistan
Amygdalus kuramica Korsch.	Felipe and Grasselly, Zaragoza	Shah Maksud, Afghanistan
Amygdalus bucharica Korsch.	Felipe and Grasselly, Zaragoza	Khulm, Afghanistan
Amygdalus bucharica Korsch.	Felipe and Grasselly, Zaragoza	Balkh, Afghanistan
Amygdalus bucharica Korsch.	Botanical Institute Basel	Botanical garden Frunse, Kirgistan
Amygdalus orientalis Duhamel	Botanical Institute Basel	Konya province, Karadağ, Turkey. *Legit* Aylan Erkal
Amygdalus orientalis Duhamel	University College London	Polatlı province, Turkey. *Legit* Gordon Hillman, GCH3270
Amygdalus orientalis Duhamel	Botanical Institute Basel	Ankara province, Cubuk Barajı, Turkey. *Legit* Mark Nesbitt RMN1735
Amygdalus graeca Lindley	Hacettepe University Herbarium	Antalya, Kumluca, Altınyaka road, serpentine, phrygana, 300 m, *Legit* Ali Dönmez AAD3970
Amygdalus scoparia Spach	Felipe and Grasselly, Zaragoza	Between Sahrekord and Ispahan, Iran (planted)
Amygdalus scoparia Spach	Botanical Institute Basel	Botanical garden Teheran, Market, Iran
Amygdalus georgica Desf.	Botanical Institute Basel	Botanical garden Tbilisi, Georgia
Amygdalus spinosissima Bunge	Felipe and Grasselly, Zaragoza	Zaragoza, Spain (planted)
Amygdalus spinosissima Bunge	Felipe and Grasselly, Zaragoza	Shah Maksud, Afghanistan
Amygdalus brahuica Boiss.	Felipe and Grasselly, Zaragoza	Salang, North Afghanistan
Prunus divaricata Led.	Botanical Institute Basel	Botanical garden Erevan, (wild)
Prunus divaricata Led.	Botanical Institute Basel	Sofia, Bulgaria (wild)
Prunus divaricata Led.	Botanical Institute Basel	Botanical garden Izmir, Spildaği, Turkey
Prunus divaricata subsp. *ursina* (Kotsch.) Browicz	University College London	Turkey. *Legit* Sebastian Payne, SP156

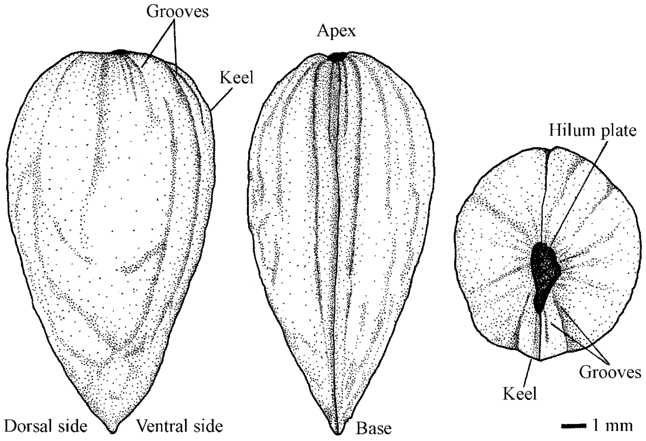


Fig. 2 Modern *Amygdalus graeca* Lindley (Hacettepe University Herbarium AAD 3970) with the essential features of *Amygdalus* and *Prunus* endocarps

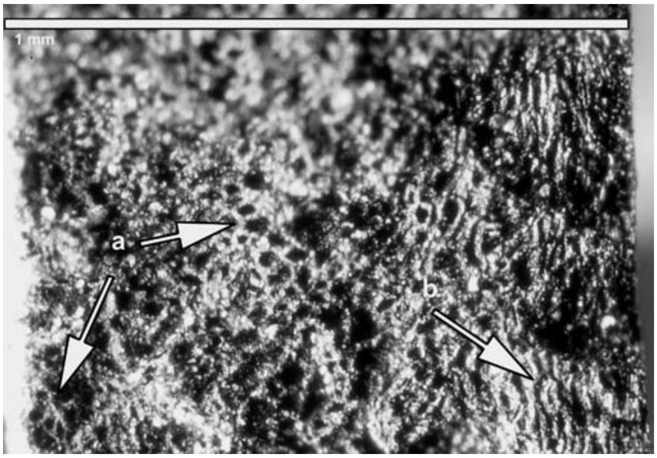


Fig. 3 Anatomical structure of the transverse section of an endocarp fragment from Öküzini. *a*, rounded cells, *b*, tangentially elongated cells (Photograph G. Haldimann)

only arbitrary spits overlapping two different geological horizons (GH) had to be eliminated. This study includes the botanical remains from the levels attributed to the Epipalaeolithic period (anthropological phases I to IV; Otte et al. 2003), from which more than 4,000 litres of sediments have been processed. The "nutshell" remains, including endocarps, uncovered in Öküzini were identified by comparing their morphology and anatomy (in particular the cell structure of the transverse section) to those in modern specimens. A binocular (Wild M3Z 6–40 X; Leica MZ125 8–100 X), a reflection microscope (Laborlux 12ME 200–500 X) and a scanning electron microscope (SEM Laboratory University College London) were used. The "nutshell" remains could easily be separated into a *Pistacia*, a *Quercus* and an *Amygdalus* or *Prunus* category. The specific identification of this last group was the most problematic because of the number of potential species and the difficulty in examining an exhaustive endocarp collection of *Amygdalus* and *Prunus* from southwest Asia. In addition, the high interspecific similarity, the possibility of hybridisation and the confusion in the taxonomy makes it even more difficult. Despite the examination of different specialised seeds and fruits collections (Botanical Institute Basel, University College London, British Institute of Archaeology Ankara, Institute of Mediterranean Agriculture Zaragoza), the range of modern endocarps studied remains incomplete (Table 1). Additional collections are dispersed between different countries and it was not possible, within the scope of this study, to consult them all. As a consequence, the descriptions of the modern endocarps had to be completed with those found in the literature (Meikle 1966; Browicz 1969; Browicz 1972a, 1972c; Grasselly 1976a; Grasselly and Crossa-Raynaud 1980; Browicz and Zohary 1996).

The essential morphological features of *Amygdalus* and *Prunus* endocarps (Fig. 2) are their shape and size, the arrangement of the ventral and dorsal sutures and the surface pattern, the latter being the most characteristic feature, even when, unfortunately, it is not always constant (Browicz 1969). The ventral suture is generally well built, more or less protruding and sharp, composed of lips outlined by the vascular bundles. Laterally, the vascular bundles diverge into secondary bundles, the imprints of which induce more or less reticulate, pitted, rugulate, grooved or areolate sculptures over the endocarp. The texture of the endocarp shell itself varies from dense to fibrous, with vascular bundles included in the shell or not.

In this paper, we follow the taxonomy and nomenclature from the Flora of Turkey and the East Aegean Islands (Davis et al. 1965-1988) and the latest revision of the *Amygdalus* genus (Browicz and Zohary 1996).

Results

Description of the plant finds from Öküzini

Around 1,280 carbonised fragments of different size and shape (the largest measuring 5 by 5 mm) attributed to endocarps were recovered. They were accompanied in the samples by other "nutshell" and fruit remnants (like *Pistacia*, *Quercus*, *Crataegus*, *Celtis*, *Pyrus*, *Rosa* and *Vitis*), wood charcoals, indeterminate residues belonging probably to roots or tubers, and some sporadic small seeds (*Alkanna*, *Galium*, Poaceae, Cyperaceae, Trifolieae). The endocarp fragments possessed smooth borders, so that they were probably fragmented before carbonisation and deposition in the sediments. The features they share are a 0.8 to 1 mm thick shell with a similar histological arrangement in transverse section: the endocarps are composed of an outer layer of rounded cells with thick walls and small lumen irregularly arranged, and an internal layer made up of tangentially elongated cells (Fig. 3).

Different types of fragments could be observed according to the part of the endocarp they came from or to their preservation state (Fig. 4). The fragments originating from the surroundings of the hilum plate bore deep and more or less thick grooves (Fig. 4a,b,c,f,g). They were curved, reflecting a rounded, though laterally slightly flattened, hilum apex. Some of them comprised parts of the round-elongated hilum plate (Fig. 4a,g). Other fragments comprised segments of the ventral keel, which were well individualised and sharp (Fig. 4a,b,d,e). A strong main groove delimited the keel on each side, bordered by one, sometimes two, weaker grooves incising the lips. In cross-section, the cavity of the main vascular bundle was visible in the centre of the keel or slightly displaced to the inner side (Fig. 4e). Many fragments came from the flanks of the endocarps and differed only through their ornamentation, which could be longitudi-

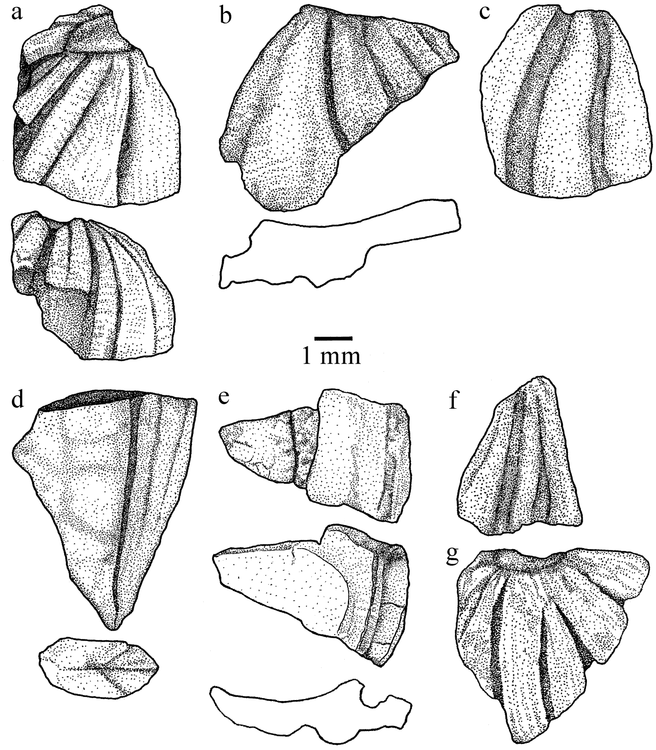


Fig. 4a–g Fossil endocarp fragments uncovered from Öküzini. **a** fragment with hilum plate and keel; **b** fragment from the apex with keel, grooves and main vascular bundle cavity; **c** fragment with grooves; **d** pointed base fragment with keel; **e** fragment from the middle of the endocarp, with keel and main vascular bundle cavity; **f** fragment with grooves; **g** fragment with hilum plate and grooves

nally grooved, reticulate or smooth. Some pieces came from the basal extremity: they were laterally flattened and pointed (Fig. 4d).

Additional fragments with similar anatomical structure were small or eroded and lacked any ornamentation. The fragments were usually slightly curved.

Identification of the *Prunus*/*Amygdalus* endocarps

The lack of whole specimens in the assemblage makes a specific identification difficult. However, the simultaneous presence of the various fragments and several overlapping anatomical and morphological features, induce a high probability that the fragments belong to endocarps from the same species. So, when considering the whole range of features shared between the different fragments, it should be possible to refine the identification to a species or at least to a group of species. The modern natural geographical distribution of the plants can also be of some help, although it must be kept in mind that the present distribution is the result of the woodland expansion, which started at the Pleistocene/Holocene transition, and partly human impact. Therefore, present distribution areas have been considered very broadly.

As already mentioned, the endocarp fragments belong either to *Prunus* or *Amygdalus*. According to shape and ornamentation, the genus *Padus* and *Cerasus* could be eliminated from the possible identifications. Among the five *Prunus* species occurring in Turkey (Browicz 1972c), only the *Prunus divaricata* endocarps offer some similarity with the remains recovered. Their endocarps can be smooth or scabrous and they have sometimes very shallow sub-marginal furrows (Meikle 1966; Browicz 1972c), but are never grooved. The hilum extremity can be blunt or elongated and the endocarps are usually laterally compressed and sulcate (grooved).

The genus *Amygdalus* is divided into two subgenera, subg. *Amygdalus*, which is large and diverse and includes three sections, and subg. *Dodecandra*, which is small, uniform and consists of only five species. Subgenus *Amygdalus* is composed of the sections *Amygdalus*, consisting of the *Communis* and the *Orientalis* species groups, *Chamaeamygdalus*, and *Spartioides*. So, the genus *Amygdalus* contains five natural groups, each representing a cluster of taxonomically closely related, largely vicarious species. Within each such natural group, member species seem to be fully (or almost fully) interfertile, but they occupy separate geographic territories (Browicz and Zohary 1996). Many species are an unlikely identification because of their morphology and/or irrelevant distribution area.

Five of the nine species in the *Communis* species group have a pitted or partially pitted shell (*Amygdalus communis*, *A. trichamygdalus*, *A. fenzliana*, *A. webbii*, *A. browiczi*). The four remaining species have a distant distribution area (*Amygdalus hausknechtii*, *A. kuramica*, *A. bucharica*, *A. tangutica*). Moreover, some of them have a distinct morphology like the typical sculpture for *Amygdalus kuramica*, superficial and weak grooves for *A. bucharica* and a roughened endocarp for *A. tangutica* (Kester and Gradziel 1996). The species from the *Communis* group can therefore be excluded from a possible identification.

In the *Orientalis* group, the species *Amygdalus orientalis* has an ovoid, elongated, up to 19×10 mm endocarp. The hilum plate is oval. The keel is sharp, protruding and bordered with one deep and broad groove on each side over the whole length of the endocarp. Sometimes a secondary, longitudinally weaker groove is present in the upper half of the lips. The surface pattern is composed of longitudinal grooves starting around the hilum plate and getting weaker on the flanks (Fig. 5). In some cases, these grooves can make ramifications on the flanks and form a dense reticulate pattern. *Amygdalus graeca* is a species closely related to *A. orientalis,* or not completely separated from each other (Ali Dönmez, pers. comm.). According to the descriptions found (Browicz 1972a; Browicz 1972b), its endocarps are highly similar, though smoother, and the keel is usually less strongly built (Fig. 2). There is a variation in stone shape and ornamentation in both species. *A. kotschyi* has a pitted endocarp (Antonio Felipe, pers. comm.). The three remaining species show very confined (*A. eleagnifolia*,

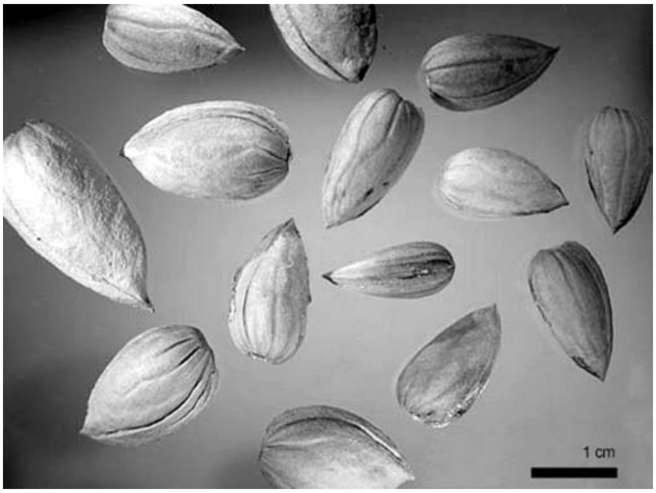


Fig. 5 Modern *Amygdalus orientalis* Duhamel endocarps (University of Basel Collection RMN1735)

A. carduchorum) or distant (*A. mongolica*) distributions (Browicz and Zohary 1996) and are therefore unlikely to be represented in Öküzini.

The morphology of the endocarps of the species from the section *Chamaeamygdalus* remains largely undescribed, but we could examine some specimens of *A. georgica*. They have a broadly ovate fruit with a distinct reticulate pattern of shallow grooves. All the species from this section have a northern distribution today (*A. nana, A. ledebouriana*) or are endemic to regions in Georgia or China (*A. georgica, A. petunnikovii*) and are therefore absent from Anatolia (Browicz and Zohary 1996).

Among the *Spartioides* section, *Amygdalus arabica* has an endocarp which is smooth or has indistinct grooves near the hilum extremity and is also a rather improbable identification according to its distribution (Meikle 1966; Browicz 1972a; Browicz and Zohary 1996).

The second species of this group, *A. scoparia*, has an almost smooth endocarp and is essentially an Iranian species (Browicz and Zohary 1996).

The five species from the *Dodecandrae* subgenus have small endocarps (approx. 15 mm long) and are adapted to very arid environments. The morphological description of *Amygdalus lycioides* (Browicz 1972a) does not fit well with the shell remains from Öküzini. Moreover, it grows in Iran and only in a few localities in south Anatolia. The other four species (*A. spinosissima*, *A. eburnea*, *A. brahuica*, *A. erioclada*) have distant distributions (Browicz and Zielinski 1984; Browicz 1989; Browicz and Zohary 1996) and are therefore unlikely candidates for identification.

From the morphological comparison and the geographical distribution, a number of species could be eliminated as possible determinations. In conclusion, the two closely related species *A. orientalis* and *A. graeca* (Figs. 2, and 5) are the most probable identifications of the endocarp fragments recovered in Öküzini cave, especially with regard to the high frequency of clearly grooved fragments, although the presence of remains belonging to *Prunus divaricata* cannot be completely excluded. According to the shape and size of the keel, *A. orientalis* is more likely, according to the modern distribution areas, *A. graeca* is expected (Ali Dönmez, pers. comm.).

In order to get a finer identification, experimental carbonisations of *Amygdalus orientalis* and *Prunus divaricata* were carried out and the anatomy of the transverse section of the endocarps compared. The examination of the histological arrangement showed a good similarity with the transverse section of the fossil endocarp fragments. The cross section from *Amygdalus orientalis* was composed of two layers: an outer layer of isodiametric cells and an inner layer of longitudinally flattened sclerotic cells (Fig. 3). Antoni (1971) has also observed this organisation in the bitter and sweet almonds (*A. communis*). Endocarps of the *Prunus divaricata* species and others identified as *Prunus divaricata* subsp. *ursina* have been observed and had three layers: the outer and the middle layers are similar to those from *Amygdalus*, the third and inner layer was composed of small isodiametric sclerotic cells. Unfortunately, this innermost layer often disappears due to carbonisation and probably erosion in the soil, so that the transverse sections of *Amygdalus orientalis* and *Prunus divaricata* can look alike and do not permit a clear distinction.

Anthracological (charcoal) analyses have shown the presence of a steppe-forest vegetation type in the neighbourhood of the site during the period from 17,600 to 12,490 cal B.C., *Amygdalus* being clearly the dominant woody taxon (Thiébault 2002). The presence of almond trees in the vicinity of the site suggests that the endocarps were gathered locally.

Because of the fragmentation of the endocarp remains and furthermore, because of their eroded borders, we can conclude that they were probably cracked to free the seeds and then thrown into or near a fire. Other “nut remains”, like the less sturdy *Pistacia* pericarps, which do not need cracking to be consumed, were regularly preserved whole.

Discussion

Taxonomy and autecology of the almond plant

The almond (Rosaceae family, sub-family Prunoideae) has long been considered as a separate genus, but because it can interbreed easily with other genera (*Prunus*, *Persica*, *Cerasus*), some authors consider *Amygdalus* as a subgenus of an extended *Prunus* genus (Rehder 1940; Socias i Company 1998). This monophyletic nature of *Prunus* has been confirmed recently with phylogenetic studies (Lee and Wen 2001; Bortiri et al. 2001). However, we still use *Amygdalus* for the genus designation because it is the terminology adopted in most works about the flora of southwest Asia.

In the last 40 years, almonds were subject to intense investigations by several botanists who studied the flora and vegetation of southwest and middle Asia (Meikle 1966; Browicz 1969; Browicz 1972a, 1989). Due to the high degree of variability in almonds and the numerous ecotypes and hybrids, their taxonomy is very complex. Almost all wild species (as well as most modern cultivars) are self-incompatible, so that self-pollinisation is impossible. This results in a high degree of heterozygosity (outbreeding), expressed in a high degree of variability in morphological as well as physiological characters (Browicz and Zohary 1996; Socias i Company 1998). A great number of different species have been described, which in fact reflects the high intraspecific variability. For example Browicz (1989) listed 39 species and 19 hybrids, when some years later Browicz and Zohary (1996) reported only 26 species and some 20 hybrids or problematic taxa.

Amygdalus orientalis is a shrub, 0.5 to 3 m tall, usually growing in open sunny niches such as sandy hills covered with steppe or steppe-forest, on limestone cliffs or on rocky calcareous slopes. It grows between 350 and 1,500 m, however most frequently between 800 and 1,200 m (Browicz 1972a). The plant has today a large distribution area over central, south and east Anatolia. It is one of the most common wild almond species in south and central Anatolia and in northern Iraq (Browicz 1969).

A. graeca is a shrub or small tree between 1 and 4 m in height, which grows on limestone rocks in phrygana, between 10 and 500 m altitude. Its present distribution covers northwest, central and southwest Anatolia and some Greek islands (Davis et al. 1965–1988). It is a xerophytous and low-altitude plant.

Botanically the almond is classified among the drupes, but horticulturally, it is considered a “nut” because the edible seed is enclosed in the hard shell. *Amygdalus graeca* fruits reach their maturity in July and August, the ones from *A. orientalis* slightly later in August and September (Dönmez 1997). The plants can already reach maturity after 2 to 4 years and require some winter chilling in order to set fruit. Although the seeds are small, the fruit yield of *Amygdalus orientalis* is very good (Ak et al. 2000). The endocarps could be collected in late summer, at the same time as the hunting activities took place (Atıcı and Stutz 2002), but they could also be stored.

Nutritional data

The bitter taste of almond, as in other stone fruits, is due to the production of the glucoside amygdalin. This substance is not produced in the kernel, but is transported from the mother plant, so that all the kernels of a tree will have either sweet or bitter seeds (Dicenta and Garcia 1992). Amygdalin, in the presence of water and the enzyme emulsin, both present in the seed but in different cells, is hydrolysed to benzaldehyde, hydrocyanic acid (or prussic acid HCN) and glucose through crushing, chewing, or any injury to the seed. It is the hydrocyanic acid that is bitter and toxic (Socias i Company 1998). Almost all wild almond taxa have bitter nuts, an effective chemical defence against casual herbivores. Sweet types may occur, but seemingly in low frequency (Grasselly and Crossa-Raynaud 1980; Ladizinsky 1999).

The bitter or sweet taste of the seed is a hereditary character in almond and is determined by just one gene with two alleles: one dominant, responsible for sweet flavour and one recessive, responsible for the bitter flavour (Dicenta and Garcia 1992; Socias i Company 1998). In heterozygous trees, the dominance can sometimes be altered and the bitter flavour is expressed in reduced form (Dicenta and Garcia 1992). The degree of bitterness differs also between almond species and populations (Grasselly 1976a).

The difficulty in removing the bitterness from the seeds and the rarity of sweet mutations in wild stands has brought Ladizinsky (1999) to suggest that it is inconceivable that the wild almonds could have been used as a source of food for humans before a sweet type was selected. However, nutritional data shows that, when cyanogenic plants are eaten slowly or over a period of time, there might be no symptoms of cyanide poisoning. Humans can consume 30–35 mg HCN per day when ingestion is distributed over the whole day and have the physiological ability to detoxify cyanide satisfactorily, given an adequate protein diet (Jones 1998). The toxicity is also overcome by careful food processing before they are eaten: the simple grinding of almonds in a mortar and leaving them for a few hours induces a loss of the bitter volatile HCN (evaporation temperature 24 °C) and an increased sweetness due to the glucose left behind (Jones 1998).

Amygdalus orientalis, like other nuts, has a high fat content. Seeds collected at maturity in the Konya region (Turkey) had 48.5% from dry weight of oil, with the mono-unsaturated oleic fatty acids dominant over the poly-unsaturated linoleic ones (Beyazoglu and Dural 1991). So, due to their high lipid content, almond kernels are a concentrated energy source. Almond is considered to be sustaining as a nutrient: the staying power conferred by a meal of almonds (here *A. communis*) and raisins is well known in Armenia (Ghandelian and Barseghian 1998). But they are more than just a source of fat. They contain several nutrients postulated to provide a protective effect against Coronary Heart Disease (CHD), such as fibre, arginine and antioxidants. Almond, like other nuts, has a cholesterol-lowering effect, and additionally its oils are anti-cancer agents (Agar et al. 1998). The nuts also contain considerable protein (ca. 20%), minerals and some vitamins.

In conclusion, if consumed in moderate quantities or if efficiently detoxified, wild almond seeds have valuable nutritional properties.

Table 2 Archaeobotanical remains of almonds in prehistoric Anatolia

	Site	Location	Date		Period	Identified as	Full description	Kind of remain(s)	Number of remains	Illustration	Archaeological context
			B.P.	B.C.							
1	Hallan Cemi	SE Anatolia	10,000		Terminal Epicalpalaeolithic	*Amygdalus* sp.	Wild almond. Pitted endocarp fragments present.	Charred endocarp fragments	Many	Photograph	Several parts of the mound yielded concentrations of wild almonds. They were clearly of great economic importance despite their latent toxicity. Existence of processing of almonds, for example through roasting.
2	Çayönü	SE Anatolia	9,200–8,700	8,250–7,750	PPN	*Amygdalus* sp.	Only fragmented almond fruitstones have been recovered. The thick-walled fragments have a pitted and grooved surface and in some of them the lateral keel can be observed. The shape of some large fragments indicates that the stones must have had a length of about 2 to 2.5 cm.	Charred endocarp fragments	Fair amount	Drawing	Ash pit and unknown
3	Çafer Höyük	SE Anatolia	9,500–8,400		PPNB	Rosaceae	Thick nutshell possibly *Amygdalus*	Charred endocarp fragments	Few	-	Hearth, layers, postholes and burnt area
4	Nevali Çori	SE Anatolia		8,400	PPNB	*Amygdalus* sp.	Nutshell pitted, no additional description	Charred endocarp fragments	30 whole (estimate)	Drawing	-
5	Aşıklı Höyük	Central Anatolia	8,900–8,500	8,000–7,500	PPN	*Amygdalus* sp. including *Amygdalus orientalis*	Wild almond	Charred endocarp fragments	Few	-	-
6	Çatal Höyük	Central Anatolia		7,480–6,218	PN	*Amygdalus* cf. *orientalis*, *Amygdalus* type	It is a small kind. Similar to *Amygdalus orientalis*.	Charred endocarps and seeds whole and fragments	Many	-	-
7	Çatal Höyük	Central Anatolia		7,480–6,220	PN	*Amygdalus* sp., probably *Amygdalus orientalis*		Charred endocarps and seeds, whole and fragments	Many	-	Oven, burial
8	Hacilar	Central Anatolia	7,400–6,900		PN	*Amygdalus* cf. *orientalis*	Only fragments of almond shells were found at Hacilar. They were fairly thick and the stone was keeled, but not pitted. The same type was found at Çatal Höyük	Charred endocarp fragments	-	-	Well

Ethnographic record of use

Up to today and in spite of their potential toxicity, wild almonds are consumed and appreciated in different parts of their distribution area. For example the green, light bitter fruits of *Amygdalus orientalis* are eaten in the spring in Kızılkaya (central Anatolia) and in the Şanliurfa province before the fruit stones harden (Ertuğ 1997; Ak et al. 2000). The very bitter seeds from the same species are also eaten when the endocarp is hard and needs to be broken (Aylan Erkal pers. comm.). Experiments showed that the bitterness decreases when the fruits are roasted (Ertuğ 1997).

Other wild almonds are also eaten, so for example the fruits of *A. bucharica*, locally consumed and used for medical and cosmetic purposes (Browicz and Zielinski 1984). The fruits of *A. arabica* are also eaten locally and sold on the market (Meikle 1966; Browicz and Zielinski 1984): the edible and the bitter seeds are even given different names. Grasselly (1976b) reports that the wild fruits of section *Euamygdalus* and *Lycioides* are often gathered by natives for the production of oil. If the almond oil is extracted by the cold-press method, amygdalin stays in the sediment (Beyazoglu and Dural 1991).

In southern California, the seeds of several *Prunus* species, in particular of *P. ilicifolia*, are eaten and even enjoyed by indigenous Indians. The bitter taste and poisonous properties seem to have been dealt with effectively by preparation methods like pounding, drying, steeping and boiling (Timbrook 1982). These *Prunus* seeds did not merely represent a more or less nutritious, storable resource, but were also important in the social life, as a readily available gift or exchange product. In northern Iraq, it has been observed that the kernels of *Prunus mahaleb* L. were also consumed in that they were baked on top of bread (Townsend and Guest 1966).

Different cyanogenic glycosides have been found in other plants widely used as food, for example the cassava plant (*Manihot esculenta*) in the Amazon (FAO 2002). Traditional processing and cooking methods of cassava can, if efficiently carried out, reduce the cyanide content to non-toxic levels. First, by disintegrating the microstructure of the cassava root, one will release the enzyme (linamarase) and bring it into contact with the glucoside (linamarin) that is converted into hydrogen cyanide (HCN). The liberated cyanide will dissolve in the water when fermentation is effected by prolonged soaking, and will evaporate when the fermented cassava is dried.

On the other hand, some tribal people in the Amazon rain forest eat as much as one kilogram of cooked fresh cassava per person per day and consume up to three litres of fermented cassava beer, but no diseases related to cassava toxicity have been reported. These tribes also consume a considerable amount of animal and fish protein and thus have high levels of sulphur-amino acids and iodine in their diet, which seem to have an antagonist effect (FAO 2002).

Other endocarp finds in prehistoric Anatolia

As already mentioned, very few Epipalaeolithic sites in Anatolia have been investigated for botanical macroremains. Beside the Epipalaeolithic almond finds from Öküzini and those similar ones from the neighbouring Karain B cave, Hallan Çemi, a terminal Epipalaeolithic site in Anatolia, yielded deposits of wild almonds in several parts of the mound (Table 2) (Rosenberg et al. 1995, 1998). Many specimens had a very eroded surface but some well-preserved ones definitely had pitted shells (pers. comm. Manon Savard). This frequency led the authors to conclude a great economic importance of the almonds. No other Epipalaeolithic plant remains have been recovered so far from Anatolia.

In the Neolithic, a site with important almond finds is Çatal Höyük. Almond remains are recurrently present in occupation horizons, middens, floors around hearth and ovens, etc, and also in deposits from an oven and “in a little heap comprising a dozen shells” in a building (Helbaek 1964; Ağcabay and Killackey 2002; Fairbairn et al. 2002). Most Neolithic plant assemblages from Anatolia regularly yield charred *Amygdalus* endocarp fragments (see Table 2). However they are absent from sites without systematic sampling, as for example Höyücek (Martinoli and Nesbitt in press), where only storage contexts have been examined. The descriptions and identifications of the almond finds are often fragmentary.

The fossil endocarp remains recovered in archaeological excavations do not attract much attention, unless they are present in important quantities or exceptionally well preserved. The review of wild almond finds from Anatolian sites, however, shows a high frequency of occurrence and gives evidence for a long tradition of use starting at least in the Epipalaeolithic. It seems that even in the Neolithic, when subsistence mainly relied on domestic plants, wild almonds were still consumed. The wild almonds of the *A. orientalis* type have been exploited in central Anatolia, when an almond with pitted shell occurs in southeast Anatolia. This is probably a reflection of the distinct landscapes present in each of these regions.

Conclusion

The recovery and identification of endocarp remains in the Öküzini cave indicate that wild almond endocarps of the *A. orientalis/graeca* type were collected in a mature state. Although the almond remains are dominant in the Öküzini plant assemblage, we must keep in mind that the endocarp fragments are favoured for being preserved because of their hardiness during the taphonomical process, and that other softer botanical remains hardly survive. The whole plant assemblage from Epipalaeolithic Öküzini and its chronological changes will be examined in a later paper (Martinoli and Jacomet in prep.). Fragmentation surfaces indicate a cracking of the nuts and therefore the use of the seeds. The almond shell, being a waste product, was often put into the fire and charred. This matches with the frequent recovery of the endocarp fragments in charred contexts like oven and hearth remains.

We suppose that this high-energy food was eaten and could have played a remarkable role in prehistory because of its high nutritional value, its predictability and good storage and transport faculties. Almonds therefore represent an advantageous food resource, but for their toxicity. However, ethnographic sources and dietary research have shown that the consumption of cyanogenic food is possible, if in low quantity and in combination with a high meat consumption or even simple processing could have been employed to make the almonds edible. The examination of other Anatolian settlements suggests that wild almond was a widely used supply in pre-agrarian as well as in agrarian periods, but more data are eagerly awaited to strengthen this view.

Acknowledgements This research has been funded by the research grant 12–64974.01 awarded by the Swiss National Science Foundation. The authors would like to thank the directors of the Öküzini excavation, I. Yalçınkaya (Ankara University) and M. Otte (Liège University), for allowing us to study the plant remains from Öküzini cave;. Hillman and D. Fuller (University College London), H. Elton (British Institute of Archaeology in Ankara), A. Felipe and R. Socias i Company (Institute of Mediterranean Agriculture in Zaragoza), M. Nesbitt (Botanical Garden Kew) and D. Samuel (University College London) for giving us access to their seed and fruit collections, René Cappers and an anonymous reviewer for the revision of the manuscript. Our study has benefited from the help and comments of Sue Colledge (University College London), Ali Dönmez (Hacettepe University), Aylan Erkal (University of California, Berkeley), Fusun Ertug-Yaras (Istanbul University), Mark Nesbitt (Royal Botanical Garden Kew), Manon Savard (Cambridge University), Emin Uğurlu (Ege University) and the teams of archaeobotanists both at the University of Basel and at University College London.

References

Ağar, I.T., Kafkas, S., Kaska, N. (1998) Effect of cold storage on the kernel fatty acid composition of almonds. Acta Horticulturae 470:349–358

Ağcabay, M., Killackey, K. (2002) Macro Botany 2002. Çatalhöyük 2002 Archive Report http://catal.arch.cam.ac.uk/catal/Archive_rep02/a06.html

Ak, B.E., Acar, I., Sakar, E. (2000) An investigation on determination of pomological and morphological traits of wild almond grown at Sanliurfa province. The XI GREMPA Seminar 56, pp 139–144

Antoni, Z. (1971) Histogenetic study on the exocarp, mesocarp and endocarp of the almond. Acta Agronomiae Scientiarium Hungaricae 20:27–34

Atıcı, L., Stutz, A. (2002) Analysis of the ungulate fauna from Öküzini: a preliminary reconstruction of site use, seasonality, and mortality pattern. In: Yalçınkaya, I., Otte, M., Kozlowski, J., Bar-Yosef, O. (eds) Öküzini: final Palaeolithic evolution in southwest Anatolia. Eraul, Liège, pp 101–108

Beyazoglu, O., Dural, H. (1991) Determination of the fatty acids from the seeds of some *Amygdalus* species. Turk J Biol 15:206–209

Bortiri, E., Oh, S.H., Jiang, J., Bagget, S., Granger, A., Weels, C., Buckingham, M., Potter, D., Parfitt, D.E. (2001) Phylogeny and systematics of *Prunus* (Rosaceae) as determined by sequence analysis of ITS and the chloroplast trnL-trnF spacer DNA. Syst Bot 26:797–807

Browicz, K. (1969) *Amygdalus*. In: Rechinger KH (ed) Flora Iranica. Akademische Druck-u. Verlagsanstalt, Graz, Austria, pp 166–187

Browicz, K. (1972a) *Amygdalus*. In: Davis PH (ed) Flora of Turkey. Edinburgh University Press, pp 21–28

Browicz, K. (1972b) Distribution of woody Rosaceae in W. Asia IX. *Amygdalus orientalis* Duh. and closely related species. Arboretum Kornickie 17:5–18

Browicz, K. (1972c) *Prunus*. In: Davis PH (ed) Flora of Turkey. Edinburgh University Press, pp 8–12

Browicz, K. (1989) Conspect and chorology of the genera *Amygdalus* L. and *Louiseania* Carrière. Arboretum Kornickie 34:31–54

Browicz, K., Zielinski, J. (1984) Chorology of trees and shrubs in southwest Asia and adjacent regions. Polish Scientific Publishers, Warsaw

Browicz, K., Zohary, D. (1996) The genus *Amygdalus* L. (Rosaceae): species relationships, distribution and evolution under domestication. Genet Resour Crop Ev 43:229–247

Colledge, S. (2001) Plant exploitation on Epipalaeolithic and early Neolithic sites in the Levant. BAR International series 986, Archaeopress, Oxford

Davis, P.H. et al (1965–1988) Flora of Turkey and the East Aegean Islands. Vol. 1 (1965); Vol. 2 (1967); Vol. 3 (1970); Vol. 4 (1972); Vol. 5 (1975); Vol. 6 (1978); Vol. 7 (1982); Vol. 8 (1984). Edinburgh University Press, Edinburgh

Dicenta, F., Garcia, J.E. (1992) Inheritance of the kernel flavour in almond. Heredity 70:308–312

Dönmez, A. (1997) Türkyie Pruneae (Rosaceae) tribusunun revizyonu. Doktora Tezi Hacettepe Üniversitesi

Emery-Barbier, A. (2002) La grotte d'Öküzini: analyse palynologique. In: Yalçınkaya, I., Otte, M., Kozlowski, J., Bar-Yosef, O. (eds) La grotte d'Öküzini: évolution du Paléolithique final du sud-ouest de l'Anatolie. Eraul, Liège, pp 85–87

Ertuğ, F. (1997) An ethnoarchaeological study of subsistence and plant gathering in central Anatolia. Doctoral dissertation, Washington University

Fairbairn, A., Asouti, E., Near, J., Martinoli, D. (2002) Macrobotanical evidence for plant use at Neolithic Çatalhöyük, south-central Anatolia, Turkey. Veg Hist Archaeobot 11:41–54

Fairbairn, A., Martinoli, D., Butler, A. (2003) The plant remains from Neolithic Çatalhöyük (in prep)

FAO (2002) Roots, tubers, plantains and bananas in human nutrition. Toxic substances and antinutritional factors. FAO, Rome, http://www.fao.org/docrep/T0207E/T0207E08.htm

Ghandelian, P.A., Barseghian, M.A. (1998) The history and use of wild almonds in Armenia. Acta Horticulturae 470:34–37

Grasselly, C. (1976a) Les espèces sauvages d'amandiers. Options Méditerranéennes 32:28–43

Grasselly, C. (1976b) Origine et évolution de l'amandier cultivé. Options Méditerranéennes 32:45–49

Grasselly, C., Crossa-Raynaud, P. (1980) L'amandier. Maisonneuve et Larose, Paris

Hansen, J. (1991) The palaeoethnobotany of Franchthi Cave. Indiana University Press, Bloomington, Indianapolis

Helbaek, H. (1964) First impressions of the Çatal Hüyük plant husbandry. Anatolian Studies 14:121–123

Helbaek, H. (1970) The plant husbandry of Hacılar. In: Mellart J (ed) Excavations at Hacılar. British Institute of Archaeology at Ankara, Occasional Publication, Edinburgh University Press, pp 189–247

Hillman, G.C. (2000) Abu Hureyra I: The Epipalaeolithic. In: Moore AMT, Hillman GC, Legge AJ (eds) Village on the Euphrates. From foraging to farming at Abu Hureyra. Oxford University Press, Oxford, pp 327–399

Hopf, M., Bar-Yosef, O. (1987) Plant remains from Hayonim cave, western Galilee. Paléorient 13:117–120

Jones, D.A. (1998) Why are so many food plants cyanogenic? Phytochemistry 47:155–162

Kester, D.E., Gradziel, T.M. (1996) Almonds. In: Janick, J., Moore, J. (eds) Fruit breeding. Wiley, New York, pp 1–97

Kislev, M.E., Nadel, D., Carmi, I. (1992) Epipalaeolithic (19,000 B.P.) cereal and fruit diet at Ohalo II, Sea of Galilee, Israel. Rev Palaeobot Palynol 73:161–166

Kyparissi-Apostolika, N. (1999) The Palaeolithic deposits of Theopetra Cave in Thessaly (Greece). In: Bailey GN, Adam E, Panagopoulou E, Perlès C, Zachos K (eds) The Palaeolithic archaeology of Greece and adjacent areas. Proc ICOPAG Conf, September 1994. British School of Athens Studies, pp 232–239

Ladizinsky, G. (1999) On the origin of almond. Genet Resour Crop Ev 46:143–147

Lee, S., Wen, J. (2001) A phylogenetic study of *Prunus* and the Amygdaloides (Rosaceae) using ITS sequences of nuclear ribosomal DNA. Am J Bot 88:150–160

Martinoli, D. (2002) Les macrorestes botaniques de la grotte d'Öküzini. In: Yalçınkaya I, Otte M, Kozlowski J, Bar-Yosef O (eds) La grotte d'Öküzini: évolution du Paléolithique final du sud-ouest de l'Anatolie. Eraul, Liège, pp 91–94

Martinoli, D., Jacomet, S. (in prep) Plant, food economy, temporal changes and seasonality pattern at Epipalaeolithic Öküzini and Karain B caves, southwest Anatolia

Martinoli, D., Nesbitt, R.M. (in press) Plant stores at Pottery Neolithic Höyücek, southwest Turkey. Anatolian Studies

McLaren, F.S. (1995) Plums from Douara Cave, Syria: the chemical analysis of charred stone fruits. In: Kroll H, Pasternak R (eds) Res Archaebotanicae, 9th Symposium IWPG, Kiel, pp 195–218

Meikle, R.D. (1966) Rosaceae. In: Townsend CC, Guest E (eds) Flora of Iraq. Ministry of Agriculture, Republic of Iraq, Baghdad, pp 102–171

Moulins, D. de (1997) Agricultural changes at Euphrates and steppe sites in the mid-8th to 6th millennium B.C. BAR International Series 683

Noy, T., Legge, A.J., Higgs, E.S. (1973) Recent excavations at Nahal Oren, Israel. Proc Prehistoric Soc 39:75–99

Otte, M., Lopez Bayon, I., Noiret, P., Bar-Yosef, O., Yalcınkaya, I., Kartal, M., Léotard, J.-M., Pettitt, P. (2003) Sedimentary deposition rates and carbon-14: the Epipalaeolithic sequence of Öküzini cave (Southwest Turkey). J Archaeol Sci 30:325–341

Pasternak, R. (1998) Investigation of botanical remains from Nevali Çori PPNB, Turkey: a short interim report. In: Damania AB, Valkoun J, Willcox G, Qualset CO (ed) The origins of agriculture and crop domestication. The Harlan Symposium, ICARDA, Aleppo Syria, pp 170–177

Rehder, A. (1940) Manual of cultivated trees and shrubs (2nd edn). Macmillan, New York

Rosenberg, M., Nesbitt, R.M., Redding, R.W., Strasser, T.R. (1995) Allan Çemi Tepesi: some preliminary observations concerning early Neolithic subsistence behaviours in eastern Anatolia. Anatolica 21:1–12

Rosenberg, M., Nesbitt, R.M., Redding, R.W., Peasnall, B.L. (1998) Hallan Çemi, pig husbandry, and post-Pleistocene adaptations along the Taurus-Zagros arc (Turkey). Paléorient 24:25–41

Socias i Company, R. (1998) Fruit tree genetics at a turning point: the almond example. Theor Appl Genet 96:588–601

Thiébault, S. (2002) Approche de l'environnement végétal du site d'Öküzini (Turquie) au Tardiglaciaire par l'analyse anthracologique. In: Yalçınkaya, I., Otte, M., Kozlowski, J., Bar-Yosef, O. (eds) Öküzini: final Paleolithic evolution in southwest Anatolia. Eraul, Liège, pp 95–99

Timbrook, J. (1982) Use of wild cherry pits as food by the Californian Indians. J Ethobiology 22:162–176

Townsend, C., Guest, E. (1966) Flora of Iraq, vol 2. Ministry of Agriculture, Baghdad

Woldring, H. (2002) The Early-Holocene vegetation of Central Anatolia and the impact of farming. In: Cappers, R.T.J., Bottema, S. (eds) The dawn of farming in the Near East. Ex Oriente, Berlin, pp 39–48

Yalçınkaya, I., Otte, M., Kozlowski, J., Bar-Yosef, O. (eds) (2002) Öküzini: final Palaeolithic evolution in southwest Anatolia. Eraul, Liège

Zeist, W. van, Bakker-Heeres, J.A.H. (1984/1986) Archaeobotanical studies in the Levant. 3. Late-Palaeolithic Mureybit. Palaeohistoria 26:171–199

Zeist, W. van, Roller, G.J. de (1994) The plant husbandry of aceramic Çayönü, SE Turkey. Palaeohistoria 33/34:65–96

3.2. Martinoli Danièle (in press). “Plant food use, temporal changes and site seasonality at Epipalaeolithic Öküzini and Karain B caves, southwest Anatolia, Turkey”. Paléorient.

PLANT FOOD USE, TEMPORAL CHANGES AND SITE SEASONALITY AT EPIPALAEOLITHIC ÖKÜZINI AND KARAIN B CAVES, SOUTHWEST ANATOLIA, TURKEY

D. MARTINOLI

Manuscrit reçu le 10 mai 2004, accepté le 16 décembre 2004

Abstract : The analyses of the plant macro-remains (excluding wood charcoals) from the multi-phase Epipalaeolithic site of Öküzini (16 560 ±180 uncal BP (18 200-17 400 cal BC) to 12 130 ±100 uncal BP (14 400-11 800 cal BC)) and Karain B (*ca* 15 000 uncal BP) identified at least 18 taxa and "categories" of remains, mainly carbonised. The importance and the role of the plants – particularly in the diet and the mobility – have been evaluated with quantitative and qualitative data. Nuts (principally *Amygdalus*, wild almond), fruits (principally *Pyrus*, wild pear), bulbs, roots or tubers seem to have occupied a particularly important place in these societies during all Epipalaeolithic phases, at the expense of small-seeded plants. The attested plant foods would have provided carbohydrates, lipids and micronutrients complementing well the meat diet and were for the most predictable resources, easy to gather and to process. The almonds, by their richness in fats, could represent a vital seasonal resource that justified the additional work required for their detoxification. Judging from the seasonality indices of the plants and ungulate fauna at Öküzini, the cave could have been inhabited in all seasons periodically, but particularly in spring and autumn.

Résumé : Au moins 18 taxa et "catégories" de restes, pour la plupart carbonisés, ont été identifiés lors des analyses des macro-restes botaniques (charbons de bois exclus) du site Epipaléolithique multi-phase de Öküzini (16 560 ±180 uncal BP (18 200-17 400 cal BC) à 12 130 ±100 uncal BP (14 400-11 800 cal BC)) et Karain B (env. 15 000 uncal BP). L'importance et le rôle des plantes – en particulier dans l'alimentation et la mobilité – ont été évalués à l'aide de données quantitatives et qualitatives. Les noix (principalement *Amygdalus*, amande sauvage), fruits (essentiellement *Pyrus*, poire sauvage), bulbes, racines ou rhizomes semblent avoir occupé une place particulière dans ces sociétés pendant toutes les phases de l'Epipaléolithique, au détriment des plantes à petites graines.

Les plantes alimentaires attestées fournissaient des hydrates de carbone, lipides et micronutriments complétant bien l'alimentation carnée et représentaient pour la plupart des ressources prédictibles, faciles à cueillir et à préparer. Les amandes, par leur richesse en graisse, pouvaient représenter une ressource saisonnière vitale, justifiant l'addition de travail requis pour enlever leur toxicité. Selon les indices de saisonnalité des plantes et de la faune ongulée de Öküzini, la grotte pourrait en toutes saisons avoir été occupée de façon périodique et plus particulièrement au printemps et en automne.

Key-Words : Archaeobotany, Hunter-gatherer, Plant food, Subsistence strategy, Diet, Mobility pattern, Seasonality, Near East.

Mots Clefs : Archéobotanique, Chasseur-cueilleur, Plantes alimentaires, Stratégie de subsistance, Alimentation, Mobilité, Saisonnalité, Proche Orient.

The transition to farming is one of the main themes in archaeobotany. Several aspects of this fundamental change in subsistence are the focus of interest, especially questions relating to location, timing, the process by which the transition took place, the way farming/agriculture diffused across Eurasia[1] and its influence on diet and health[2]. On the other hand, very little is known about the range of subsistence strategies that foragers practiced prior to the emergence and adoption of agriculture in the different environments and among the different cultures present in southeastern Europe and the Near East. Since ethnographic studies established the important roles played by plants in hunter-gatherer subsistence strategies[3], it has been necessary in archaeological research to recover all sizes of plant remains, even the smallest, so as not to overlook those that may be of economic significance. Examples of remarkable Pleistocene plant assemblages from Eurasia associated with human settlements are those from Abu Hureyra I and Ohalo II[4].

In this paper, we will describe the full spectra of plant remains[5] recovered from the Epipalaeolithic occupation levels from Öküzini and Karain B caves and analyse the composition and variation of the assemblages through time. The hypotheses was that despite the poor preservation usually present at such early forager sites, and despite the imprecise excavation method that was used, a number of interpretations about plants in the diet, overall subsistence strategy, seasonality and settlement pattern were possible with the archaeobotanical evidences complemented with taphonomical, ethnological, botanical, other archaeobiological and archaeological data. We will argue that such a study was worthwhile and legitimate in regard to the paucity of knowledge about how Epipalaeolithic hunter-gatherers in Anatolia exploited their vegetal environment.

ARCHAEOLOGICAL RESEARCH OF THE EPIPALAEOLITHIC IN MEDITERRANEAN ANATOLIA

Firstly, to enable the reader to more fully appreciate the significance of Öküzini and Karain B caves, we briefly review the state of archaeological research in mediterranean Anatolia. In this area, investigations of Pleistocene and early Holocene archaeology is at the initial stage[6]: surveys in Antalya province brought to light several caves and rock shelters with traces of Epipalaeolithic activities, in particular in the Katran Mountain: Öküzini, Karain, Kizilin and Çarkini (fig. 1). I. Kiliç Kökten excavated some of them in the 1950's[7]. On the plain in front of Öküzini and Karain caves, fifteen prehistoric open-air sites not dated precisely have been located[8]. Southwest of Antalya, along the coast, the Bey Mountains also revealed traces of Epipalaeolithic occupation in caves and rock shelters, including Belpinar Karain, Sarinçinar Siginagi, Hayitligöl Siginagi, Beldibi/Kumbucagi and Belbasi, the latter two excavated by Enver Bostanci[9]. North of Antalya, in the high valleys of the Lake District, three additional sites, Bogazköy, Baladiz/Baradiz and Kapaliin, yielded artefacts dated to the Epipalaeolithic[10]. A surface scatter of lithics was found during the survey in the

---

[1] See for example CAPPERS and BOTTEMA (eds), 2002 ; DAMANIA *et al.* (eds), 1998 ; HARRIS (ed.), 1996.

[2] HILLMAN, 2000 ; LARSEN, 2000.

[3] LEE and DEVORE (eds), 1968.

[4] HILLMAN, 2000 ; KISLEV*et al.*, 1992 ; NADEL *et al.*, 2004 ; WEISS *et al.*, 2004.

[5] Excluding the wood charcoals, which will be published in a separate paper.

[6] See also KARTAL, 2003.

[7] KÖKTEN, 1955, 1958, 1961, 1963.

[8] PAWLIKOWSKY, 2002 : 75.

[9] BOSTANCI, 1965 ; TAY PROJECT

[10] TAY PROJECT

Aksu Valley, situated east of Antalya, indicating the presence of prehistoric occupations[11]. Unfortunately, most of these sites are known only from survey and recovered surface artefacts. The few sites that have been excavated provide an incomplete documentation and their chronological assignment remains imprecise. No plant remains were recovered from Epipalaeolithic deposits.

New excavations in Öküzini were undertaken from 1989 to 1999 and in Karain B from 1985 and are still ongoing, originally by a team from the University of Tübingen (Germany) in collaboration with the University of Ankara[12], later through a joint project conducted by the University of Liège (Belgium) and the University of Ankara[13]. Today, a long and well-dated Epipalaeolithic sequence is known from Öküzini and a shorter one from Karain B[14]. For the first time for this period and area, plant remains were recovered[15].

Very little is known about the transition to a Neolithic economy in Anatolia. It is generally accepted that central and southern Anatolia were not implicated in the process of plant domestication, lying outside of the distribution area of most wild progenitors of "the Neolithic plant package". Recent research have questioned the dating of the only Aceramic Neolithic site known in mediterranean Anatolia, Hacılar, and have assigned it rather to Early Ceramic Neolithic[16]. As in the central and western parts of the peninsula, there is a rather sudden increase in the number of sites by the Pottery Neolithic period : 96 Ceramic Neolithic settlements are known[17]. Among these, only at Hacılar, Erbaba and Höyücek have there been any archaeobotanical analyses[18].

It appears that the Epipalaeolithic occupations of the area have initiated very few detailed excavations and therefore the knowledge about these early societies is poor. The timing and process of Neolithisation of this territory are also far from being understood and, even if a higher number of Neolithic sites have been investigated, the picture of the plant subsistence base during this time is still unsatisfactory.

---

[11] KAYAN *et al.*, 1987 : 10.

[12] ALBRECHT, 1988 ; ALBRECHT *et al.*, 1992.

[13] YALÇINKAYA *et al.*, 1995 ; YALÇINKAYA *et al.* (eds), 2002c.

[14] The latter yielded only traces of habitation dated to the earliest Epipalaeolithic phases.

[15] MARTINOLI, 2002.

[16] TAY PROJECT.

[17] TAY PROJECT ; ÖZDOĞAN and GATSOV, 1998.

[18] HELBAEK, 1970 ; MARTINOLI and NESBITT, 2003 ; VAN ZEIST and BUITENHUIS, 1983.

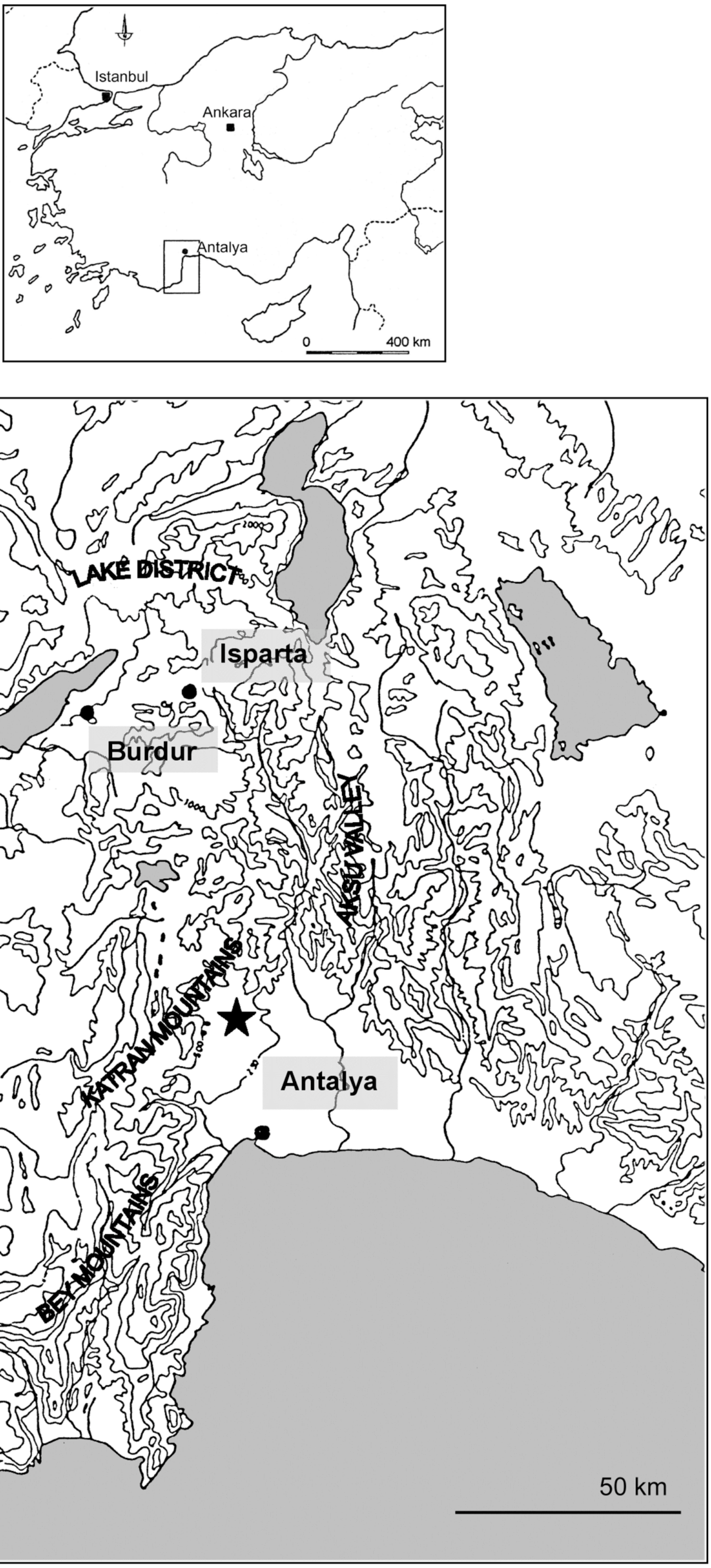


Figure 1. Situation map. The star indicates the location of Karain and Öküzini caves.

DESCRIPTION OF THE SITES AND EXCAVATION STRATEGY

The mediterranean coastland of southwest Anatolia is bordered by the Taurus Mountains, an anticlinal system frequently broken and much distorted. The streams running in the southern part of this system have formed alluvial plains, the largest of which is the Antalya plain.[19] Climatically, the area is characterised by mild, rainy winters, and hot dry summers. The mean annual maximum temperature in Antalya is 24°C, the mean minimum temperature 13,7°C, and the average annual rainfall 1 056 mm. The sites under study are situated at about 30 km north of Antalya at the boundary between an extended and nearly flat travertine plain situated at about 300 m (asl) altitude and a mountain chain with summits reaching 2 000 m above sea level. The mountain flanks near Karain and Öküzini are rather bare, but shelter in some places the remnants of the climacic evergreen maquis represented in the lower situations by *Ceratonia siliqua* (carob tree) and *Pistacia atlantica* (Mount Atlas pistache), in higher locations by *Quercus* sp. (oak) and *Olea europaea* (olive tree). The plain is today intensively cultivated, and resurgences are canalised and bordered with *Typha* (cattail), *Phragmites* (reed) and *Carex* (sedge).

Öküzini cave (37°04’ N, 30°32’ E) is situated at the base of the Katran Mountains (fig. 1), just 5 m above the plain (fig. 2). The entrance shows to the northeast and opens on a small, seasonally inundated bay. This natural cave was formed and enlarged by the outflow of water that permeated the karstic system, and which today emerges next to the cave[20]. The main chamber is an easily accessible hall about 15 m long that branches off into several narrow passages (fig. 3).

During the excavations conducted by I. Kiliç Kökten, several soundings covering roughly 150 m^2 and reaching up to 2,5 m in depth were made. These trenches destroyed a vast part of the cultural layers. The new excavations exposed two major profiles bordering Kökten’s sondage (figs 3 and 4) and went deeper, reaching the bedrock in some places[21]. In addition, the excavation surface was extended westward uncovering several Neolithic and Chalcolithic funerary pits[22].

Figure 2. Öküzini cave.

---

[19] ZOHARY, 1973 : 13.

[20] PAWLIKOWSKY, 2002 : 15.

[21] LOPEZ BAYON *et al.*, 2002 ; OTTE *et al.*, 2003.

[22] KARTAL and EREK, 2002.

From the base to the summit, all strata contained numerous anthropogenic components, like hearths and superimposed burnt deposits[23] (fig. 4). Lithics and animal bones were the principal finds. The excavated layers have been radiocarbon dated to the Epipalaeolithic and Neolithic/Chalcolithic, though the excavation reported here is primarily Epipalaeolithic. Four archaeological units, AUI to AUIV, attributed to the Epipalaeolithic have been recognised (table 1). Archaeological unit I, II and III were separated through sedimentation gaps due to episodes of erosion and absence of sedimentation (at *ca* 17 000 cal BC and between 15 000 to 14 000 cal BC)[24]. Another gap appeared at 11 000 cal BC and the overlying units, AUV and VI have Neolithic and Chalcolithic components[25].

Karain cave (37°8’ N, 30°20’ E), only 1 km westward, is also a natural cavity in the Katran Mountains. In contrast to Öküzini cave, it lies at about 150 m above the plain level. Composed of a complex of seven chambers, cavity B is small but rather deep, approximately 15 m long, with an opening towards the southwest. Like Öküzini, the cave was first excavated by Professor I. Kiliç Kökten who worked in the front part. The new excavation exposed horizons dating to the Upper Palaeolithic (PII) and Epipalaeolithic (PI.1 and PI.2), the latter contemporary with the lower levels in Öküzini[26]. No structures, for example hearths or fire-places, were observed. Stratum PI.2 consisted almost entirely of an accumulation of bones. The Epipalaeolithic levels yielded dates around 15 000 uncal BP, but the stratigraphy has not yet been analysed in detail.

---

[23] OTTE *et al.*, 2003 : 328.

[24] Description and datation of the assemblages after OTTE *et al.*, 2003.

[25] OTTE *et al.*, 2003.

[26] YALÇINKAYA *et al.*, 2000 : 19.

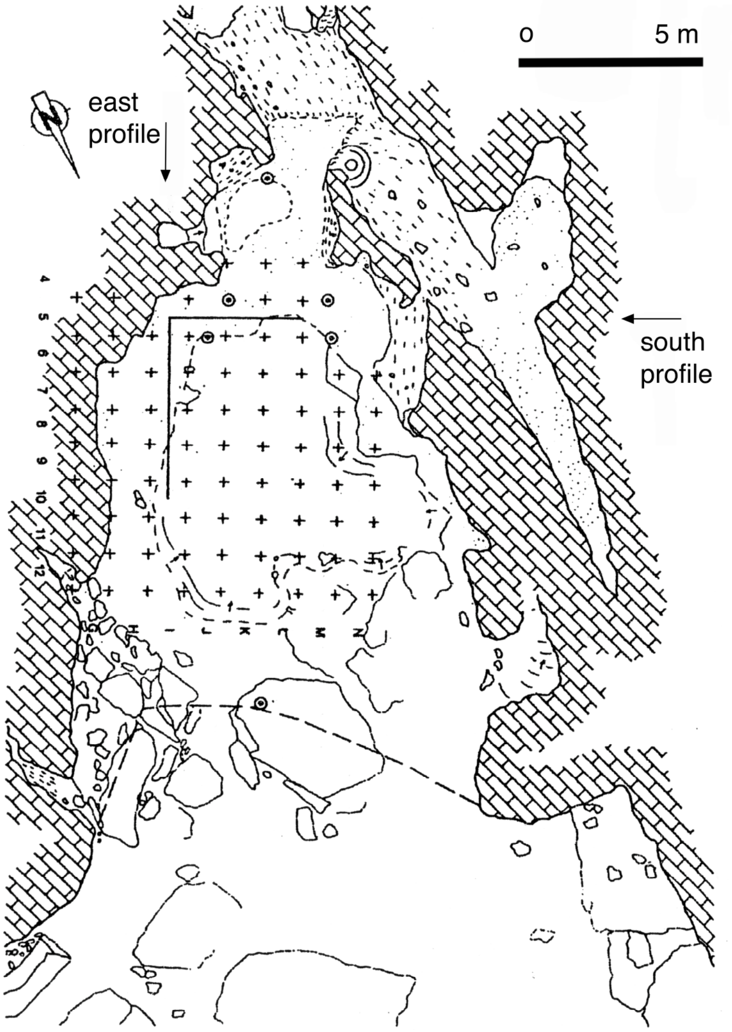
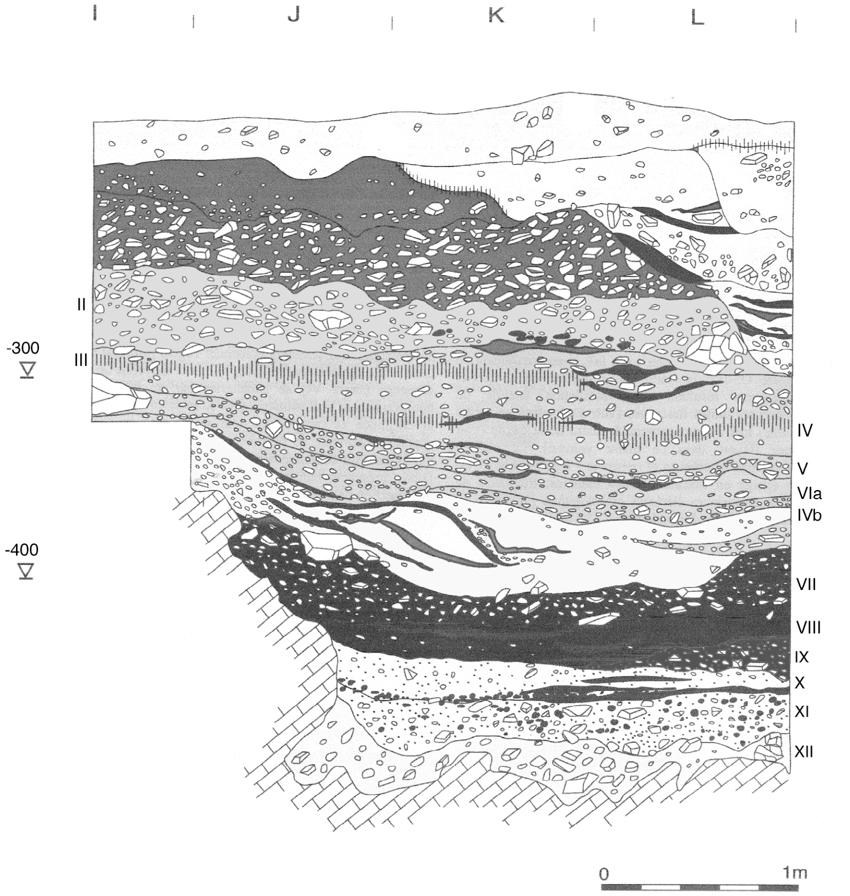


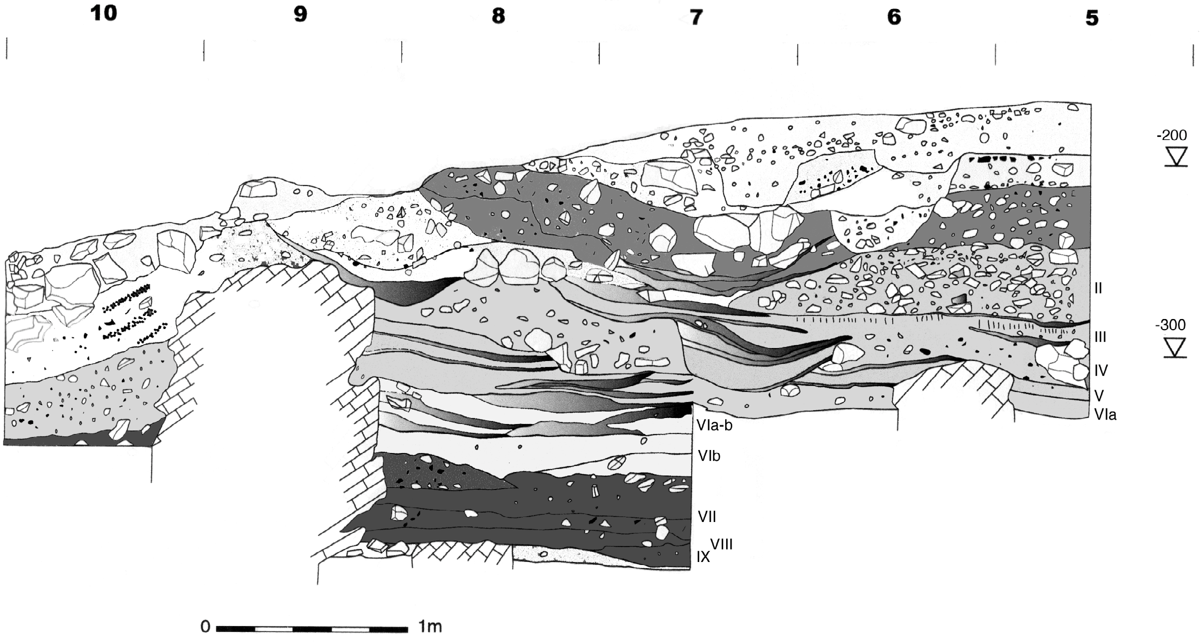
Figure 3. Map of Öküzini (adapted from LOPEZ BAYON *et al*. 2002).

Following page:
Figure 4. Öküzini: south (1) and east (2) profiles (adapted from LOPEZ BAYON *et al*. 2002).

1.


I
J
K
L
II
III
-300
-400
IV
V
VIa
IVb
VII
VIII
IX
X
XI
XII
0
1m

2.


10
9
8
7
6
5
-200
II
-300
III
IV
V
VIa
VIa-b
VIb
VII
VIII
IX
0
1m

Archaeological units (AU)	Datations	Geological horizons (GH)	Surface sampled (m^2)	Volume of floated sediments (approximation in liters)	Volume of flots (ml)	Number of samples (AH/1 square)	Number of carbonised macro-remains	Number of mineralised macro-remains
Öküzini								
IV (GHVIa-II)	12.260±90 uncalBP (12.450-12.100 calBC) to 12.130±130 uncalBP (12.400-11.800 calBC)	II	4.75	>1025	1421	53	269	166
		III	4.75	>950	756	54	543	200
		III/IV	0.75	>50	65	3	41	1
		IV	6.75	>650	2276	48	811	21
		V	3.25	>400	266	23	159	2
		V/VI	10.5	>25	15	4	19	1
		VIa	7	>25	5	2	11	0
Total						187	1853	391
III (GHVI/VII-VIab)	14.200±130 uncalBP (15.400-14.750 calBC) to 12.390±110 uncalBP (12.550-12.150 calBC to 13.100-12.600 calBC)	VIa/IVb	1.25	>375	228	51	298	3
		VIb	1	>100	10	5	19	0
		VI/VII	5.25	>75	12	4	40	1
Total						60	357	4
II (GHIX-VII)	15.460±160 uncal BP (16.900-16.150 calBC) to 14.610±150 uncalBP (15.850-15.200 calBC)	VII	0.25	>350	84	35	183	6
		VII/VIII	0.5	25	4	1	7	0
		VIII	1.5	>25	8	2	9	0
		IX	1.25	>25	25	2	7	0
Total						40	206	6
I (GHXII-X)	16.560-16.400 uncalBP (18.200-17.200 calBC)	X	0.5	>25	32	6	46	0
		XI	5	>25	55	7	46	0
		XII	6	>25	24	2	14	0
Total						15	106	0
Karain B								
	ca. 15.000 uncalBP	Pl.1-Pl.2	6	>725	1038	17	79	10

Table 1. Description of the archaeological units and archaeobotanical samples selected from Epipalaeolithic levels at Öküzini and Karain B

CHOICE OF SAMPLES AND IDENTIFICATION METHOD

All deposits in both caves were systematically processed with simple bucket flotation for recovery of wood charcoals and other plant remains during excavation. The organic remains (= flots) were collected on a 0,5mm sieve, dried and stored for later analyses. The inorganic sediments left in the bucket were wet-sieved on 4, 2 and 1mm mesh and sorted in the field with the naked eye. The whole recovery process was part of the common excavation work and principally aimed to the recovery of charcoals for dating. By the time we joined the research project in 2000, the organic remains were archived in floated state and the mineralised remains were stored together with the molluscs and micro fauna samples.

The excavation system used in Öküzini involved taking arbitrary 10 cm thick horizontal spits (called archaeological horizons AH) over 50 x 50 cm squares. Inevitably, some of the spits were overlapping two geological horizons (denoted GH and composed of sediments from the same deposition episode) and were therefore mixed. Flotation samples (corresponding to the archaeological horizon over one square) were excluded from our analyses if there was any uncertainty concerning their purity, or when there were no identifiable seed or fruit macro-remains in the samples. Another consequence of the excavation strategy was that the samples taken were not related to context or features excavated. The excavation method was similar in Karain B, but used 1x1m squares.

The present analysis concerns only plant remains (other than wood charcoal) belonging to the Epipalaeolithic phases. After exclusion of the mixed samples, the material from Öküzini (table 1) corresponds to more than 4 000 litres of floated sediment (a minimal estimate made subsequent to the excavation), 5 286 ml of flots and 2 522 carbonised and more than 400 mineralised macro-remains. In Karain B, a total of more than 725 litres of sediments (a minimal estimate made subsequent to the excavation) were analysed ; 1 038 ml of organic remains (flots), containing 79 carbonised and 10 mineralised plant items have been collected.

The plant remains recovered in both caves have been identified by comparison with modern specimens from several collections (Institute for Prehistory and Archaeological Sciences in Basel, University College in London, British Institute of Archaeology in Ankara and Institute of Mediterranean Agriculture in Zaragoza) using a stereoscopic binocular (Wild M3Z 6-40X ; Leica MZ125 8-100X), a reflection microscope (Laborlux 12ME 200-500X) and a scanning electron microscope (Zentrum für Mikroskopie Universität Basel). The total amount of macro-remains (larger than 0,5 mm) were counted for each sample and weighed when appropriate (i.e. for categories with high fragmentation) (table 2).

RESULTS

PRESERVATION AND RANGE OF PLANT TAXA

Because sediment volume could not be estimated accurately, it was not possible to calculate the charred material and charcoal densities, despite their importance as indices of the rates and circumstances of deposition. Nevertheless, it was clear that very low densities of charred plant material were recovered. The plant remains were frequently poorly preserved, fragmented, sometimes eroded and distorted. This, together with the lack of a comprehensive seed reference collection for Anatolia, often limited the identifications to genus or family level and led additionally to the creation of identification categories that comprised items which were grouped on the basis of similar morphologies, but which were not necessarily related taxonomically. *Confer* (*cf*) was used for uncertain identifications largely due to poor preservation.

Thirteen taxa were positively identified, two were only of uncertain identification (*cf*) and at least five identification categories were recognised (table 2). Of special interest was the recovery of remains of soft fruits, like *Pyrus* (pear), *Vitis* (grape) and *Rosa* (rosehip), which are rarely preserved in archaeological deposits. Most remains were carbonised, two taxa were present both in carbonised and mineralised form (*Vitis*/grape and *Pistacia*/wild pistache); two taxa were exclusively mineralised (*Celtis*/hackberry and *Alkanna*/alkanet).

Fragments from the hard shell (= endocarp) of an almond type, *Amygdalus graeca* or *orientalis*[27] (fig. 5.3), plus a category of endocarp fragments lacking the whole set of identification features (cf. *Amygdalus*) were identified. The attributes they shared were a 0,8 to 1 mm thick shell with a transverse section composed of an outer layer of irregularly arranged round cells with thick walls and small lumen, and an inner layer made up of tangentially elongated cells[28]. The category "nutshell fragments 0,8-1 mm thick" comprised badly preserved items, but which still presented a similar transverse section.

---

[27] For a detailed description of the criteria used for the identification see MARTINOLI and JACOMET, 2004 : 49.

[28] This feature is the attribute of non-pitted *Amygdalus* and *Prunus divaricata*, which discrimination remains problematic MARTINOLI and JACOMET, 2004 : 49.

Other "nuts" recovered were whole and fragments of *Pistacia* nutlets (= endocarps). The globular, slightly longer than broad and laterally more or less compressed whole nutlets presented a flat base (hilum plate) and a rounded apex tapering in a small point (fig. 5.6). Fragments, even small, could still be identified to genus level when viewed at high magnification (400x) thanks to their distinctive transverse section with one layer of elongated palissadic cells along the inner border. Of the five species growing in Turkey, two could be eliminated on morphological grounds (*P. lentiscus* and *P. eurycarpa*) and a third is unlikely due to its present-day very local distribution (*P. khinjuk*)[29]. The two species left, *P. atlantica* and *P. terebinthus*, produce nutlets very similar to the fossil remains.

Fragments of acorn cotyledons (*Quercus*) were also recovered. They had a dense texture with typical radial cracks. Some of them may come from stratigraphically mixed deposits because they were found in the same excavation sector as the Neolithic/Chalcolithic burials containing acorn remains[30], which may well have drifted through the sediment, loose around the burials[31]. However, acorns were also found in other sectors, although in small number, and *Quercus* charcoals have been attested in the Öküzini assemblage from AUII, GHVIII-VII[32].

Whole and fragments of *Pyrus* fruits were identified with the help of four traits: presence of stone cells, structure of the testa fragments, morphology of the calyx remains or shape of the seeds. Clusters of different sizes (0,2-1,2 mm) of thick-walled stone cells surrounded by elongated parenchyma cells (fig. 6) were particularly numerous around the cavity of the seeds and at the bases of calyx and peduncle. The fruit testa, where preserved, was composed of small hexagonal to round convex cells. The calyx remains were formed of a circle of five sepal remains, bordered on the inside with numerous stalk-like stamen bases, in the centre of which the bottom part of five styles were erected (fig. 5.1). The seeds were drop-like, laterally compressed and thinly striated. A secure identification relied on the simultaneous presence of stone cells and one additional criterion, otherwise it was considered uncertain (*cf*). The attempt to identify the pears to species level was not successful. We suspect that most of the remains in the category "fruit flesh/fruit flesh with testa/fruit flesh with seed imprints", which groups fragments with an irregularly and thin-walled vacuolated structure, but lacking the features mentioned above, also belonged to *Pyrus*.

Among other soft fruits, nearly whole and fragments of grape berries (*Vitis sylvestris*) were found. The fruits were globular often with a wrinkled surface. The presence of the pentagonal peduncle scar or of part of seeds embedded in the fruit flesh allowed secure identification (fig. 5.4). The grape pips were small, subglobose to heart-shaped, and bore a short stalklet at one extremity. A round or slightly oval structure (the chalaza) was carved on one side; two elongated and parallel deep grooves incised the other.

Seeds and two fruit fragments (pseudocarp) belonging to *Rosa* (rosehip) (fig. 5.5), as well as fragments of the typical thick-walled *Crataegus* (hawthorn) pyrenes, were also identified.

Small-seeded Vicieae (small legumes), belonging to wild species, as well as seeds and fruits of *Rumex* (dock), *cf. Zygophyllum fabago* (a small shrub), Trifolieae (clover-like plants), *Galium* (a cleaver), *cf. Sparganium* (bur-reed), Cyperaceae (sedge family), *Scirpus* (sedge), Poaceae (grass) and *Bromus* (brome grass) were recovered in very small number (table 2).

The suspicious presence of a few seeds of the size of domestic varieties of *Vicia ervilia* (bitter vetch) and *cf. Lens* (lentil) was noticed. AMS dating showed that they were intrusive,

---

[29] DAVIS, 1967 : 544-548.

[30] KARTAL and EREK, 2002 : 348.

[31] M. OTTE, pers. comm.

[32] THIÉBAULT, 2002 : 96.

probably from later Neolithic and Chalcolithic occupations (table 3). The same was true for the *Triticum monococcum* seed (domestic einkorn) recovered. Consequently, all these remains, plus the large-seeded Vicieae (large probably domestic legumes) and the *Cerealia* grain (domestic cereal), were excluded from further analyses. Similarly, we could not exclude a same pattern for the above mentioned small seeds (small-seeded Vicieae, *Rumex*, *Galium*, etc.), which could also drift through the sediment and are common weeds. However, their rarity in the assemblages did not generate elaborated interpretations.

The category “amorphous objects” groups remains with a compact structure. Micromorphological examination revealed the presence of a small-vacuolated, rather dense parenchyma and vascular elements (fig. 5.2). Their imprecise identification was due in part to the lack of adequate modern comparative reference material and to the small size and poor quality of the fossil specimens. The remains belong to fragments of vegetative underground organs like roots, bulbs and tubers from different taxa.

The double identification category “amorphous objects/fruit flesh” included items with a more or less densely vacuolated structure, that could not, on the base of their morphology, be identified as fragments of fleshy fruits or of parenchymous underground plant tissue.

The unidentified seeds (*Indeterminata* seeds) included mainly unidentifiable remains and some indeterminate items. An identification category “nutshell fragments <0,5 mm thick” has been created for small and badly preserved specimens. Their identification remains speculative. A category of enigmatic remains, probably vegetative plant parts, called *Indeterminata* type g were regularly present in the samples. Additionally, fragments with oval-elongated inclusions have been identified as cf. faeces.

The mineralised remains belonged to *Celtis*, *Alkanna*, *Pistacia* and *Vitis*. *Celtis* has nearly spherical endocarps made of two symmetric halves and a rugulose surface covered with a coarse reticulate pattern. Four species of *Celtis* grow in Anatolia[33] with quite similar pericarps, so that we left the identification to genus level. However, *C. tournefortii*, *C. australis* and *C. glabrata* are the best candidates based on their present-day distribution.

The range of taxa and identification categories was even more restricted in Karain B and all of them were already present in Öküzini (table 2) : *cf. Amygdalus* endocarp fragments, *cf. Pyrus* fruit and fruit flesh fragments, “nutshell fragments 0,8-1 mm thick”, “amorphous objects”, “fruit flesh” and “amorphous objects/fruit flesh” are the only identified carbonised finds. In addition, specimens similar in size and shape to domestic varieties, and thus assumed to be contaminants, were present (Vicieae large-seeded, *cf.* Vicieae large-seeded, *Vicia ervilia*, *cf. Lens*, *Lathyrus* (grass pea), *Triticum dicoccum* (emmer), *Hordeum vulgare* (barley) and *Cerealia* (cereal grain)). Two taxa were found mineralised (*Celtis* and *Alkanna*). A carbonised fragment with oval inclusions, possibly a fragment of *faeces,* was also recovered.

---

[33] DAVIS, 1982 : 649-652.

		KB	OK																
Archaeological units (AU)			I	I	I	II	II	II	II	III	III	III	IV	IV	IV	IV	IV	IV	IV
GH attribution		PI.1-PI.2	XII	XI	X	IX	VIII	VII-VIII	VII	VI-VII	VIb	VIa-VIb	VIa	V-VI	V	IV	III-IV	III	II
Taxa, carbonised preservation																			
Amygdalus graeca/orientalis endocarp	weight (g)	.	.	.	.	.	.	.	.	.	.	0.02	.	.	0.03	0.14	0.003	0.13	0.04
	fragments count	.	.	.	.	.	.	.	.	.	.	1	.	.	1	10	1	13	3
cf. *Amygdalus* endocarp	weight (g)	0.02	0.01	0.004	0.03	.	0.003	.	0.07	0.02	.	0.18	0.01	.	0.10	1.15	0.04	1.28	0.53
	fragments count	5	1	1	5	.	1	.	9	1	.	29	1	.	10	119	6	162	55
Bromus seed	count	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.
Crataegus pyrene	count	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.
cf. *Crataegus* pyrene	count	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	.	.
Cyperaceae seed	count	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.
Galium seed	count	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1
Indeterminata seed	count	.	.	.	.	.	.	.	3	.	.	7	.	3	1	9	1	11	14
Pistacia endocarp	count	.	.	.	.	.	.	.	2	1	.	.	.	.	.	9	2	.	.
cf. *Pistacia* endocarp	count	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
Poaceae seed	count	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
Pyrus fruit/fruitfelsh	weight (g)	.	.	0.02	.	.	.	.	.	.	.	.	.	.	.	0.34	.	0.31	0.14
	fragments count	.	.	1	.	.	.	.	.	.	.	.	.	.	.	4	.	5	3
cf. *Pyrus* fruit/fruit flesh	weight (g)	0.09	0.01	0.05	0.05	0.02	0.001	0.003	0.08	0.03	0.01	0.07	0.004	0.01	0.08	0.42	0.15	0.99	0.81
	fragments count	6	2	11	1	2	1	3	12	6	2	25	1	1	11	61	8	61	43
cf. *Pyrus* peduncle	count	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.
cf. *Pyrus* seed	count	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
Quercus acorn	weight (g)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1.51	.	0.31	1.59
	count	.	.	.	.	.	.	.	.	.	.	.	.	.	.	18	.	5	28
Rosa pseudocarp	weight (g)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0.04	.	.	0.01
	count	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	1
Rosa seed	count	.	.	.	.	.	.	.	.	.	.	.	.	.	.	5	.	1	.
Rumex seed	count	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
Scirpus seed	count	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	.	.
cf. *Scirpus* seed	count	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.
cf. *Sparganium* seed	count	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.
Trifolieae seed	count	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
Vicieae small seed	count	.	.	.	.	.	.	.	1	.	.	.	.	.	.	3	.	3	.
Vitis fruit/fruit flesh	weight (g)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0.01	0.003
	count	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	7	1
Vitis seed	count	.	.	.	.	.	.	.	4	.	.	26	.	2	8	51	6	.	.
cf. *Vitis* seed	count	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.
cf. *Zygophyllum fabago* seed	count	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
Taxa, mineralised preservation																			
Alkanna seed	count	4	.	.	.	.	.	.	.	1	.	2	.	.	1	1	.	.	1
Celtis endocarp	whole count	1	.	.	.	.	.	.	3	.	.	1	.	1	1	16	1	31	23
	half count	5	.	.	.	.	.	.	2	.	.	.	.	.	.	3	.	166	132
	fragment weight (g)	0.13	.	.	.	.	.	.	0.086	.	.	.	.	.	0.076	0.039	.	2.241	1.461
Pistacia endocarp	count	.	.	.	.	.	.	.	1	.	.	.	.	.	.	1	.	.	.
Vitis seed	count	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	10
Identification categories, carbonised preservation																			
"Amorphous objects" *indeterminata*	weight (g)	0,12	.	0.03	.	.	.	.	0.07	.	.	0.08	.	.	0.01	0.10	0.01	0.02	0.07
	count	13	.	4	.	.	.	.	15	.	.	5	.	.	3	7	3	2	6
"Amorphous objects/fruit flesh" *indeterminata*	weight (g)	0.18	0.05	0.06	0.06	0.01	0.01	0.01	0.20	0.04	0.03	0.24	.	0.002	0.16	0.26	0.01	0.20	0.10
	count	44	10	22	13	2	4	3	103	25	14	98	.	4	73	105	2	58	35
(*Cerealia* seed)	count	(5)	.	.	.	.	.	.	.	.	.	.	.	.	.	(1)	.	.	.
cf. *Faeces* (with oval inclusions)	weight (g)	0.001	.	0.001	0.002	.	0.01	.	.	.	.	0.02	0.01	.	0.003	0.04	.	0.03	.
	count	1	.	1	2	.	5	.	.	.	.	6	2	.	1	6	.	2	.
"fruit flesh/fruit flesh with testa/fruit flesh with seed imprints" *indeterminata*	weight (g)	0.24	.	0.002	0.01	0.02	.	0.002	0.02	0.01	.	0.01	.	0.004	0.05	0.16	0.01	0.14	0.16
	count	2	.	1	1	1	.	1	2	1	.	10	.	2	7	38	2	38	23
Indeterminata g	count	.	1	.	.	.	.	.	2	.	.	4	.	.	.	3	.	3	.
"Nutshell fragments 0,8-1 mm thick" *indeterminata*	weight (g)	0.03	.	0.02	0.08	0.004	0.01	.	0.10	0.003	0.02	0.35	0.02	0.002	0.11	1.07	0.06	0.99	0.25
	count	9	.	6	26	1	3	.	26	5	3	83	9	1	42	336	10	165	41
"Nutshell fragments <0,5 mm thick" *indeterminata*	weight (g)	.	.	.	.	0.001	.	.	0.003	0.001	.	0.003	.	0.002	.	0.02	.	0.01	0.01
	count	.	.	.	.	1	.	.	4	1	.	9	.	6	.	25	.	7	9
Omitted from the analysis, suspected contaminants																			
(*Hordeum vulgare*)	count	(4)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
(*Lathyrus* seed)	count	(1)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
(cf. *Lens* seed)	count	(7)	.	.	.	.	.	.	.	.	.	.	.	.	.	(4)	.	(4*)	.
(*Triticum dicoccum* seed)	count	(1)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
(*Triticum monococcum* seed)	count	.	.	.	.	.	.	.	(1*)	.	.	.	.	.	.	.	.	.	.
(Vicieae large seed)	count	(1)	.	.	.	.	.	.	.	.	.	(1)	.	.	.	(3)	.	(1)	(4)
(cf. Vicieae large seed)	count	(1)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
(*Vicia ervilia* seed)	count	(4)	.	.	.	.	.	.	(2*)	.	.	.	.	.	.	(1)	.	.	.

Table 2. Raw data from Epipalaeolithic Karain B and Öküzini

* AMS date showed intrusive nature

( ) contaminants omitted from the analysis

Table 2. Raw data from Öküzini and Karain B

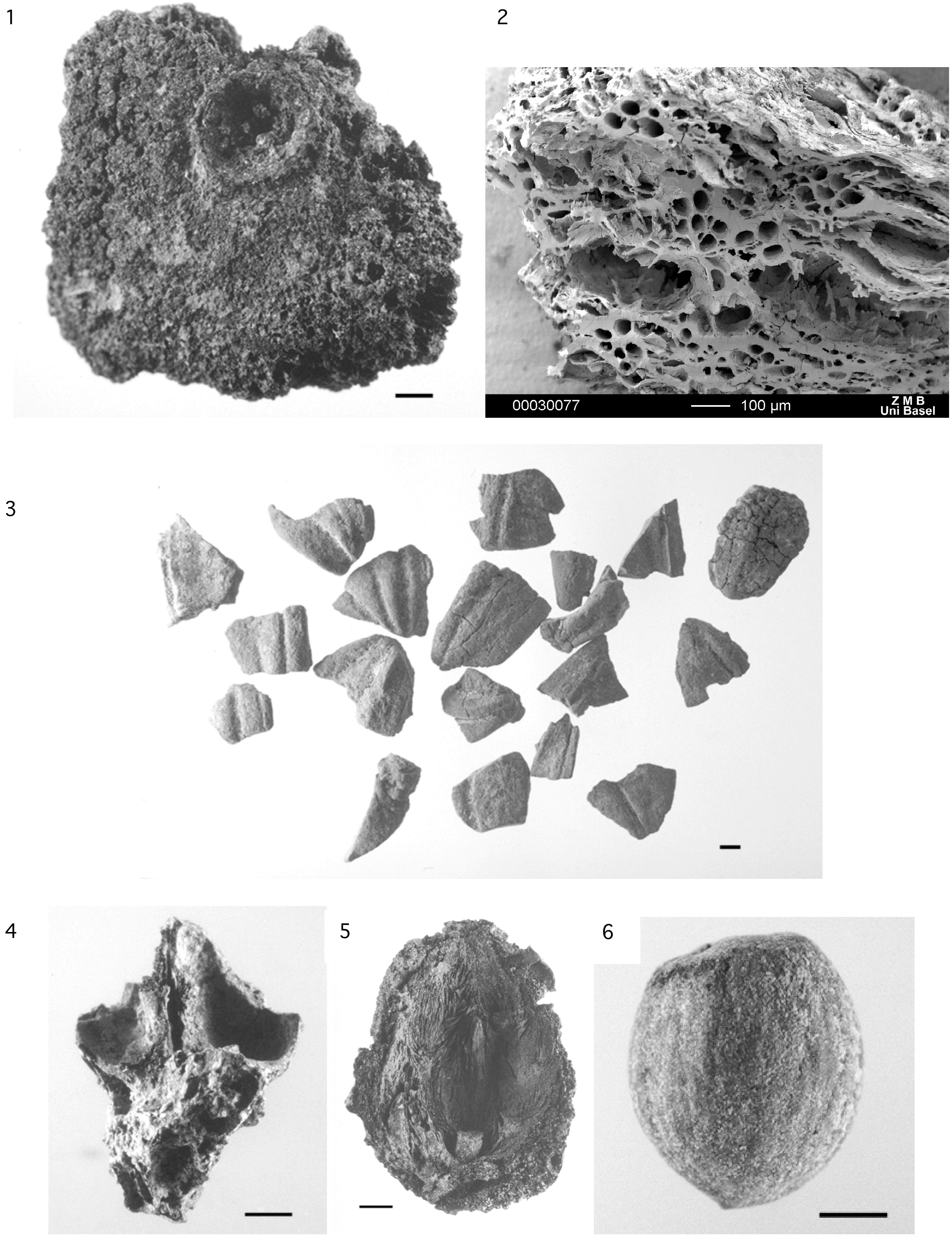


Figure 5. Photographs of some plant remains. 1. *Pyrus* fruitflesh 2. Amorphous object *indeterminata* 3. *Amygdalus graeca/orientalis* endocarp fragments 4. *Vitis* fruitflesh with seed fragments 5. *Rosa* pseudocarp 6. *Pistacia* endocarp (scale 1mm). Photographed by G. Haldimann and Zentrum für Mikroskopie Universität Basel.

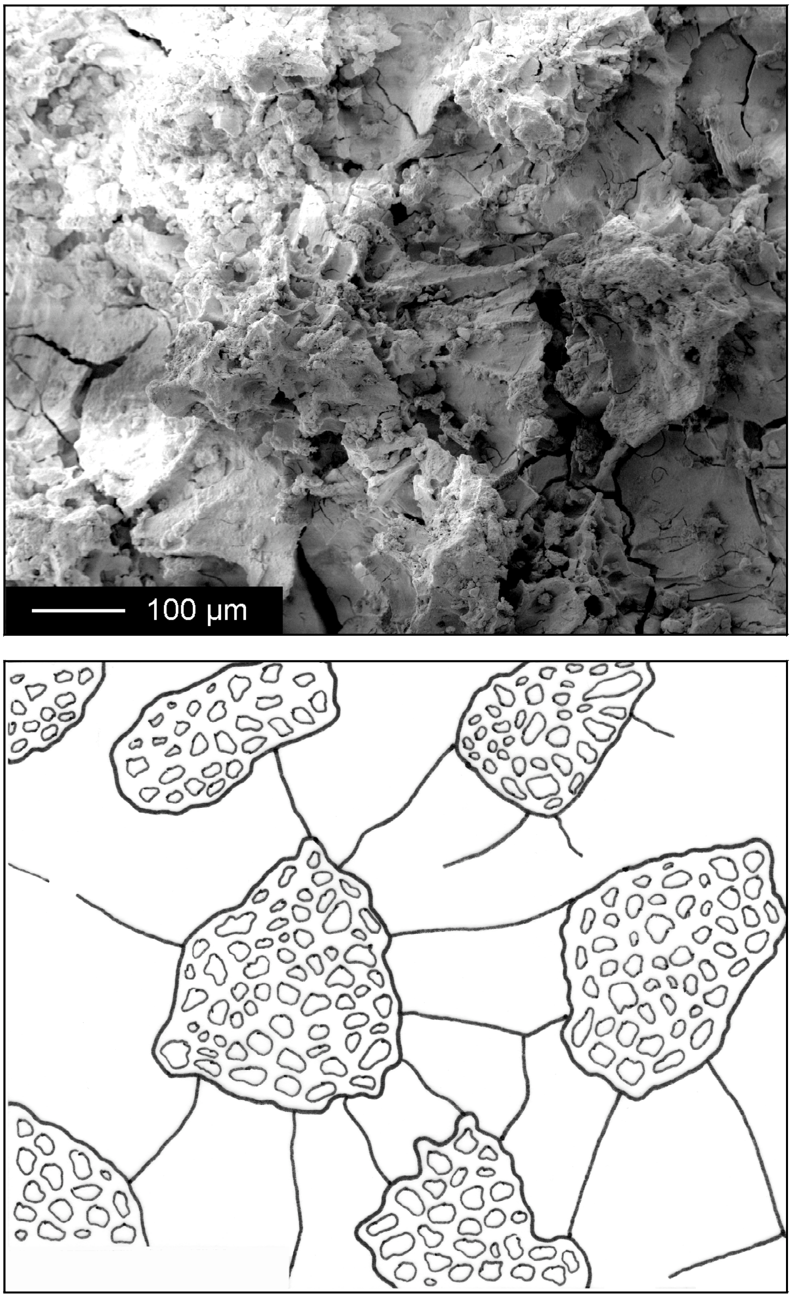


Figure 6. Scanning electron microscopy photograph and draft of pear fruit flesh (*Pyrus*) showing groups of thick-walled stone cells surrounded by elongated parenchyma cells forming rosettes (photograph ZMB Uni Basel).

Sample	GH	14C datation BP	14C datation cal BC	Lab. No.
cf Lens	III	7970±50	7060-6690 (95,4% probability)	Poz-1858
Vicia ervilia	VII	4440±40	3340-2920 (95,4% probability)	Poz-1930
Triticum monococcum	VII	8030±50	7090-6700 (95,4% probability)	Poz-1859

Table 3. 14C dates (AMS) and calibration results with OxCal software (Laboratory Poznan) of plant remains from Öküzini

ANALYSES

The limited size of the plant assemblages does not allow a fine resolution scale for comparison of taxa composition at the level of the geological strata (GH), so the data from the same archaeological units (AU) have been plotted together. But even so, the extent of the assemblages remain often small : 79 charred and 10 mineralised remains in 17 samples in Karain B (PI.1-PI.2), 106 charred remains in 15 samples in Öküzini in AUI, 206 charred and 6 mineralised remains in 40 samples in AUII, 357 charred and 4 mineralised remains in 60 samples in AUIII, 1853 charred and 391 mineralised remains in 187 samples in AUIV (table 1). Therefore, comparison between the archaeological units must be made with caution and only the most obvious trends can be considered.

Ubiquity

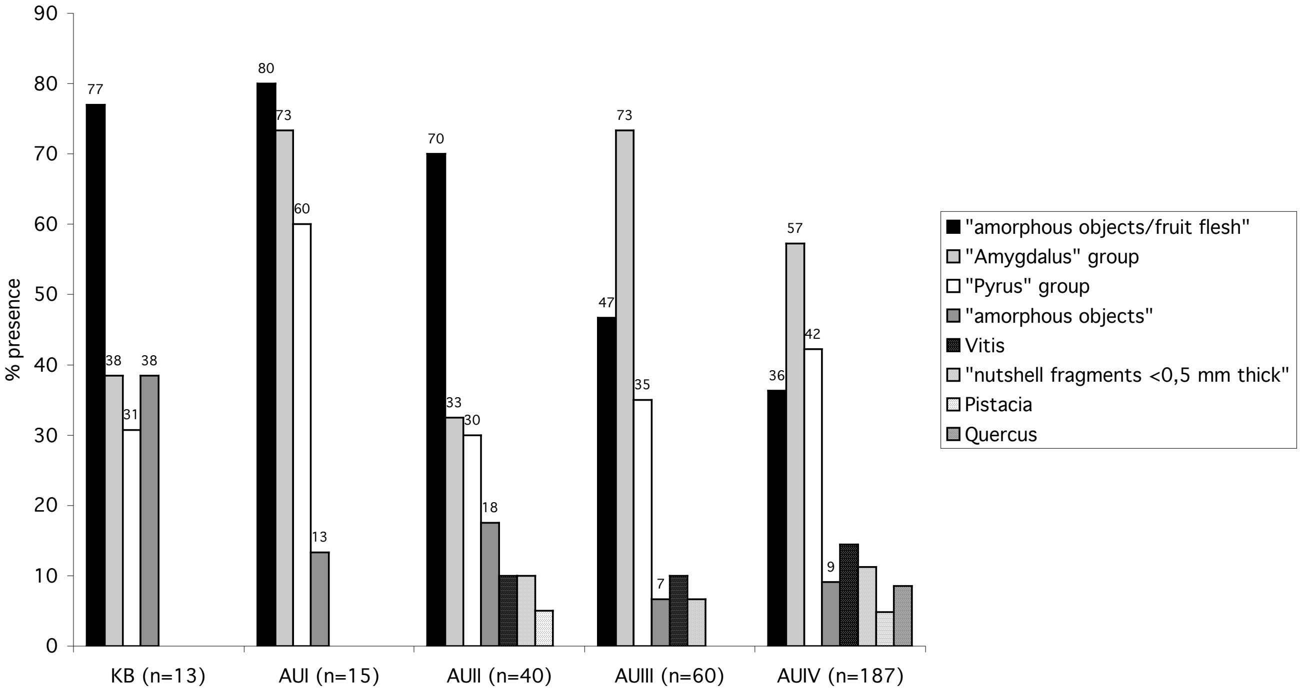
Ubiquity analysis has the advantage to reduce the effects of differences in preservation and sampling between assemblages. Nevertheless an inaccurate grouping or a low number of samples can affect the results. The ubiquity score of one taxon (percentage of samples (AH from one square) in which one taxon was present per archaeological unit) tends to measure the dispersion in the deposit of the taxa. Because the samples taken were arbitrary, an appropriate grouping was not possible and can somehow influence the results. However, the rather high number of samples should temper the misestimation[34]. We assume therefore that the ubiquity value of a taxon is an imprecise but still useful measure of its frequency and accordingly relative importance.

An "*Amygdalus*" group, combining *Amygdalus graeca/orientalis*, *cf. Amygdalus* and "nutshell 0,8-1 mm thick", and a "*Pyrus"* group, with *Pyrus*, *cf. Pyrus* and "fruit flesh" fragments, have been created for this analysis, because they were assumed to represent the same taxa at different preservation stages. The "amorphous objects/fruit flesh", the "*Amygdalus*" group and the "*Pyrus*" group (present up to 80 % to 30 %) were dominant in each archaeological unit (fig. 7). Their relative proportions vary through time, but this can largely be explained by differences in overall number of samples. In addition to the "amorphous objects/fruit flesh", remains belonging to the "amorphous objects" were regularly found in each archaeological unit, and have especially a high presence score in Karain B. Other plant remains, like *Vitis*, *Pistacia* and *Quercus*, have moderate presence scores and appear only in the later archaeological units. The variety of taxa and quantity of macro-remains recovered appears to increase through time, but this is wholly due to the higher number of samples available. In brief, a limited range of nuts and fruits and of identification categories belonging in part to roots, bulbs or tubers, appeared regularly in the Epipalaeolithic assemblages.

---

[34] POPPER, 1988 : 61.

Figure 7. Taxa ubiquity in the different archaeological units (only charred remains with >5% occurence were considered)



Ratio analysis

It seems reasonable to assume that the charcoals recovered on the sites represent remains from domestic fuel use. If we admit that the chances for the seeds and fruits to become charred do not vary much through time, then the variation of the concentration of a taxon in the volume of charcoals between the assemblages should signify variation in use[35]. The type of context sampled and differences in preservation condition, however, can affect this ratio.

In order to investigate the relative variation of the main taxa through time, the same four groups that were used for the ubiquity analysis were considered :

a) "*Amygdalus*" group,

b) "*Pyrus*" group,

c) "amorphous objects",

d) "amorphous objects/fruit flesh" (fig. 8).

The values obtained are very small and close to each other, and the significance of the results can therefore be disputed. Overall, the data show little patterning, apart from a slight decrease in the importance of the "amorphous objects" and "amorphous objects/fruit flesh" in AUIV.

---

[35] MILLER, 1988 : 75.

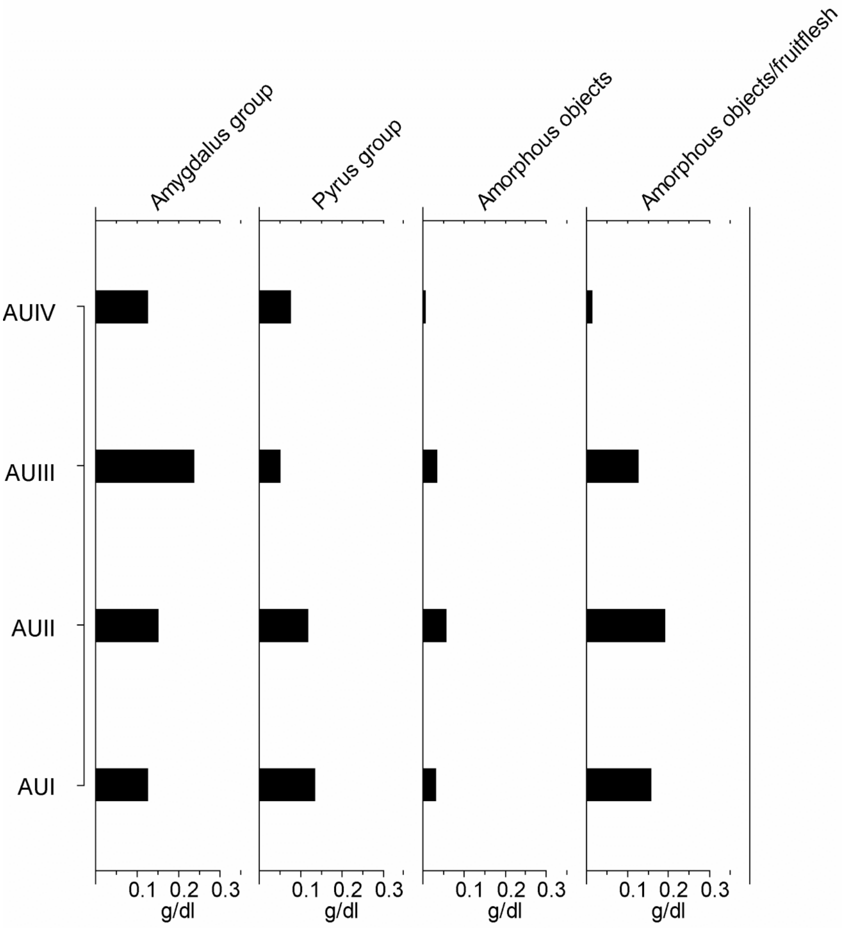


Figure 8. Öküzini: ratio of major plant groups (g)/total charcoal volume (dl)

REPRESENTATIVENESS OF THE PLANT REMAINS

The plant assemblages recovered in the cave sediments were clearly exogenous and the charred material likely reflects human activity. It is nonetheless important to understand the taphonomic processes that resulted in the deposition and preservation of the seeds and other plant parts in order to assess the extent to which they can be linked to past human activity. In Karain B and Öküzini, it was possible to study the total amount of plant remains preserved within the excavated area (apart from the samples which could not be phased correctly) ; they form the underlying patterning from which we try to reconstruct the role and importance of the various plant resources. Nevertheless, several processes interfere between the total amount of plant material once generated on a site and the carbonised assemblages recovered[36]: for example the nature and frequency of use of fire on a settlement, the "robustness" of the plants (some plant remains are rarely preserved, *e.g.*, flowers, leaves, young shoots, stems), whether a plant needs fire or heat during processing or cooking and whether a plant part is edible or represents a waste product, etc. affect the preservation chances of a plant. Once embedded in the sediment, factors such as camp maintenance activities (cleaning of hearths), trampling, changes in humidity, compression and pedoturbation may interfere. Then, during the recovery of the plant remains, handling

---

[36] This formation process has been described in detail especially in the case of pre-agrarian sites in COLLEDGE, 2001 : 18-21.

and floating expose the charred remains to more risk of damage or loss. The charred archaeobotanical assemblages are for all these reasons unlikely to be fully representative of the range of plants once used on the site.

The charred seed and fruit remains from Öküzini probably originated from the numerous hearths and fireplaces and represent discarded waste products or accidental carbonisations, assuming that wood was the principal fuel. The pattern of spatial distribution of the plant remains could not be investigated in more detail because of the sampling method (by squares and not by context) and also the low plant recovery rate. In Karain B, the excavated sector did not yield any recognisable structure and probably consisted of secondary deposits in the back part of the cave, which was used as midden.

The presence of mineralised remains of *Vitis* and *Pistacia* in the cave deposits may be explained by micro environmental variations such as water dripping from the cave roof in particular areas. *Celtis* and *Alkanna* are different; their pericarp or nutlet naturally contains high amount of calcium carbonate ($CaCO_3$) and therefore survive well in archaeological settlements.

DISCUSSION

DIET IN HUNTER-GATHERER SOCIETIES

Ethnographic data showed an enormous diversity in the proportion of food derived from plant and animal resources among modern and historic foraging societies[37]. Latitude, as well as environment[38], seems to be the major determinants of the proportion of plants in the diet, beside population density[39]. Subsistence supplied by hunted animals appeared to be relatively constant (26-35 % subsistence by weight) regardless of latitude, whereas plant food use markedly decreased towards the poles, and was replaced where possible by increased reliance on aquatic resources[40].

At the end of the Palaeolithic, the climate in mediterranean Anatolia was colder than today[41]. Öküzini and Karain were located in an ecotonal zone with a steppe-forest and riverine woodland[42] in an otherwise open landscape[43]. The plant and animal remains recovered offer little information about the relative proportions of meat and plant food in the prehistoric diet. From the importance and diversity of the animal assemblage however, we assume that protein was not a limiting factor in the diet. Judging from past environment, fish and plant resources might have been of substantial importance.

Cordain and colleagues[44] have attempted to reconstruct the macronutrient composition of the hunter-gatherer diet that transcends geographical and ecological boundaries. Their model is based on estimates of the projected dietary macronutrient intake (in percentage of energy) in a number of hunter-gatherer societies and incorporates various plant : animal ratios and percentage of body fat in various prey species. A mean energy density for wild plants and animal food has been used. The widely recognised toxicity of a high level of protein in human diet was considered, as well as the increased protein tolerance provided by

---

37. Jenike, 2001 : 209 ; Lee and DeVore (eds), 1968.
38. Cordain *et al.*, 2000 : 689.
39. Keeley, 1992 : 35.
40. Cordain *et al.*, 2000 : 687-688.
41. Kuzucuoğlu and Roberts, 1998 : 12.
42. Thiébault, 2002.
43. Kuzucuoglu *et al.*, 2002.
44. Cordain *et al.*, 2000.

both fat and carbohydrates[45]. The model predicts that the percentages of the total energy required from the macronutrients in hunter-gatherer societies would be 19-35 % for protein, 22-40 % for carbohydrate and 28-58 % for fat, *i.e.*, a diet that is relatively poor in carbohydrate and high in lipids according to modern standards.

Because temperature, rainfall and, therefore, plant and animal productivity vary seasonally, forager's diet also varies. Hunter-gatherer for which good information on seasonal variation in the diet is available seems to feature adequate or excessive protein content during all seasons. However, many are likely to be seasonally impoverished in dietary fats, carbohydrate and therefore energy, because of the limited availability of plant foods and the leanness of game[46]. Finding adequate non-protein energy sources to complement the diet may become increasingly difficult in critical seasons and has been proposed as an important nutritional constraint for hunter-gatherers living in temperate areas[47]. Several options appear to circumvent the limit of dietary protein intake : for example exploitation of plant food high in energy, hunting of larger animals (with higher percentage of fat) or selecting the more fatty portions of the carcass.

Considering the archaeobiological assemblages recovered, the limiting factor for a balanced diet appears to be the carbohydrates and the lipids, especially in periods of lean meat from game in late winter and spring. The vegetative underground organs would be the most concentrated carbohydrate resources (high in starch), accessible mostly in winter and spring. The nutty seeds would have been the most concentrated resources for vegetal fat, accessible in late summer and autumn. The availability of these high-energy plant resources before and during the winter could be a reason for their use and an explanation for the exploitation of resources that need to be detoxified, like the cyanogenic wild almonds. Conversely, a diet high in animal protein could have been vital for populations eating cyanogenic foods because of the detoxification properties of the methionin[48]. Additionally, plant foods provided several key nutrients that animal products either lack or provide in lower quantities : various carotenoids, vitamin E, vitamin C and fibres, as well as added more diversity to the diet.

DIETARY PROPERTIES, USES AND GATHERING REQUIREMENTS OF THE PLANTS RECOVERED

The relative importance in the economy of the plants recovered, for example how the plants were used, their nutritional contribution to the diet, or the amount of time and labour required to procure them, can be approached with qualitative data. In the investigation of Öküzini and Karain B plant remains, as on other pre-agricultural sites, the focus has been on the use of plants as food, almost to the exclusion of any other explanation for their presence, as medicine, dyes, fuel, matting material or other.

Wild almonds' kernels are concentrated energy sources; seeds of *A. orientalis* collected at maturity in the Konya region had 48,5 % from dry weight of oil, with the mono-unsaturated oleic fatty acids dominant over the poly-unsaturated linoleic[49] (table 4). They also contain proteins (*ca* 20 %), minerals and some vitamins. However, seeds of wild almond species are usually bitter and toxic due to the production of the glucoside amygdalin, but they represent a valuable nutrient when consumed in moderation or

---

45. *Ibid.* : 688.
46. JENIKE, 2001 : 214.
47. SPETH, 1991 : 172.
48. JONES, 1998 : 157.
49. BEYAZOGLU and DURAL, 1991 : 208.

efficiently detoxified[50]. These "nuts" grow on perennial thorny bushes or small trees and so would have been readily available in season[51]. Processing is not required when young green fruits are consumed, but becomes essential with mature fruits; the nuts have to be cracked, then ground and detoxified either by drying, roasting or leaching[52]. Different species of wild almonds were recovered in Epipalaeolithic sites, like Franchthi, Ohalo II, Hayonim and Hallan Çemi, although their importance in the assemblages varied[53].

The nutty fruits of both *Pistacia* species identified (*P. atlantica* and *P. terebinthus*) are commonly used as food in Turkey and the Near East[54]. They are eaten fresh or roasted or, more rarely, are used for the extraction of oil. The fruits are very nutritious : for example, *P. atlantica* has a high oil content (45 %)[55], consisting mainly in unsaturated fatty acids (oleic 46 % and linoleic 27,5 %). The gum and fruits of both trees have also medicinal uses[56]. Gathering would have been easy as the nuts grow on small to medium trees. This perennial resource was predictable. The majority of near eastern Epipalaeolithic sites for which plant remains have been recovered comprised shells of *Pistacia*, like Ohalo II, Tell Abu Hureyra I, Mureybit I-III and Hallan Çemi[57].

The use of acorns as human food is well known and extensively documented[58]. Acorns are relatively high in carbohydrate, have a variable fat content but are poor in protein. They contain tannins to a varying degree, which need to be removed by processing of some kind (leaching, roasting or just embedding in the soil for several months) before they become palatable. In Turkey, several oak species have edible acorns and these are consumed either raw or roasted[59]. This perennial resource was predictable, although the production of acorns varies from year to year[60]. Epipalaeolithic acorn remains are rare; the only other site where they were recovered was Ohalo II[61].

Celtis drupes have a thin fleshy mesocarp especially rich in vitamin C[62] and a stony endocarp containing a seed rich in oil (seeds of *C. australis* contain 48 % oil[63]). Fats recovered from these drupes provided oils for burning in antiquity[64]. Being a perennial tree, the fruits are predictable and also easy to collect. They need no processing prior to consumption of the pulp, but pounding or cracking is necessary to extract the seed[65]. The inhabitants of Abu Hureyra and Franchthi in the Epipalaeolithic have used hackberry fruits[66]. They were also frequent in Neolithic settlements in Anatolia, like Asıklı Höyük and Çatal Höyük[67].

The fruits from *Crataegus*, *Pyrus*, *Rosa* and *Vitis* are all edible and have moderate

---

50. MARTINOLI and JACOMET, 2004 : 50.

51 DÖNMEZ, 1997 : 253-254, 262-263.

52. JONES, 1998 : 158.

53. HANSEN, 1991 : 120-121, 129-130, 135-136 ; HOPF and BAR-YOSEF, 1987 : 117 ; ROSENBERG *et al.*, 1998 : 32 ; WEISS *et al.*, 2004 : 9551.

54. COULADIS *et al.*, 2003 : 136 ; ZOHARY, 1996 : 7.

55. YOUSFI *et al.*, 2002 : 1049.

56. DAVIS, 1967 : 544-548.

57. HILLMAN, 2000 : 341 ; KISLEV *et al.*, 1992 : 162 ; ROSENBERG *et al.*, 1998 : 32 ; VAN ZEIST and BAKKER-HEERES, 1984/1986 : 179.

58. MASON, 1992.

59. ERTUG-YARAS, 1997 : 164.

60. MASON, 1992 : 251-256.

61. WEISS *et al.*, 2004 : 9551.

62. HANSEN, 1991 : 76.

63. ERCIYES *et al.*, 1989 : 1461.

64. *Ibid. :* 1459.

65. ERTUG-YARAS, 1997 : 171.

66. HANSEN, 1991 : 123 ; HILLMAN, 2000 : 341.

67. FAIRBAIRN *et al.*, 2002 : 45 ; VAN ZEIST and ROLLER DE, 1995 : 183-184.

carbohydrate content (mainly in the form of monosaccharides), are high in vitamin C and in fibres, but are low in lipids and proteins as shown by the examples of some wild equivalents[68] (table 4). In Cyprus, fruits of *C. azarolus* are eaten fresh or used for the preparation of a jam[69]. The small and hard fruits of *P. communis* become edible when overripe[70]. Several species of wild pears are eaten when matured or alternatively can be dried or roasted, for example *P. eleagnifolia* in Aksaray, *P. amygdaliformis* in Buldan-Denizli[71] and *P. syriaca* in Iraq[72]. *P. eleagnifolia* has even been grown intentionally as fruit-tree in certain regions[73]. Wild pear fruits are known from Epipalaeolithic Franchthi and Abu Hureyra, but were not abundant[74]. Although rare in the assemblages, *Rosa* pseudocarps are edible fresh or dried and are used today for jam and tea in central Anatolia[75]. *Vitis sylvestris* bears sour berries[76]. Nonetheless, they were also exploited by other Epipalaeolithic populations, as evidenced by the finds at Franchthi and Ohalo II[77]. Hooper[78] mentioned confectionary made of a mixture of raisins and nuts, or raisins and almonds, which was eaten in Iraq in the winter as a substitute for fresh fruits.

Most of the fruits recovered belong to small to medium phanerophytes or woody climbers (table 5) and would therefore represent an easy to collect and predictable resource. Processing is not necessary to make them palatable, although most fruits become sweeter when they are dried. These wild plants usually have higher concentrations of fibres, vitamins, minerals and phytochemicals of higher potential nutritional significance than their domesticated/cultivated counterparts[79].

Several of the small-seeded plants recovered have valuable nutritional properties, for example being rich in starch, although they require labour-intensive processing in order to render them edible and physiologically assimilable[80]. The seeds of small-seeded Vicieae, *Scirpus* and *Rumex* have been interpreted as plant food in Epipalaeolithic Abu Hureyra, for example, where they were recovered in large number[81].

Roots, tubers and bulbs are underground vegetative storage organs rich in starch with numerous uses as food when eaten raw or cooked[82]. Such remains were never identified in Epipalaeolithic sites from southwest Asia; but, recently, examination of new samples from Mesolithic Franchthi in Greece showed their presence[83]. Ethnobotanical investigations in the central Anatolian plateau and the Aegean coast have evidenced an unexpected high number of gathered wild plants, among which species used for their bulbs, roots or stems for food or beverage were numerous[84]. Their gathering and processing seemed not to be labour intensive.

---

[68] DEBUSSCHE *et al.*, 1987 : 249; FRANKE, 1997 : 252.

[69] SAVVIDES, 2000 : 46.

[70] BROWICZ, 1992 : 24.

[71] F. ERTUG, pers. comm.

[72] TOWNSEND and GUEST, 1966 : 110.

[73] BROWICZ, 1982 : 50.

[74] HANSEN, 1991 : 123, 129, 137 ; HILLMAN, 2000 : 341.

[75] ERTUG-YARAS, 1997 : 162.

[76] DAVIS, 1967 : 521-522.

[77] HANSEN, 1991 : fig. 53 ; WEISS *et al.*, 2004 : 9551.

[78] HOOPER, 1937.

[79] JENIKE, 2001 : 208.

[80] HILLMAN, 2000 : 354-358.

[81] *Ibid.*

[82] ERTUG-YARAS, 1997 : 144-148 ; HILLMAN, 2000 : 368.

[83] MASON *et al.*, 2002 : 190.

[84] ERTUG, 2004 : 165 ; ERTUG-YARAS, 1997 : 144-148.

	Plant part	Water %	Carbohydrate %	Lipids %	Protein %	Life form	Processing requirements	Storability	Season of maturity
Amygdalus graeca	seed							dried	7-8
Amygdalus orientalis	seed			48.5	~20	MP	high	dried	8-9
Celtis australis fruit	fruit pulp	37	40	1	3	TP	low	dried	9-10
Celtis australis seed	seed			48		TP	low	?	9-10
Crataegus monogyna	fruit pulp	73	19	1	3	MP	low	dried	
Crataegus spp.	fruit							dried	9-10-11
Pistacia atlantica	seed			45		TP	low	roasted	9-10
Pistacia terebinthus	seed	34	5	61	4	MP	low	roasted	9-10
Pyrus amygdaliformis	fruit pulp	73	37	1	1	MP	low	dried	9-10
Cerris, Ilex, Quercus species group	acorn		83.2	5.5	5.5	MP-TP	low-high	dried	8-9-10
Rosa sect. *canina*	fruit pulp	46	31	1	3	SP	low	dried	
Vitis sylvestris	fruit							dried	9-10
Vitis vinifera	fruit pulp	81.1	15.24	0.28	0.68	PV	low	dried	

Table 4. Dietary features and seasonality of plant availability (TP tall phanerophyte (4-8m,) MP medium-sized phanerophyte (2-4m), SP small phanerophyte (0.3-2m), PV phanerophyte vine).

SUBSISTENCE STRATEGY

It appears that the bulk of the plant foods recovered consisted in a variety of wild "nuts" and wild soft fruits that were reliable and predictable, and underground storage organs. All these resources required rather little time and labour to procure and process, apart from the wild toxic almonds. The subsistence was completed with hunted animal resources (mainly ovicaprines, fallow deer, roe deer, red deer and wild boar[85]), various birds, reptiles and fishes.

Even though absence is not a reliable measure of insignificance, the low number of small seeds of annual plants seems to exclude their intensive use. Moreover, their correct chronological assignment has been questioned (see "Preservation and range of plant taxa"). Seeds are much more likely to survive, once exposed to fire, than other fragile plant parts[86]. As seeds of most of the species recovered require roasting or cooking to become edible[87], one would expect them to be better represented in the carbonised assemblages if they had been used for food. Furthermore, the animal remains in Öküzini attest hunting activities, and therefore occupation, in the early summer, when seeds of the herbaceous annuals would be ripe.

There is little temporal patterning in the assemblages in Öküzini; the suggested decrease in the importance of exploitation of roots, bulbs and tubers between the early AUI, II, III

---

[85] Lopez Bayon *et al.*, 2002 : 37-38.

[86] Boardman and Jones, 1990 ; Wilson, 1984.

[87] Hillman, 2000 : 354-358.

and AUIV could be correlated with a change in the vegetation cover, such as an expansion of the forest or changes in its density. Such a trend was evidenced in the charcoal as well as in the faunal records with a progressive change from a dominance of steppe forest species to a dominance of temperate oak and riverine forest species, together with an increase of the importance of animal species living in forested environments[88].

Several artefacts can be connected with plant gathering and processing. For example, the imprints of woven material were found in a small fragment of clay from Öküzini cave (GHIII), possibly representing a bag or basket, which could have been used to gather plants. Oval pebbles with a concavity on one face resulting from percussion were recovered from Öküzini as well – GHVIII and IV to II and from the Kökten excavation ("galet à cupule")[89] – and could have been used to crack nuts such as almonds. The presence of "harvesting knives" made of bone and grinding-stones[90] from AUIV[91] are further evidence for plant collection and processing and would indeed correlate well with the presence of small seeds in AUIV. However, these tools could also serve for the gathering and processing of other resources, including matting material or roots and even meat[92].

SEASONALITY AND SETTLEMENT PATTERN

The season of occupation of transitory camps can be inferred from patterns of exploitation of animal and plant resources. The preliminary analysis of the ungulate fauna from Öküzini showed mortality profiles that suggested spring and early summer hunting activities throughout the Epipalaeolithic sequence. The tooth data provided direct evidence for late spring to early autumn hunting of juvenile ovicaprines and fallow deer[93].

The season of availability of the identified plant foods is an approximate measure of the season during which gathering would have been possible. The time of maturity of the species *Vitis sylvestris*, *Pistacia atlantica* and *P. terebinthus*, *Amygdalus graeca* and *A. orientalis*, *Crataegus* spp., *Pyrus* spp., *Quercus* spp., *Celtis australis* and *C. tournefortii* under present-day climatic conditions stretches from July to October, possibly extending to November (table 4). The simultaneous presence of nuts or fruits and wood of *Amygdalus*, *Pistacia*, *Quercus* and *Pyrus* suggests local gathering and therefore occupation of the site during the maturity period. It was not possible to find out the season of availability of the underground storage organs recovered, as they could not be identified further, but in general, bulbs, tubers and roots are best collected for food use in the spring[94] and the roots of riverine plants can be harvested between autumn and spring[95], before the growth of the plants depletes the carbohydrate reserves. We cannot assume exact correlation between the gathering seasons and seasons of site occupation, because many of the plants recovered could be stored and consumed later, extending the period of occupation of the sites for some time after the major plant foods ceased to be readily available.

Overall, the recovered plant foods point to an occupation at Öküzini in late summer and autumn, when most fruits and nuts were mature, and could extend to winter and spring, when the vegetative underground organs would have been most palatable.

---

[88] LOPEZ BAYON *et al.*, 2002 : 37-38 ; OTTE *et al.*, 2003 : 333-335 ; THIÉBAULT, 2002 : 96.

[89] ALBRECHT, 1988 : 218 ; YALÇINKAYA and OTTE, 2002 : 333.

[90] OTTE *et al.*, 2003 : 333.

[91] YALÇINKAYA *et al.*, 2002a : 277.

[92] ERTUG-YARAS, 1997 : 421.

[93] ATICI and STUTZ, 2002 : 104.

[94] ERTUG-YARAS, 1997 : 144-148.

[95] HILLMAN, 2000 : 368.

Combined with the archaeozoological results, a year round occupation of the cave appears possible. It seems however reasonable to assume that the occupation of Öküzini was intermittent, based on the archaeological remains recovered. Öküzini cave might have been inhabited irregularly for single and discrete repeated events, or during different seasons in a year. Both assumptions imply more or less frequent residential moves. An increase in the frequency or length of use of the cave, as suggested by the animal record[96], could not be confirmed by the plant macro-remains.

It is difficult to make any suggestion about the area exploited by the mobile hunter-gatherers who settled in Öküzini and Karain B. No plant species typical of the seacoast or of the higher plateau have been found. However, the use of marine shells as ornament objects has been attested during the Epipalaeolithic[97] whereas evidence for contacts with the Anatolian plateau is present at the top of the sequence only, with the recovery of obsidian pieces[98]. The hypothesis[99] that people moved seasonally between the foothills of the Taurus (Karain and Öküzini) and the seacoast (Beldibi/Kumbucagi and Belbasi) may be valid, but could not be tested by the plant remains.

CONCLUSION

This study offers the first insight for the use of vegetal resources by Epipalaeolithic hunter-gatherers of mediterranean Anatolia and will thus form a basis for future studies of similar kind. Even if the imprecise method of excavation and the small plant assemblages recovered limited the number of potential investigations, the analyses of the macro-remains allowed some interpretations about the role of the plants in the diet, overall subsistence strategy and shed some light on the settlement pattern. Nonetheless, the data were not adequate to explore in more details taphonomical processes, subtle temporal and spatial changes, variations in concentrations and contextual relations. In spite of that, we hope that our results have demonstrated that it was worthwhile and legitimate to study the plant remains from these excavations. To enhance our understanding of the relationships between plants and people at forager sites like Öküzini and Karain B, the number of comparative sites should be increased and the quality of the archaeobotanical data needs to be improved: on one hand with the help of more precise excavation methods and sampling, on the other hand with the use of more efficient recovery methods and smaller meshes, and with the integration of analyses of very small botanical remains, like phytoliths and starch grains.

---

96. ATICI and STUTZ, 2002 : 105.
97. YALÇINKAYA *et al.*, 2002b : 340.
98. OTTE *et al.*, 2002 : 383.
99. As suggested by BAR-YOSEF, 2002 : 377.

Acknowledgements : This research has been possible with the financial support of the Swiss National Science Foundation (project number 1214-64974.01 and 101312-101585/1). We want to thank both excavation directors, I. Yalçınkaya and M. Otte, for letting us study the plant material, and G. Hillman for making the material available to us. I wish to thank Stefanie Jacomet (University Basel), Sue Colledge (University College London) and Levent Atıcı (Harvard University) for their critical review of the manuscript, three anonymous reviewers for their valuable suggestions and critics, and Lucia Wick (University Basel) for her help with the TILIA software. Many people contributed to this study with their help and support and I would like to express my gratitude to them all.

Danièle Martinoli
University of Basel
IPAS, Institute of Prehistory and Archaeological Sciences
Spalenring 145
CH – 4055 Basel
Switzerland
dmartinoli@arso.org

BIBLIOGRAPHY

ALBRECHT G.

1988 Preliminary results of the excavation in the Karain B cave near Antalya/Turkey : the Upper Palaeolithic assemblages and the Upper Pleistocene climatic development. *Paléorient* 14,2 : 211-222.

ALBRECHT G., ALBRECHT B., BERKE H., BURGER D., MOSER J., RAEHLE W., SCHOCH W., STORCH G., UERPMANN H.P. and URBAN B.

1992 Late Pleistocene and Early Holocene finds from Öküzini : a contribution to the settlement history of the bay of Antalya, Turkey. *Paléorient* 18,2 : 123-141.

ATICI L. and STUTZ A.

2002 Analysis of the ungulate fauna from Öküzini : a preliminary reconstruction of site use, seasonality, and mortality pattern. *In* : YALÇINKAYA I., OTTE M., KOZLOWSKI J. et BAR-YOSEF O. (éd.), *Öküzini : final paleolithic evolution in southwest Anatolia* : 101-108. Liège : Université de Liège, Service de Préhistoire (*Eraul* 96).

BAR-YOSEF O.

2002 Öküzini cave – a view from the Levant. *In* : YALÇINKAYA I., OTTE M., KOZLOWSKI J. et BAR -YOSEF O. (éd.), *La grotte d'Öküzini : évolution du Paléolithique final du sud-ouest de l'Anatolie* : 375-379. Liège : Université de Liège, Service de Préhistoire (*Eraul* 96).

BEYAZOGLU O. and DURAL H.

1991 Determination of the fatty acids from the seeds of some *Amygdalus* species. *Turkish Journal of Biology* 15 : 206-209.

BOARDMAN S. and JONES G.

1990 Experiments on the effects of charring on cereal plant components. *Journal of Archaeological Science* 17 : 1-11.

BOSTANCI E.

1965 The mesolithic of Beldibi and Belbaşı and the relation with the other findings in Anatolia. *Antropoloji* 3 : 91-148.

BROWICZ K.

1982 *Chorology of trees and shrubs in South-West Asia and adjacent regions*. Vol 1. Warszava, Poznan : Polish Scientific Publishers.

1992 *Chorology of trees and shrubs in South-West Asia and adjacent regions*. Vol 9. Poznan, Daszewice : Sorus.

CAPPERS R. and BOTTEMA S. (eds)

2002 *The dawn of farming in the Near East*. Berlin : ex oriente (*SENEPSE* 6).

COLLEDGE S.

2001 *Plant exploitation on Epipalaeolithic and early Neolithic sites in the Levant*. Oxford. (*BAR Int. Ser.* 986)

CORDAIN L., BRAND MILLER J., BOYD EATON S., MANN N., HOLT S.H.A. and SPETH J.D.

2000 Plant-animal subsistence ratios and macronutrient energy estimations in worldwide hunter-gatherer diets. *American Journal of Clinical Nutrition* 71,3 : 682-692.

COULADIS M., ÖZCAN M., TZAKOU O. and AKGÜL A.

2003 Comparative essential oil composition of various parts of the terpentine tree (*Pistacia terebinthus* L.) growing wild in Turkey. *Journal of the Science of Food and Agriculture* 83 : 136-138.

DAMANIA A.B., VALKOUN J., WILLCOX G. and QUALSET C.O. (eds)

1998 *The origins of agriculture and crop domestication : the Harlan symposium*. Aleppo : ICARDA, International Plant Genetic Resources Institute.

DAVIS P.H.

1967 *Flora of Turkey and the East Aegean Islands*. Vol. 2. Edinburgh : Edinburgh University Press.

1982 *Flora of Turkey and the East Aegean Islands*. Vol. 7. Edinburgh : Edinburgh University Press.

DEBUSSCHE M., CORTEZ J. and RIMBAULT I.

1987 Variation in fleshy fruit composition in the Mediterranean region : the importance of ripening season, life-form, fruit type and geographical distribution. *Oikos* 49 : 244-252.

DÖNMEZ A.A.

1997 *Türkyie Pruneae* (Rosaceae) *tribusunun revizyonu*. Ankara : Doktora Tezi, Hacettepe Üniversitesi.

ERCIYES A.T., KARAOSMANOGLU F. and CIVELEKOGLU H.

1989 Fruit oils of four plant species of turkish origin. *Journal of the American Oil Chemists' Society* 66,10 : 1459-1464.

ERTUG F.

2004 Wild edible plants of the Bodrum Area (Muğla, Turkey). *Turkish Journal of Botany* 28 : 161-174.

ERTUG-YARAS F.

1997 *An ethnoarchaeological study of subsistence and plant gathering in central Anatolia.* Washington : PhD Washington University.

FAIRBAIRN A., ASOUTI E., NEAR J. and MARTINOLI D.

2002 Macro-botanical evidence for plant use at Neolithic Çatalhöyük, south-central Anatolia, Turkey. *Vegetation History and Archaeobotany* 11 : 41-54.

FRANKE W.

1997 *Nutzpflanzenkunde. Nutzbare Gewächse der gemässigten Breiten, Subtropen und Tropen*. Stuttgart : Georg Thieme.

HANSEN J.

1991 *The palaeoethnobotany of Franchthi Cave.* Vol 7. Bloomington, Indiana : Indiana University Press.

HARRIS D. (ed.)

1996 *The origins and spread of agriculture and pastoralism in Eurasia*. London : University College London.

HELBAEK H.

1970 The plant husbandry of Hacılar. *In* : MELLAART J. (ed.), *Excavations at Hacılar* : 189-247. Edinburgh : Edinburgh University Press.

HILLMAN G.C.

2000 Abu Hureyra I: The Epipalaeolithic. *In* : MOORE A.M.T., HILLMAN G.C. and LEGGE A.J. (eds), *Village on the Euphrates. From foraging to farming at Abu Hureyra* : 327-399. Oxford : Oxford University Press.

HOOPER D.

1937 *Useful plants and drugs of Iran and Irak.* Vol 9.3. Chicago : Field Museum of Natural History.

HOPF M. and BAR-YOSEF O.

1987 Plant remains from Hayonim cave, western Galilee. *Paléorient* 13,1 : 117-120.

JENIKE M.R.

2001 Nutritional ecology : diet, physical activity and body size. *In* : PANTER-BRICK C., LAYTON R.H. and ROWLEY-CONWY P. (eds), *Hunter-gatherers an interdisciplinary perspective* : 205-238. Cambridge : Cambridge University Press.

JONES D.A.

1998 Why are so many food plants cyanogenic ? *Phytochemistry* 47,2 : 155-162.

KARTAL M.

2003 Anatolian Epi-Palaeolithic period assemblages : problems, suggestions, evaluations and various approaches. *Anatolia* 24 : 45-61.

KARTAL M. and EREK C.M.

2002 The burials in Öküzini cave (SW Anatolia). *In* : YALÇINKAYA I., OTTE M., KOZLOWSKI J. et BAR-YOSEF O. (éd.), *La grotte d'Öküzini : évolution du Paléolithique final du sud-ouest de l'Anatolie* : 347-351. Liège : Université de Liège, Service de Préhistoire (*Eraul* 96).

KAYAN I., MINZONI-DEROCHE A. and YALÇINKAYA I.

1987 Prospection préhistorique dans la région d'Antalya. Notices préliminaires. *Anatolia Antiqua (Varia Anatolica)* 1 : 9-13.

KEELEY L.H.

1992 The use of plant foods among hunter-gatherers : a cross-cultural survey. *In* : ANDERSON P.C. (éd.), *Préhistoire de l'agriculture : nouvelles approches expérimentales et ethnographiques* : 29-38. Paris : CNRS.

KISLEV M.E., NADEL D. and CARMI I.

1992 Epipalaeolithic (19 000 BP) cereal and fruit diet at Ohalo II, Sea of Galilee, Israel. *Review of Palaeobotany and Palynology* 73 : 161-166.

KÖKTEN K.

1955 Ein allgemeiner Überblick über die prähistorischen Forschungen in Karain-Höhle bei Antalya. *Belleten* XIX : 271-293.

1958 Tarsus-Antalya arası sahil seriti üzerinde ve Antalya bölgesinde yapılan Trihöncesi arastırmaları. *Türk Arkeoloji Dergisi* VIII,2 : 10-16, X-XVII.

1961 Ein kurzer Bericht über dauernde Untersuchungen der Urgeschichte in Maraş und Antalya. *Türk Arkeoloji Dergisi* XI,1 : 40-44.

1963 Die Stellung von Karain innerhalb der türkischen Vorgeschichte. *Anatolia* VII : 58-86.

KUZUCUOGLU C., EMERY-BARBIER A., FONTUGNE M. and KUNESH S.

2002 The Öküzini marshes : a new Upper Pleistocene record on the anatolian mediterranean coast. *In* : YALCINKAYA I., OTTE M., KOZLOWSKI J.K. et BAR-YOSEF O. (éd.), *La grotte d'Öküzini : évolution du Paléolithique final du sud-ouest de l'Anatolie* : 79-82. Liège : Université de Liège, Service de Préhistoire (*Eraul* 96).

KUZUCUOGLU C. and ROBERTS N.

1998 Evolution de l'environnement en Anatolie de 20 000 à 6 000 BP. *Paléorient* 23,2 : 7-24.

LARSEN C.S.

2000 Determining what our ancestors ate. *In* : KIPLE K.F. and ORNELA K.C. (eds), *The Cambridge World History of Food* : 13-34. Cambridge : Cambridge University Press.

LEE R. and DEVORE I. (eds)

1968 *Man the hunter*. Chicago : Aldine.

LOPEZ BAYON I., LEOTARD J.-M. et KARTAL M.

2002 Séquence stratigraphique de la grotte d'Öküzini. Remplissage naturel et remplissage anthropique. *In* : YALÇINKAYA I., OTTE M., KOZLOWSKI J. et BAR-YOSEF O. (éd.), *La grotte d'Öküzini : évolution du Paléolithique final du sud-ouest de l'Anatolie* : 25-39. Liège : Université de Liège, Service de Préhistoire (*Eraul* 96).

MARTINOLI D.

2002 Les macrorestes botaniques de la grotte d'Öküzini. *In* : YALÇINKAYA I., OTTE M., KOZLOWSKI J. et BAR-YOSEF O. (éd.), *La grotte d'Öküzini : évolution du Paléolithique final du sud-ouest de l'Anatolie* : 91-94. Liège : Université de Liège, Service de Préhistoire (*Eraul* 96).

MARTINOLI D. and JACOMET S.

2004 Identifying endocarp remains and exploring their use at Epipalaeolithic Öküzini in southwest Anatolia, Turkey. *Vegetation History and Archaeobotany* 13 : 45-54.

MARTINOLI D. and NESBITT M.

2003 Plant stores at pottery Neolithic Höyücek, southwest Turkey. *Anatolian Studies* 53 : 17-32.

MASON S., HATHER J.G. and HILLMAN G.C.

2002 The archaeobotany of European hunter-gatherers : some preliminary investigations. *In* : MASON S.L.R. and HATHER J.G. (eds), *Hunter-Gatherer Archaeobotany. Perspectives from the northern temperate zone* : 188-196. London : Institute of Archaeology University College London.

MASON S.R.L.

1992 *Acorns in human subsistence*. London : PhD University College London.

MILLER N.F.

1988 Ratios in Paleoethnobotanical Analysis. *In* : HASTORF C.A. and POPPER V.S. (eds), *Current Paleoethnobotany* : 72-85. Chicago and London : The University of Chicago Press.

NADEL D., WEISS E., SIMCHONI O., TSATSKIN A., DANIN A. and KISLEV M.E.

2004 Stone Age hut in Israel yields world's oldest evidence of bedding. *Proceedings of the National Academy of Science* 101,17 : 6821-6826.

OTTE M., LOPEZ BAYON I., NOIRET P., BAR-YOSEF O., YALÇINKAYA I., KARTAL M., LÉOTARD J.-M. and PETTITT P.

2003 Sedimentary deposition rates and carbon-14 : the Epi-paleolithic sequence of Öküzini cave (southwest Turkey). *Journal of Archaeological Science* 30 : 325-341.

OTTE M., YALÇINKAYA I. et KOZLOWSKI J.K.

2002 Conclusions. *In* : YALÇINKAYA I., OTTE M., KOZLOWSKI J. et BAR-YOSEF O. (éd.), *La grotte d'Öküzini : évolution du Paléolithique final du sud-ouest de l'Anatolie* : 381-383. Liège : Université de Liège, Service de Préhistoire (*Eraul* 96).

ÖZDOGAN M. and GATSOV I.

1998 The aceramic Neolithic period in western Turkey and in the Aegean. *Anatolica* XXIV : 209-232.

PAWLIKOWSKY M.

2002 Ancient lake near Öküzini and Karain caves (southern Turkey). *In* : YALÇINKAYA I., OTTE M., KOZLOWSKI J. et BAR-YOSEF O. (éd.), *La grotte d'Öküzini : évolution du Paléolithique final du sud-ouest de l'Anatolie* : 75-77. Liège : Université de Liège, Service de Préhistoire (*Eraul* 96).

POPPER V.S.

1988 Selecting quantitative measurements in Paleoethnobotany. *In* : HASTORF C.A. and POPPER V.S. (eds), *Current Paleoethnobotany* : 53-71. Chicago : The University of Chicago Press.

ROSENBERG M., NESBITT R.M., REDDING R.W. and PEASNALL B.L.

1998 Hallan Çemi, pig husbandry, and post-Pleistocene adaptations along the Taurus-Zagros arc (Turkey). *Paléorient* 24,1 : 25-41.

SAVVIDES L.

2000 *Edible wild plants of the Cyprus flora*. Nicosia : Loucas Savvides.

SPETH J.D.

1991 Nutritional constraints and Late Glacial adaptative transformations : the importance of non-protein energy sources. *In* : BARTON N., ROBERTS A.J. and ROE D.A. (eds), *The late glacial in north-west Europe : Human adaptation and environmental change at the end of the Pleistocene* : 169-178. London : Council for British Archaeology.

TAY PROJECT. www.tayproject.org.

THIEBAULT S.

2002 Approche de l'environnement végétal du site d'Öküzini (Turquie) au Tardiglaciaire par l'analyse anthracologique. *In* : YALÇINKAYA I., OTTE M., KOZLOWSKI J. et BAR-YOSEF O. (éd.), *Öküzini : final paleolithic evolution in southwest Anatolia* : 95-99. Liège : Université de Liège, Service de Préhistoire (*Eraul* 96).

TOWNSEND C.C. and GUEST E.

1966 *Flora of Irak*. Vol 2. Bagdad : Ministry of Agriculture and Agrarian Reform.

1980 *Flora of Irak*. Vol 4. Bagdad : Ministry of Agriculture and Agrarian Reform.

VAN ZEIST W. and BAKKER-HEERES J.A.H.

1984/1986 Archeobotanical Studies in the Levant. 3. Late-Palaeolithic Mureybit. *Palaeohistoria* 26 : 171-199.

VAN ZEIST W. and BUITENHUIS H.

1983 A Palaeobotanical Study of Neolithic Erbaba, Turkey. *Anatolica* 10 : 49-89.

VAN ZEIST W. and ROLLER DE G.J.

1995 Plant remains from Asıklı Höyük, a pre-pottery Neolithic site in central Anatolia. *Vegetation History and Archaeobotany* 4 : 179-185.

WEISS E., WETTERSTROM W., NADEL D. and BAR-YOSEF O.

2004 The broad spectrum revisited : evidence from plant remains. *Proceedings of the National Academy of Science* 101,26 : 9551-9555.

WILSON D.G.

1984 The carbonisation of weed seeds and their representation in macrofossil assemblages. *In* : ZEIST VAN W. and CASPARIE W.A. (eds), *Plants and ancient man* : 201-206. Rotterdam : Balkema A A.

YALÇINKAYA I., LEOTARD J.M., KARTAL M., OTTE M., BAR-YOSEF O., CARMI I., GAUTIER A., GILOT E., GOLDBERG P., KOZLOWSKI J., LIEBERMAN D., LOPEZ-BAYON I., PAWLIKOWSKI M., THIEBAULT S.T., ANCION V., PATOU M., EMERY-BARBIER A. and BONJEAN D.

1995 Les occupations tardiglaciaires du site d'Oküzini (sud-ouest de la Turquie), résultats préliminaires. *L'Anthropologie* 99,4 : 562-583.

YALÇINKAYA I. et OTTE M.

2002 La grotte d'Öküzini : objets de pierre. *In* : YALÇINKAYA I., OTTE M., KOZLOWSKI J. et BAR-YOSEF O. (éd.), *La grotte d'Öküzini : évolution du Paléolithique final du sud-ouest de l'Anatolie* : 333-338. Liège : Université de Liège, Service de Préhistoire (*Eraul* 96).

YALÇINKAYA I., OTTE M., ATıCı A.L. et KÖSEM M.B.

2002a La grotte d'Öküzini : l'industrie osseuse. *In* : YALÇINKAYA I., OTTE M., KOZLOWSKI J. et BAR-YOSEF O. (éd.), *La grotte d'Öküzini : évolution du Paléolithique final du sud-ouest de l'Anatolie* : 277-283. Liège : Université de Liège, Service de Préhistoire (*Eraul* 96).

YALÇINKAYA I., OTTE M. et KÖSEM B.

2002b La grotte d'Öküzini : objets de parure. *In* : YALÇINKAYA I., OTTE M., KOZLOWSKI J. et BAR-YOSEF O. (éd.), *La grotte d'Öküzini : évolution du Paléolithique final du sud-ouest de l'Anatolie* : 333-338. Liège : Université de Liège, Service de Préhistoire (*Eraul* 96).

YALÇINKAYA I., OTTE M., KOZLOWSKI J. et BAR-YOSEF O. (eds)

2002c *La grotte d'Öküzini : évolution du Paléolithique final du sud-ouest de l'Anatolie*. Liège : Université de Liège, Service de Préhistoire (*Eraul* 96).

YALÇINKAYA I., OTTE M., TASKıRAN H., ÖZÇELIK K., ATıCı A.L., KÖSEM M.B., EREK C.M. and KARTAL M.

2000 1998 yili Karain kazısı. *Kazı Sonuçları Toplantısı* XXI,I : 15-28.

YOUSFI M., NEDJMI B., BELLAL R., BEN BERTAL D. and PALLA G.

2002 Fatty acids and sterols of *Pistacia atlantica* fruit oil. *Journal of the American Oil Chemists' Society* 79 : 1049-1050.

ZOHARY D.

1996 The genus *Pistacia*. *In* : PALUDOSI S., CARUSO T. and BARONE E. (eds), *Taxonomy, distribution, conservation and uses of Pistacia genetic resources. Report of a workshop, 29-30 June 1995, Palermo, Italy*. Rome : International Plant Genetic Resources Institute.

ZOHARY M.

1973 *Geobotanical Foundations of the Middle East*. Vol 1-2. Amsterdam : Swets and Zeitlinger.

3.3. Martinoli Danièle (submitted) “Reconstruction of local woodland vegetation and use of firewood at two Epipalaeolithic cave sites in southwest Anatolia (Turkey)”. In: Andrew Fairbairn and Ehud Weiss (eds). Hillman Festschrift, Oxbow Monographs.

RECONSTRUCTION OF LOCAL WOODLAND VEGETATION AND USE OF FIREWOOD AT TWO EPIPALAEOLITHIC CAVE SITES IN SOUTHWEST ANATOLIA (TURKEY)

Martinoli Danièle

SUMMARY

This paper presents a case study of palaeoenvironmental reconstruction using anthracological data. Charcoal assemblages from Öküzini and Karain B, two cave sites located in southwest Anatolia and occupied during the Epipalaeolithic (between 16500 uncalBP to 12200 uncalBP), were analysed. The diversity of fuel wood used was moderate and at both sites, *Acer* (maple), *Amygdalus* (wild almond) and *Fraxinus* (ash) were the most common and important taxa. Secondary taxa were composed of Maloideae, *Pyrus* (wild pear), *Prunus* (wild plum), *Quercus* (cadufoliate oak), and *Rhamnus*/*Phillyrea* (buckthorn/mock privet). No chronological changes were observed. The major difference between both caves was the presence of hygrophilous and mesophilous taxa in Öküzini, whereas Coniferous wood was more common in Karain B, leading to the interpretation of an opportunistic exploitation of the surroundings of each site. Despite the poverty of the Late Glacial vegetation, there was no indication of use of alternative fuel material. These Epipalaeolithic populations seem to have responded to shortages rather through mobility, small populations and/or little use of plant resources. The anthracological results have been integrated to present-day knowledge of the past environment of southwest Anatolia in an attempt to reconstruct the local vegetation.

Keywords: Turkey - Epipalaeolithic - Karain B – Öküzini – cave sites - charcoal analyses – fuel wood - site catchment area- vegetation history

1. INTRODUCTION

During the Late Glacial Maximum, a cold and arid climate under which precipitations were a limiting factor for the growing of trees covered most of Anatolia (Kuzucuoglu & Roberts, 1998). Even if excavations have an extremely unbalanced geographical distribution, the archaeological record points to the presence of small mobile foraging groups living in rock shelters and open camp sites (Kartal, 2003; Özdogan, 1998). The living conditions are thought to have been rigourous for human populations, with a temperature depression of 6 to 8°C between 18000 and 16000 BP (Van Zeist & Bottema, 1991). Archaeobotanical studies at such settlements are very rare, although they can shed some light on strongly related topics such as subsistence pattern, diet, site catchment area, mobility, use of firewood and palaeoenvironmental reconstruction. Previous analyses at the Epipalaeolithic cave sites of Öküzini and Karain B showed that nuts (wild almonds, wild pistachios, acorns) and fruits (wild pears, wild grapes), as well as underground plant storage organs, i.e. rather low labour demanding resources, played an important role among the food plants of these Late Glacial foragers, rather than labour expensive small seeds (Martinoli, in press-b; Martinoli & Jacomet, 2004). Archaeological evidences, at Öküzini at least, pointed to a transitory camp with seasonal occupation during summer and autumn (Atici & Stutz, 2002; Martinoli, in press-b). Use of the diet breadth model gave rise to the hypothesis that the plant subsistence base of these societies was probably related to a sufficiently good availability and abundance in the environment of high ranked plant resources (Martinoli, in press-a).

The aim of this paper is to propose a palaeoenvironmental reconstruction of the late Pleistocene local vegetation based on anthracological analysis, and incidentally to estimate the local vegetal resources available in the surroundings of the two Epipalaeolithic cave sites. Up to now, the plant collection from Öküzini and Karain B contain the only charcoals of Epipalaeolithic age in southwest Anatolia. Charcoals from domestic contexts provide a record of the human use of plants within a chronological framework. Identifications, completed with autecological interpretations, allow us to go beyond simply listing what was uncovered at a site: the method allows us to recreate the structure of the landscape and the availability of woodlands. In order to assess the relevance of the charcoal assemblages to represent former woodland vegetation, it is first necessary to estimate the taphonomic biases which influenced the composition of the charcoal assemblages, to explore the strategies used for collecting the fuel and finally to test the anthracological results against other available palaeoenvironmental data.

2. LOCATION AND SHORT DESCRIPTION OF THE ARCHAEOLOGICAL SITES

In the Mediterranean coastland of Anatolia, the Taurus mountain chains form an anticlinal system consisting of a series of folded arches frequently broken and much distorted. The smaller streams running in the southern part of this system have formed alluvial plains, the largest of which is the Antalya Plain. Climatically, the Mediterranean coastland is characterised by a mild winter, which is the rainy season, and a hot summer, the dry season. The mean annual maximum temperature in Antalya is 24°C, the mean minimum temperature 13,7°C, and the average annual rainfall 1,056mm (Zohary, 1973).

Öküzini and Karain B are natural caves located about 30km North of Antalya, in the foothills of the Taurus Mountains (Fig. 1). A significant set of natural geomorphologic conditions at the confluence between an extended and nearly flat travertine plain situated at about 300m (asl), bordered on the North and East by a mountain chain with summits reaching 2000m (asl) initially created an attractive location for Epipalaeolithic hunter-gatherers. The settlements were first identified and sounded by I. K. Kökten in the 1950's. A Turkish and Belgian team directed by I. Yalcinkaya conducted new excavations at Öküzini from 1989 to 2000 and at Karain B since 1990 (Yalçinkaya *et al.*, 2002; Yalçinkaya *et al.*, 1996; Yalçinkaya *et al.*, 2000).

Present-day and historic records enable a reconstruction of the potential vegetation under similar climatic conditions. The natural forest region in the coastal area goes from sea level to 2000 m and even higher (Louis, 1939), varying in composition according to altitudinal zonation, but also edaphic factors and local climatic conditions. The natural forest zones are at present often highly degraded, sparsely wooded and almost unrecognisable. However, evidences for more densely forested areas can be found in the reports of antique authors or even in the notes of field botanists of the past 200 years (see (Mayer & Akso, 1986).

From sea level to 300 m, a zone composed of xerophytic elements expends, with the evergreen *Quercus coccifera/calliprinos*, *Olea europaea, Calycotome villosa, Spartium junceum, Erica verticillata* and deciduous *Pistacia palaestina* as characteristic species (Bottema, 1991; Zohary, 1973). Alternating with this shrubbery are stands of *Pinus brutia*, sometimes with undergrowth of typical maquis. Also found in this area and throughout the broad, intensively cultivated plain of Antalya are single specimens or small stands of *Quercus cerris*, *Q. boissieri*, *Pyrus boissieri* and *Pistacia atlantica*, often preserved in graveyards. In the Eu-Mediterranean zone of the lower mountains (from 300-800 m), two plant associations of the evergreen maquis (Ceratonieto-Pistacietum lentisci and Quercus calliprinos-Pistacia palaestina association) merge together (Zohary, 1973). At about 800 m, the typical maquis is sometimes associated with *Pinus brutia* or *Quercus cerris,* and from 800-1000 m, Juniperetum execelsae occurs, especially on the northern slopes, mixed with specimens of *Quercus calliprinos* and *Pistacia palaestina*. *Pinus nigra, Cedrus libani*, *Abies cilicica* and *Juniperus excelsa* occur at an altitude of about 1500 m. The northern slopes meet the inner Anatolian steppe-forest or steppe quite abruptly.

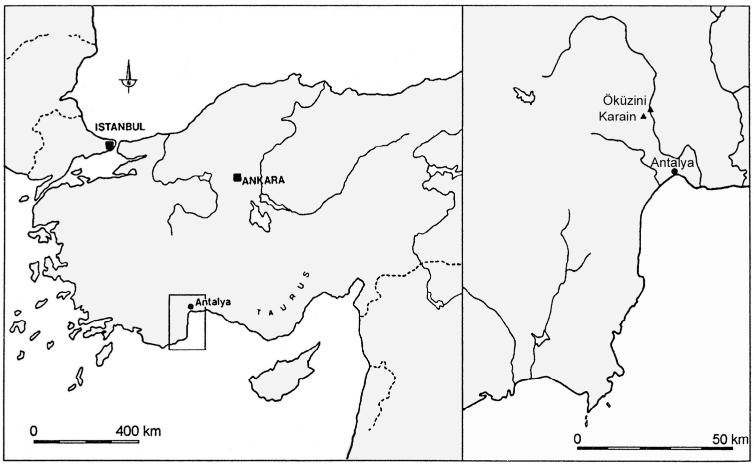


Figure 1. Location map for Öküzini and Karain B

Öküzini cave is situated just 5m above a large plain, in a small bay (Fig. 2). The excavation work was conducted in the main chamber first in "cleaning" the two main profiles bordering the Kökten sondage, then by digging deeper until the bedrock was reached. Additionally, the excavation surface was enlarged westward uncovering several Neolithic and Chalcolithic burials (Lopez Bayon, Léotard & Kartal, 2002; Otte *et al.*, 2003) From the base to the summit of the sequence, all strata contained numerous anthropogenic components like hearths and superimposed burnt deposits. At least four Epipalaeolithic phases of occupation (called archaeological units AU and defined typologically) were identified, which comprised 17 sedimentation levels (called geological horizons GH), and covered a sequence radiocarbon dated from 16500 uncalBP to 12100 uncalBP (18200 calBC to 11800 calBC) (Table 1). Systematic 14C dating of the sequence evidenced several sedimentation gaps (due to episodes of erosion and absence of sedimentation), the first ones at about 17000 calBC (between AUI and AUII) and at 15000 to 14000 calBC (between AUII and AUIII). On top, there were evidences of Pottery Neolithic and Chalcolithic occupations, including burial pits.

Figure 2. Photograph of Öküzini cave

Karain B (Fig. 3) is one chamber of the complex Karain cave, which lies at about 150m above the plain. It showed traces of Upper Palaeolithic and Epipalaeolithic occupation, covered with mixed Pottery Neolithic, Chalcolithic and Early Bronze Age deposits. Again, the excavation started with "cleaning" Kökten's sondage, and then extending the excavation area in the back part of the cave. Two Epipalaeolithic layers (PI.1 and PI.2) comprised numerous anthropogenic components (bones, stone artefacts and charcoals) and also a small hearth-like structure. PI.2 (bone-rich layer) was attributed to the older Epipalaeolithic and was dated between 16340±70 and 16210±80 uncalBP (ca.17900 to 17000 calBC), whereas PI.1 was attributed to the younger Epipalaeolithic and dated between 16430±80 and 15900±70 uncal BP (ca. 17800 and 16600 calBC) (pers. communication L. Atıcı).

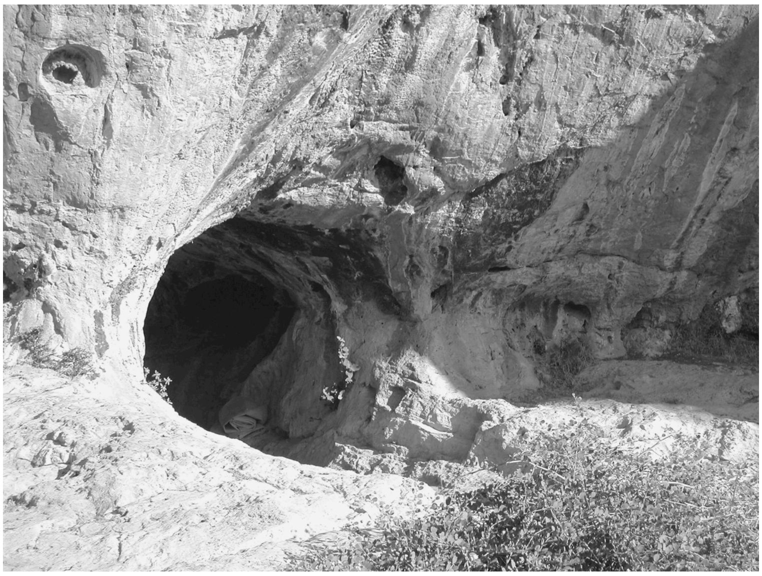


Figure 3. Photograph of Karain B cave

3. MATERIAL AND METHODS

The excavation system used in Öküzini involved taking arbitrary 10cm thick horizontal spits (called archaeological horizons AH) over 50x50cm squares. A similar method was employed in Karain B, but a larger grid-square was used (1x1m). All sediments in both caves were systematically processed with simple bucket flotation during the excavation for recovery of plant macro remains (Martinoli, 2002; Martinoli, in press-b). The organic fraction was collected on a 0.5mm sieve, dried and stored for later analyses. A consequence of the excavation strategy was that the samples taken were not related to context excavated. Despite the horizontality of the layers in the lower part of both caves, some spits were inevitably overlapping two GHs and therefore could be mixed. Since 2000, the GHs were taken separately when more than one was present in a spit, leading to a more precise sampling. The flotation samples (corresponding to the AH over one square), which were composed of two GHs, were *a posterori* omitted from the analyses, as well as the samples, which contained no charcoals larger than 2mm. After selection of the samples assigned to anthracological analyses, the flots were dry-sieved in the laboratory through a 2mm sieve.

Archaeological units (AU)	Datations	Geological horizons (GH)	Surface sampled (m^2)	Volume of floated sediments (maximum approximation	Number of samples (AH/1 square)	Number of charcoals analysed
Öküzini						
IV (GHVIa-II)	12.260±90 uncalBP (12.450-12.100 calBC) to 12.130±130 uncalBP (12.400-11.800 calBC)	II	(see Thiébault 1998, 2002)			
		III				
		III/IV				
		IV				
		V				
		V/VI				
		VIa				
III (GHVI/VII-VIab)	14.200±130 uncalBP (15.400-14.750 calBC) to 12.390±110 uncalBP (12.550-12.150 calBC to 13.100-12.600 calBC)	VIa/IVb				
		VIb				
		VI/VII				
II (GHIX-VII)	15460±160 uncal BP (16900-16150 calBC) to 14610±150 uncalBP (15850-15200 calBC)	VII	12	525	21	826
		VII/VIII				
		VIII	4	150	6	162
		IX	2	50	2	196
Total			18	725	29	1184
I (GHXII-X)	16560-16400 uncalBP (18200-17200 calBC)	X	5	125	5	315
		XI	5	150	6	446
		XII	2	100	4	181
Total			12	375	15	942
Karain B						
	16400-15900 uncal BP (17800-17300 calBC)	Pl.1	7	1400	14	1822
	16300-16200 uncalBP (17900-17600 cal BC)	Pl.2	5	900	9	1207
Total			12	2300	23	3029

Table 1. Summary of the archaeological sequence and the samples collected in Öküzini and Karain B (for the upper part of the sequence from Öküzini, see Thiébault 1998, 2002).

In Öküzini cave, charcoal analysis was performed on samples belonging to the lower Epipalaeolithic (AU I and II, from GH XII to VII) (Table 1), the upper phases having already been analysed by S. Thiébault (Thiébault, 1998; Thiébault, 2002). 29 samples, corresponding to an estimate of 1050l of unprocessed sediments, were entirely analysed and contained between 2 and 141 fragments each, or between 162 and 826 fragments when the charcoals from the same GH were put together (Table 1). In all, 2126 charcoals were analysed.

As samples rich in charcoals were more numerous in Karain B, we made a selection in order to examine at least two samples per square and per geological horizon (Table 1). The 23 samples analysed corresponded to a total of approximately 2300l of unprocessed sediments. Most of them contained large numbers of charcoals and were subsampled with the aid of a geological sample splitter (riffle-box) in order to optimise the analysis. Subsample size was determined according to the taxa composition: the analyses lasted until taxa composition was stable and no « additional» species was identified. Subsamples between 50% and 3.12% of the original samples were examined and all size classes of charcoal fragments larger than 2mm were analysed. Between 100 and 200 charcoals per subsample were necessary to reach a stable composition. In principle, a number of 100 fragments are considered as the minimum requirement for obtaining a satisfactory assessment of sample composition (Asouti & Hather, 2001), but 250 to 400 fragments are considered as optimal (Chabal, 1992). This number is depending on the relative frequency of the taxa (diversity). All subsamples counted together, 3029 pieces of charcoals were analysed.

The charcoals were fractured to expose fresh surfaces in the transverse, tangential and radial planes. These were supported in sand and examined using a Leitz Laborlux 12 ME incident light microscope at a magnification of up to 500X and the anatomical structures were compared to wood atlases (Fahn, Werker & Baas, 1986; Schoch *et al.*, 2004; Schweingruber, 1990a; Schweingruber, 1990b). Analyses of the diameters of the woods were not performed due to the small size of the fragments recovered. Note that the Anatolian flora is very diverse and relatively poorly known. This is reflected in the use of type or genus level identifications below. Nomenclature follows Davis (Davis, 1965-1985).

4. RESULTS

4.1. IDENTIFICATION AND PRESENCE OF TAXA (OCCURRENCE)

The Öküzini assemblages comprised a total of 14 different taxa (between 7 and 9 per GH), whereas in Karain B, 9 taxa were present (Table 3). Particular anatomical features observed are described here in reviewing the charcoal finds in decreasing order of importance. On the base of ray width, *Acer platanoides* and *A. pseudoplatanus* can be ruled out for the identification of the most common *Acer* type present (rays 3-5 cells wide). Curl wood was regularly observed. Some much less common specimens had larger or narrower rays (4 to 6 cells wide and 2 to 3 cells wide) and may correspond to another species. *Amygdalus* (almond) charcoals could be differentiated from akin *Prunus* (plum) species on the base of their ring-porous wood, but a more precise identification was not possible. When fragments were small or badly preserved, but still owned the typical features common to the Prunoideae, they were identified to subfamily level. According to the absence of tangential parenchyma bands in *Fraxinus* (ash) specimens, the charcoals belong rather to *F. excelsior* than to *F. angustifolia* or *F. ornus* (Schweingruber, 1990a). Some of them displayed curl wood or fungal hyphae. Identifications as Maloideae could in some cases be brought down to *Pyrus*-type, which groups the genus *Pyrus* (pear), *Malus* (apple), *Crataegus* (hawthorn) and *Cydonia* (quince). No attempt was made to differentiate between the numerous (22) *Rhamnus* (buckthorn) species and the akin *Phillyrea latifolia* (mock privet). The charcoals indentified as *Prunus* fit the descriptions of *P. avium* and *P. cerasus* (Schweingruber, 1990a). However, with the highly diversified and closely related genus *Prunus* and *Cerasus* (Davis, 1965-1985), caution is uttered with species identification level. The oak wood could, when the fragments were big enough, be attributed to caducifoliate species on hand of their ring-porous wood. One piece of charcoal was thought to belong to *Pistacia* (wild pistachio) but was badly preserved. The charcoals identified as *Olea* (wild olive)*,* *Salix* (willow) and *Tamarix* (tamarisk) exhibit the typical features of each genus. All coniferous wood fragments were compressed wood (they showed helicoidal fissures in the wall structure) and small, the anatomical features were therefore very difficult to recognise. In some of them, the possible presence of resin ducts could point to *Pinus* sp., but we preferred to leave the identifications to Coniferae. *Confer* (cf) was used when the features observed did not allow secure identification; *indeterminata* for charcoals with bad preservation (incrusted with calcareous concretions, with cells more or less fused together or very brittle structure). Most *indeterminata* belonged to Dicotyledonous species.

For the calculation of ubiquity scores (number of samples in which a taxon was present over the total number of samples), the samples needed to be discontinuous, i.e. not adjacent, therefore the AHs from a same square and same GH were merged. Although the presence scores for GH XII to VIII in Öküzini are not very informative because of the small number of samples (Table 2), the commonest taxa in all horizons were clearly *Acer* (100 %), *Amygdalus* (between 100 – 50 %) and *Fraxinus* (between 100 – 63 %). Maloideae and *Rhamnus/Phillyrea* were regularly recorded throughout the sequence but with smaller scores. *Prunus* and *Quercus* were less common, but still present in each horizon from GH XI to VII. Several taxa were sporadically present like *Acer* (R 2-3), cf *Pistacia*, *Olea* and *Salix*. It is worth noting that *Tamarix* and Coniferae gave a single fragment each. In Karain B, *Acer* (presence score 100%), *Amygdalus* (100%) and *Fraxinus* (100%) were clearly the most common taxa. Maloideae and Coniferae were quiet common, the first especiall in PI.2 (100%), the latter in PI.1 (100%). *Acer* (R 4-5-6), *Prunus*, *Quercus* and *Rhamnus*/*Phillyrea* were regularly present with smaller scores.

	Number of samples in which taxa were present								% presence scores							
	Öküzini						**Karain B**		**Öküzini**						**Karain B**	
Geological horizons	XII	XI	X	IX	VIII	VII	PI.2	PI.1	XII	XI	X	IX	VIII	VII	PI.2	PI.1
Acer (R 2-3) (maple)	1								50							
Acer (R 3-4(5)) (maple)	2	5	5	2	4	16	4	6	100	100	100	100	100	100	100	100
Acer (R 4-5-6)							1	2							25	33
cf Acer (maple)	1	3	1					1	50	60	20					17
Amygdalus (almond)	2	4	5	2	4	8	4	6	100	80	100	100	100	50	100	100
cf Amygdalus (almond)		2	1		1	1				40	20		25	6		
Prunoideae	2	1	1			1	4	6	100	20	20			6	100	100
Fraxinus (ash)	2	5	5	2	3	10	4	6	100	100	100	100	75	63	100	100
cf Fraxinus (ash)		1				1		1		20				6		17
Prunus (wild plum)		2	2	2	1	2	1	1		40	40	100	25	13	25	17
Maloideae Pyrus-type (hawthorn/pear)	1	2			1	4	4	3	50	40			25	25	100	50
Maloideae sp.	1	3	2	1	1	5		1	50	60	40	50	25	31		17
Quercus caducifoliate (caducifoliate oak)	1	2			1	2	1	3	50	40			25	13	25	50
Quercus sp. (oak)		1		1		2		2		20		50		13		33
cf Quercus (oak)		1	1			1				20	20			6		
cf Pistacia (terebinth)				1								50				
Rhamnus/Phyllirea (buckthorn/mock privet)	1	3	3	1	1	4	1	3	50	60	60	50	25	25	25	50
cf Rhamnus/Phyllirea							1								25	
Olea (olive tree)		1	1			1				20	20			6		
Salix (willow)						2								13		
Tamarix (tamarisk)					1								25			
Total Coniferae (coniferous wood)		1					1	6		20					25	100
Total number of samples	2	5	5	2	4	16	4	6	100	100	100	100	100	100	100	100

AHs from same square and same GH were considered as belonging to the same sample

Table 2. Absolute count and percentage presence scores of taxa occuring in all horizons in Öküzini and Karain B.

4.2. ANTHRACOLOGICAL DIAGRAMS

In order to give a clearer picture of the fluctuations in the abundances of individual taxa, percentage fragment counts were calculated after excluding the indeterminates from the sums (Table 3). In all levels in Öküzini, it was clearly visible from the anthracological diagrams (Table 3 and Fig. 4) that the most abundant taxa were *Acer*, followed by *Amygdalus* and *Fraxinus*. These 3 taxa amply dominate the charcoal assemblages with average percentages of 91.9% (between 89.4% in GHXII and 95.1% in GH IX). Rare were the secondary taxa with scores exceeding even 2% (only *Prunus*, Maloideae and *Pyrus*). There was no obvious chronological change in the abundances of the main and secondary taxa.

In Karain B, the dominance of the 3 taxa *Acer*, *Amygdalus* and *Fraxinus* was even stronger, reaching 97.3% in PI.2 and 93.2% in PI.1 (Table 3 and Fig.5). The secondary taxa reaching 2% were different from those in Öküzini (Prunoideae and Coniferae, both in PI.1). The only chronological change in Karain B was the greater importance of the coniferous wood in PI.1.

	Absolute fragment counts								% fragment counts							
	Öküzini						**Karain B**		**Öküzini**						**Karain B**	
Geological horizons	XII	XI	X	IX	VIII	VII	PI.2	PI.1	XII	XI	X	IX	VIII	VII	PI.2	PI.1
Acer (R 2-3) (maple)	1								0.7							
Acer (R 3-4(5)) (maple)	96	216	156	87	93	463	595	870	63.6	63.3	64.2	60.4	63.3	67.4	53.2	51.8
Acer (R 4-5-6)							3	4							0.3	0.2
cf Acer (maple)	1	2	1					1	0.7	0.6	0.4					0.1
Amygdalus (almond)	10	52	38	32	30	124	128	300	6.6	15.2	15.6	22.2	20.4	18.0	11.4	17.9
cf Amygdalus (almond)		4	1		1	3				1.2	0.4		0.7	0.4		
Prunoideae	8	2	4			1	10	42	5.3	0.6	1.6			0.1	0.9	2.5
Fraxinus (ash)	29	41	26	18	16	39	366	406	19.2	12.0	10.7	12.5	10.9	5.7	32.7	24.2
cf Fraxinus (ash)						1		1						0.1		0.1
Prunus (wild plum)		2	9	2	1	2	2	1		0.6	3.7	1.4	0.7	0.3	0.2	0.1
Maloideae Pyrus-type (hawthorn/pear)	1	4			1	14	8	6	0.7	1.2			0.7	2.0	0.7	0.4
Maloideae sp.	3	9	3	1	2	14		1	2.0	2.6	1.2	0.7	1.4	2.0		0.1
Quercus caducifoliate (caducifoliate oak)	1	2			1	5	1	8	0.7	0.6			0.7	0.7	0.1	0.5
Quercus sp. (oak)		1		1		3		2		0.3		0.7		0.4		0.1
cf Quercus (oak)		1	1			1				0.3	0.4			0.1		
cf Pistacia (terebinth)				1								0.7				
Rhamnus/Phyllirea (buckthorn/mock privet)	1	3	3	2	1	8	1	3	0.7	0.9	1.2	1.4	0.7	1.2	0.1	0.2
cf Rhamnus/Phyllirea							1								0.1	
Olea (olive tree)		1	1			1				0.3	0.4			0.1		
Salix (willow)						8								1.2		
Tamarix (tamarisk)					1								0.7			
Total Coniferae (coniferous wood)		1					3	34		0.3					0.3	2.0
Indeterminata (Dicotyledonous)	30	105	72	52	15	139	51	126	19.87	30.79	29.63	36.11	10.2	20.23	4.562	7.504
Total	181	446	315	196	162	826	1169	1805	119.9	130.8	129.6	136.1	110.2	120.2	104.6	107.5
Total (- indet)	151	341	243	144	147	687	1118	1679	100	100	100	100	100	100	100	100
Diversity	7	9	8	8	8	9	9	9								
% of indets	16.57	23.54	22.86	26.53	9.26	16.83	4.36	6.98								

Table 3. Summary of the absolute counts and percentages of the taxa identified with the charcoals from Öküzini and Karain B and rates of *indeterminata*.

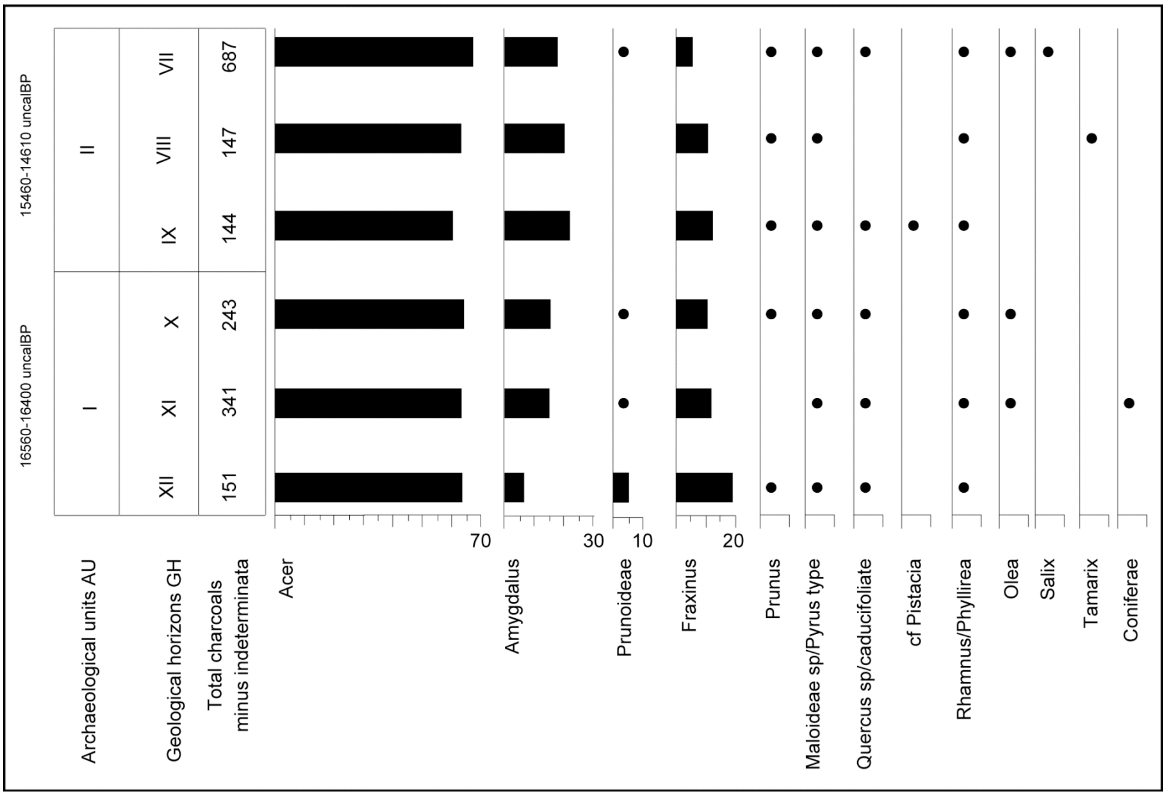


Figure 4. Öküzini: anthracological diagram (percentages of a taxa were calculated after excluding indeterminate fragments from the sums) For ease of lisibility cf *Amygdalus*, cf *Acer*, *Acer* (R 2-3) and cf *Fraxinus* were omited from the diagram. Maloideae sp. and *Pyrus* type, *Quercus* sp. and *Quercus* caducifoliate have been put together. ● ≤ 5%.

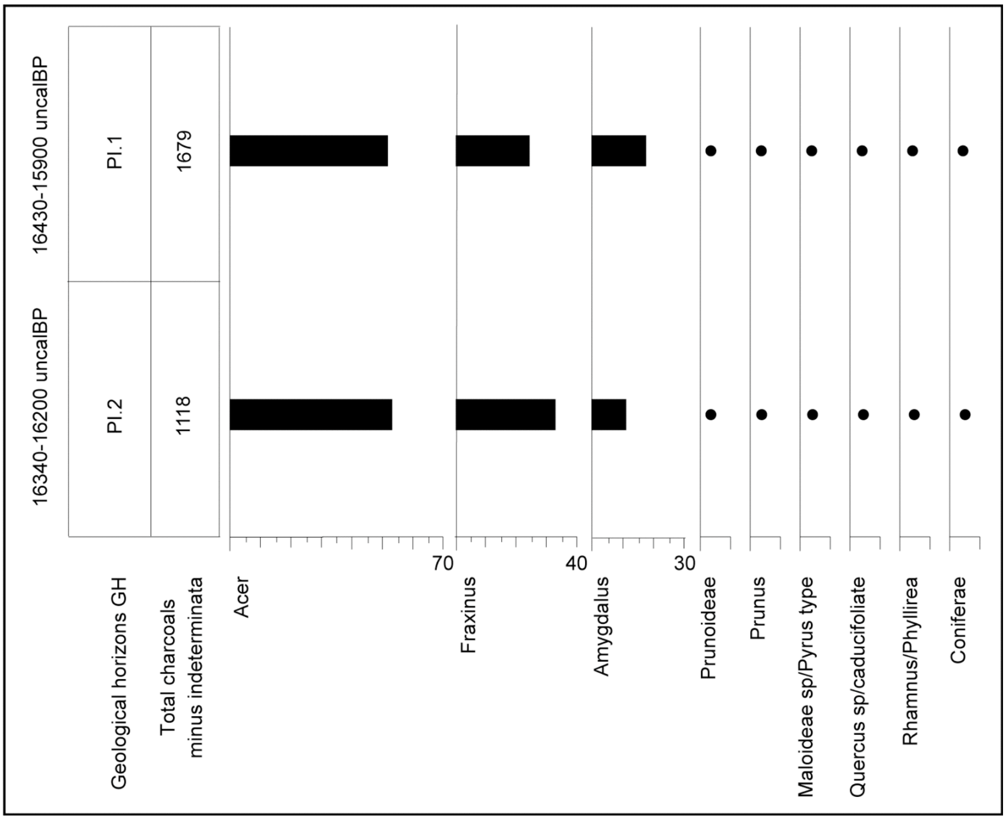


Figure 5. Karain B: anthracological diagram (percentages of a taxa were calculated after excluding indeterminate fragments from the sums). ● ≤ 5%.

4.3. TAPHONOMY

Taphonomic factors can influence the original composition of the charcoal assemblages and have incidences on their usefulness to assess palaeoenvironmental recontructions. Three measurements help to understand the taphonomic history: density, percentage of *indeterminata* and diversity (Asouti, 2003). Despite the absence of exact measurements of the volumes sampled during excavation, the charcoal densities were clearly lower in Öküzini than in Karain B (in all samples and all horizons). The percentage of indeterminate fragments among the >2mm analysed charcoals, an index which is thought to reflect overall preservation status (preservation and fragmentation) of entire charcoal assemblages, was calculated for each geological horizon. In Öküzini, this ratio varied between the geological horizons from 16 to 26 %, with a lower value in level VIII (9 %). In Karain B, the preservation index was lower (7 and 4 %), what was reflected by an overall better preservation and higher proportion of large pieces than in the material from Öküzini. The diversity (minimal estimate of number of taxa present; Table 3) was quiet constant throughout the Öküzini sequence (between 7 and 9, average 8.2). In Karain B, the diversity reached 9 taxa in both horizons.

5. DISCUSSION

5.1. TAPHONOMIC HISTORY AND REPRESENTATIVITY OF THE CHARCOAL ASSEMBLAGES

The charcoals uncovered in both caves were scattered through the layers and represent therefore the remains of fuel use originating from several burning episodes over a rather long time span, which is a prerequisite to a good representativity of the wood procurement area (Chabal, 1992). The excavation of distinct activity zones could tentatively explain differences in densities and preservation indices between the charcoal assemblages in both caves. In Öküzini, the location of the deep sondage in the centre of the cave, where traces of fireplaces were uncovered, corresponded probably to the place where major living activities of the camp took place. Regular cleaning of the fireplaces, camp maintenance activities, intense trampling as well as the important weight of the overlaying sediments (the bedrock was 5 m under the present cave floor) could influence the deposition and preservation of the charcoals. In Karain B on the other hand, the samples originated from the back of the cave, a zone probably on the edge of the activity areas, and often used as refuse areas (O'Connell, Hawkes & Blurton-Jones, 1991). This zone was probably less affected by trampling and the amount of overlaying sediment was not as important as in Öküzini. This reflects overall bader preservation conditions in Öküzini.

Besides taphonomic factors, sampling can affect the representativity of the charcoal assemblages. In Öküzini, despite the analysis of the total number of charcoals available, the number of pieces in each sample was too small to reach a stable composition. If the ratios of the most common types can still bare some informations, the total range of taxa that occur at the site is certainly incomplete. The situation was better in Karain B, where charcoals from each subsample could be identified until its composition was stable and no new species recorded. However, it is worth noting that despite this difference, the charcoal assemblage from Öküzini was more diverse than that from Karain B independent from the representativity of the sampling.

5.2. PATTERNS OF USE OF FIREWOOD

Archaeological wood assemblages may be affected by deliberate selection of preferential species, altering their palaeoecological signature. Despite differences in the taphonomic histories and degree of representativity discussed above, all 9 horizons from Öküzini and Karain B gave almost identical charcoal assemblages in terms of their taxonomic composition and relative proportions of individual taxa, especially for the dominant ones. The composition of the charcoal assemblages from Öküzini GH XII to VII was similar to that observed from GH VII to IV, although in the latter *Amygdalus* was the dominant taxon and the diversity was slightly higher (Thiébault, 2002). The coherence between the charcoal assemblages from all levels and both sites suggests that broadly the same range of firewood species was exploited at both sites throughout the Epipalaeolithic and that it probably reflects the availability within the site catchment area, respectively the local vegetation. However, differences appear between the caves when composition of the secondary taxa are considered. This can partly be attributed to the different representativity of the assemblages, but reflects more probably differences in taxa composition of the procurement areas. The coniferous species regularly present in Karain B were better adapted to dry and cold climatic conditions (and therefore to higher altitudes and rocky soils) than the species uncovered in Öküzini, particularly the mesophilous species *Olea*. This might reflect distinct fuel procurement areas: the Öküzini inhabitants collected their fuel at the foothills and lower zones of the mountains, whereas those from Karain B gathered wood on the mountain flanks, i.e. from the nearest and most abundant resources in an opportunistic manner. This also coincides with the prevalence in the archaeozoological assemblages from Öküzini of sheep, goats, fallow deer, fish and bird remains, which point to principal use of the plain and lower mountains, whereas at Karain B, the dominance of sheep and goat indicate a preference for montane resources (Lopez Bayon, Léotard & Kartal, 2002). The use of *Amygdalus*, *Pyrus* and *Quercus* wood could correspond to an optimizing strategy, these taxa offering also interesting food resources (Martinoli, in press-b).

Based on the very high density of animal remains, a specialised use of Karain B cave as butchery for example could not be excluded (pers. communication L. Atici). The charcoal assemblage did not reveal a particular taxa composition, but, as stated by Théry-Parisot (Théry-Parisot, 2001), all combustion qualities can be met in all species, depending on the size of the logs, their water content and degradation state. The use of wood for a specific activity is therefore not necessarily linked to taxonomic composition and a specialised activity at Karain B cannot be excluded. The locally varying conditions might have led to different activities at the two sites or different seasons of occupation.

When we compare the taxonomic composition of the charcoal assemblages to the closest pollen data, although younger in date (14190± 65 uncalBP) (Kuzucuoglu *et al.*, 2002), we can see that the main arboreal species were juniper (*Juniperus*), caducifoliate oak (*Quercus*) and ash (*Fraxinus*). We can notice that *Pinus* was also detected in small amount among the arboreal pollen, athough it can come from distant trees, plus *Artemisia* and Chenopodiaceae, Cichoriaceae, Poaceae and semi-aquatic plants (very little aquatic plants). The proportion of non-arboreal pollen compared to arboreal pollen was high. This discordance between anthracological and palynological data can be explained through the presence among the charcoals of many insect-pollinated species (*Amygdalus*, Maloideae, *Acer*), whose visibility in the pollen sequences is very limited, whereas small sized woods and herbaceous plants have less preservation chances or were not used as fuel and were therefore not preserved as charcoals. Overall, the Epipalaeolithic populations of Öküzini and Karain B seem to have exploited the available wood resources, preferentially trees and shrubs. There were no traces of fuel shortage, such as the burning of faeces, bones or dwarf shrubs.

5.3. RECONSTRUCTION OF LOCAL ENVIRONMENT AND VEGETATION

The topography of the area would not have been radically different during the end of the Pleistocene. Information on the vegetation at around 16000 uncalBP in Anatolia is not abundant and suffers from discontinuous pollen sequences, poor pollen preservation and inadequate chronological resolution. Another problem with pollen data are the possibility of long distance contaminations and differences in pollen production rates between plants, leading to a distorted perception of the vegetation. However, pollen analyses provide a record of the arboreal as well as the herbaceous vegetation. The only data for the Mediterranean coast is provided by the profile from the Öküzini marshes (Kuzucuoglu *et al.*, 2002), later in date. The large intramontane part is hardly better known, but the Full Glacial (20000-14000 BP) appears at Sögüt, Karamik, Beysehir II and Pinarbasi (approximate distance to the caves: 100 km) and showed a mostly treeless landscape, with a dominance of steppic elements like *Artemisia*, Chenopodiaceae, Plumbaginaceae, Compositae and *Ephedra* (Bottema & Woldring, 1984; Kuzucuoglu & Roberts, 1998; Van Zeist, Woldring & Stapert, 1975). The scarcity of trees was primarily ascribed to a dry climate, which was also much colder than at present. In southwest and southcentral Anatolia, although the general conditions were not favourable to their growth, trees have succeeded to survive in some favourable habitats (Kuzucuoglu & Roberts, 1998) and it is assumed that they started to expand after ca. 14000 BP, when conditions became wetter and warmer.

At around 16000 uncalBP, the plain was presumably a dry area colonised by *Artemisia* and Chenopodiaceae dwarf shrubs and grasses. Due to the karstic nature of the mountains, water was probably available at the base of the mountains or in streams crossing the plain. *Salix* and *Tamarix* are indicators of a hydrophytic vegetation and were confined to banks of streams and rivulets. The *Vitis* fruits and seeds also uncovered in the early Epipalaeolithic layers (Martinoli, in press-b) would also have grown in this type of biotope. Only the foothills and protected valleys would have represented favourable conditions for mesophilous taxa like the olive tree (*Olea*), a typical Mediterranean species, which does not stand long periods of frost. The genus *Fraxinus* groups trees growing in deciduous or mixed scrubs or forests and streamsides (Davis, 1965-1985) and could either belong to the hydrophytic vegetation or climb along the mountain flanks. The karstic mountain slopes represented probably dry and harsh environments. *Acer*, caducifoliate *Quercus*, *Amygdalus* and *Fraxinus* in some proportion, would have been the main woody taxa colonising the lower mountain flanks, mingled with Maloideae sp., *Pyrus* and *Pistacia* trees, and bushes like *Rhamnus* or *Phillyrea*. The numerous *Acer* species growing in Anatolia today are usually trees or shrubs present in mixed forests, deciduous oak scrubs or rocky slopes or scree slopes in gorges. None of the species are leading in plant communities, but most are important associates in various deciduous forests, and some are found at the outer rim of the Anatolian steppe land (Zohary, 1973). The identification of the species could be reduced to 2 species with the analysis of the endocarp remains, *A. graeca* or *A. orientalis* (Martinoli & Jacomet, 2004), deciduous shrubs or small trees which grow today on limestone rocks in phrygana from 10 to 500 m, respectively on rocky calcareous slopes from 600 to 1500 m. The latter are common today in the steppe-forest of inner Anatolia, where it sometimes covers large sketches as a dominant. The coniferous trees, more resistant to harsh climatic conditions, settled probably on rocky outcrops on the mountain slopes, extending to the higher zones. The presence of tension wood in most of the coniferous charcoals, frequent in compression wood resulting from mechanical stress, fits well with their probable location. Overall, all species are light demanding and therefore constituted a very open vegetation.

No major temporal changes were registered in taxonomic charcoal composition between ca. 16500 and 14500 uncalBP, therefore seemingly little pressure was exerted by the hunter-gatherers on the local vegetation. Major changes in the vegetation appeared only from level GH III with a decrease of *Amygdalus* charcoals and an increase of caducifoliate *Quercus* and *Fraxinus*, and was attributed to environmental changes (Thiébault, 2002).

6. CONCLUSION

A priori, Late Glacial environments featured difficult living conditions all over Anatolia. In Öküzini and Karain B, fuel wood was gathered in an opportunistic manner, but apparently only “valuable” resources were used. The wood gathered for fuel could be collected in the surroundings of the sites, and the same taxa were sometimes exploited for their nuts or fruits. The results of the macro botanical analyses are coherent with the exploitation of high ranked food plants. Therefore, it seems that even in such an environment, the populations did not suffer from scarcity, or at least did not respond in exploiting less valuable and more labour demanding resources. The notion of abundance and scarcity of plant resources should be used with caution, as it is related to the duration of an occupation and a group’s needs of energy. Even in a poor environment, small and mobile groups can find plenty of resources. The charcoal remains from Öküzini and Karain B provide us with valuable cultural data and, especially when these are integrated, make a remarkable contribution to our limited understanding of Epipalaeolithic living conditions.

ACKNOWLEDGEMENTS

This study benefited from the financial support of the Swiss National Science Foundation (project number 1214-64974.01 and 101312-101585/1). We want to thank both excavation directors I. Yalçınkaya and M. Otte for letting us study the plant material, S. Jacomet for the supervision and A. Schlumbaum, S. Thiébault, A. Dufraisse und W. Schoch for their invaluable help for the identification of the wood charcoals. I would also like to mention all the persons who encouraged me for the pursuit of this study, in particular my colleagues from the IPNA, University of Basel, but also the co-chairs and participants to the panel « Ethnobotanist of distant past : in honour of Gordon Hillman » organised at the 9th International Congress of Ethnobiology and 45th Annual Meeting of the Society for Economic Botany at the University of Kent at Canterbury in 2004.

BIBLIOGRAPHY

Asouti, E. 2003. Woodland vegetation and fuel exploitation at the prehistoric campsite of Pinarbasi, south-central Anatolia, Turkey: the evidence from the wood charcoal macro-remains. *Journal of Archaeological Science* 30, 1185-1201

Asouti, E. & Hather, J. 2001. Charcoal analysis and the reconstruction of ancient woodland vegetation in the Konya basin, south-central Anatolia, Turkey: results from the Neolithic site of Çatalhöyük East. *Vegetation History and Archaeobotany* 10, 23-32

Atici, L. & Stutz, A. 2002. Analysis of the ungulate fauna from Öküzini: a preliminary reconstruction of site use, seasonality, and mortality pattern. In I. Yalçinkaya, M. Otte, J. Kozlowski & O. Bar-Yosef (eds), *Öküzini: final paleolithic evolution in southwest Anatolia.* Liège: Eraul. 101-108

Bottema, S. 1991. Développement de la végétation et du climat dans le bassin méditerranéen oriental à la fin du Pléistocène et pendant l'Holocène. *L'Anthropologie* 95, 695-728

Bottema, S. & Woldring, H. 1984. Late Quaternary vegetation and climate of southwesten Turkey. Part II. *Palaeohistoria* 26, 123-149

Chabal, L. 1992. La représentativité paléo-écologique des charbons de bois archéologiques issus du bois de feu. In *Actes du Colloque International Les charbons de bois, les anciens écosystèmes et le rôle de l'Homme*. Montpellier, 10-13 septembre 1991: Bulletin de la Société botanique de France. 139, 2/3/4, 213-236

Davis, P.H. 1965-1985. *Flora of Turkey and the East Aegean Islands.* Edinburgh:

Fahn, A., Werker, E. & Baas, P. 1986. *Wood Anatomy and Identification of Trees and Shrubs from Israel and Adjacent Regions.* Jerusalem: The Israel Academy of Sciences and Humanitie

Kartal, M. 2003. Anatolian Epi-Paleolithic Period Assemblages: Problems, Suggestions, Evaluations and Various Approaches. *Anadolu/Anatolia* 24, 45-61

Kuzucuoglu, C., Emery-Barbier, A., Fontugne, M. & Kunesh, S. 2002. The Öküzini marshes: a new Upper Pleistocene record on the anatolian mediterranean coast. In I. Yalcinkaya, M. Otte, J.K. Kozlowski & O. Bar -Yosef (eds), *La grotte d'Öküzini: évolution du Paléolithique final du sud-ouest de l'Anatolie.* Liège: Eraul. 79-82

Kuzucuoglu, C. & Roberts, N. 1998. Evolution de l'environnement en Anatolie de 20 000 à 6 000 BP. *Paléorient* 23, 7-24

Lopez Bayon, I., Léotard, J.-M. & Kartal, M. 2002. Séquence stratigraphique de la grotte d'Öküzini. Remplissage naturel et remplissage anthropique. In I. Yalçinkaya, M. Otte, J. Kozlowski & O. Bar -Yosef (eds), *La grotte d'Öküzini: évolution du Paléolithique final du sud-ouest de l'Anatolie*. Liège: Eraul. 25-39

Louis, H. 1939. *Das natürliche Pflanzenkleid Anatoliens geographisch gesehen.* Stuttgart: J. Engelhorns Nachf. Adolf Spemann

Martinoli, D. 2002. Les macrorestes botaniques de la grotte d'Öküzini. In I. Yalçinkaya, M. Otte, J. Kozlowski & O. Bar -Yosef (eds), *La grotte d'Öküzini: évolution du Paléolithique final du sud-ouest de l'Anatolie*. Liège: Eraul. 91-94

Martinoli, D. in press-a. Plant-food subsistence in context: an example from Epipalaeolithic southwest Anatolia. In M. Madella & M. Savard (eds), *Ancient plants and people - contemporary trends in archaeobotany*.

Martinoli, D. in press-b. Plant-food use, temporal changes and site seasonality at Epipalaeolithic Öküzini and Karain B caves, southwest Anatolia, Turkey. *Paléorient*

Martinoli, D. & Jacomet, S. 2004. Identifying endocarp remains and exploring their use at Epipalaeolithic Öküzini in southwest Anatolia, Turkey. *Vegetation History and Archaeobotany* 13, 45-54

Mayer, H. & Akso, H. 1986. *Wälder der Türkei*. Stuttgart: Gustav Fischer

O'Connell, J.F., Hawkes, K. & Blurton-Jones, N.G. 1991. Distribution of refuse-producing activities at Hadza residential base-camps: implication for analyses of archaeological site structure. In E.M. Kroll & T.D. Price (eds), *The Interpretation of Archaeological Spatial Patterning*. New York: Plenum. 61-77

Otte, M., Lopez Bayon, I., Noiret, P., Bar-Yosef, O., Yalcinkaya, I., Kartal, M., Léotard, J.-M. & Pettitt, P. 2003. Sedimentary deposition rates and carbon-14: the Epi-palaeolithic sequence of Öküzini cave (Southwest Turkey). *Journal of Archaeological Science* 30, 325-341

Özdogan, M. 1998. Anatolia from the last glacial maximum to the Holocen climatic optimum: cultural formations and the impact of the environmental setting. *Paléorient* 23, 7-24

Schoch, W., Heller, I., Schweingruber, F.H. & Kienast, F. 2004. Wood anatomy of central European Species. www.woodanatomy.ch

Schweingruber, F.H. 1990a. *Anatomie europäischer Hölzer - Anatomy of European woods*. Bern, Stuttgart: Haupt

Schweingruber, F.H. 1990b. *Mikroskopische Holzanatomie*. Birmensdorf: Eidgenössische Forschungsanstalt für Wald, Schnee und Landschaft

Théry-Parisot, I. 2001. *Economie des combustibles au Paléolithique. Expérimentation, taphonomie, anthracologie*. Paris: Dossier de Documentation Archéologique

Thiébault, S. 1998. Approche de l'environnement végétal du site d'Öküzini (Turquie) au Tardiglaciaire par l'analyse anthracologique. In M. Otte (eds), *Préhistoire d'Anatolie, Genèse de deux mondes. Actes du colloque international Liège, 28 avril-3 mai 1997*. Liège: ERAUL. 563-568

Thiébault, S. 2002. Approche de l'environnement végétal du site d'Öküzini (Turquie) au Tardiglaciaire par l'analyse anthracologique. In I. Yalçinkaya, M. Otte, J. Kozlowski & O. Bar-Yosef (eds), *Öküzini: final paleolithic evolution in southwest Anatolia*. Liège: Eraul. 95-99

Yalçinkaya, I., Otte, M., Kozlowski, J. & Bar-Yosef, O. 2002. *Öküzini: final paleolithic evolution in southwest Anatolia*. Liège: Eraul

Yalçinkaya, I., Otte, M., Taskiran, H., Kösem, M.B. & Ceylan, K. 1996. 1985-1995 Karain kazilari isiginda anadolu paleolitiginin önemi. *Kazi Sonuçlari Toplantisi* XVIII, 1-9

Yalçinkaya, I., Otte, M., Taskiran, H., Özçelik, K., Atici, A.L., Kösem, M.B., Erek, C.M. & Kartal, M. 2000. 1998 yili Karain kazisi. *Kazi Sonuçlari Toplantisi* XXI, 15-28

Van Zeist, W. & Bottema, S. 1991. Late Quaternary vegetation of the Near East. *Beihefte zum Tübinger Atlas des Vorderen Orients, Reihe A* 18, 1-156

Van Zeist, W., Woldring, H. & Stapert, D. 1975. Late quaternary vegetation and climate of southwestern Turkey. *Palaeohistoria* 17, 53-143

Zohary, M. 1973. *Geobotanical Foundations of the Middle East.* Amsterdam: Swets & Zeitlinger

3.4. Martinoli Danièle (in press). “Plant food subsistence in context: an example from Epipalaeolithic southwest Anatolia”. In: Marco Madella and Manon Savard (eds). Ancient Plants and People: Contemporary Trends in Archaeobotany, University of Arizona Press.

PLANT-FOOD SUBSISTENCE IN CONTEXT: AN EXAMPLE FROM EPIPALAEOLITHIC SOUTHWEST ANATOLIA

Danièle Martinoli (University of Basel IPAS, CH)

INTRODUCTION

The results from the archaeobotanical investigations of two Epipalaeolithic cave sites, Öküzini and Karain B, in southwest Anatolia (Martinoli 2002; Martinoli and Jacomet 2004; Martinoli in press, in preparation) offer the opportunity to explore the extend models of optimal foraging can explain aspects of subsistence decision making. The topic of this paper is to explore if, knowing the composition of the plant resources used by the Epipalaeolithic hunter-gatherer populations of Öküzini and Karain B, it would be possible to make useful predictions about the abundance of the plant resources in the environment of the sites, using a simple diet breadth optimization model.

I will first present briefly the principles of optimal foraging theory and the general predictions it enables to make. Then, I will review the archaeobotanical record of the plants exploited for food at Öküzini and Karain B, and the data available from other Late Pleistocene hunter-gatherer sites from different ecological zones across southwest Asia and southeast Europe. The pattern of variation evidenced will be discussed in terms of presence and absence of the classes of plant foods that are nuts, roots/bulbs or tubers and small seeds. To use models of optimal foraging, data about the ranking of the plant resources are necessary and these data will be gathered from the ethnographic and experimental literature. The application of a diet breadth model to the archaeobotanical data from Öküzini and Karain B will permit to make predictions about the abundance of the resources in the local vegetation, hypotheses which will be tested with the help of environmental reconstruction.

This investigation focuses on the general strategy of adaptation and implies important simplifications. For the use of optimal foraging model, we will consider only the classes of plant resources which provide most energy. Their presence or absence will be considered to best match the level of precision commonly encountered in archaeological data on subsistence.

Optimal Foraging Models

Optimal foraging models help to understand how foraging choices are made. The most basic assumption is that human decision making is oriented toward efficiency in food acquisition as a result of evolutionary selection pressures (Kelly 1995; Winterhalder and Smith 1981; Simms 1987). To understand the factors and environmental features affecting resource selection, optimal foraging models have been developed within human behavioral ecology: it is assumed that hunter-gatherers make choices that maximize their foraging efficiency and therefore fitness. Models of optimal foraging have yielded three basic predictions: foragers should i) prefer more profitable resources, ii) be more selective when profitable resources are common, iii) ignore unprofitable resources which are outside of the optimal diet regardless of how common they are. The assumption of efficiency is compatible with observed hunter-gatherer subsistence behavior (Lee 1968; Kelly 1995).

More precisely, the diet breadth model, or optimal diet model, predicts that in a fine grained environment where resources are encountered at random, a forager chooses from an available set of resources on the basis of their efficiency rank and abundance. Efficiency rank is measured as a function of the post encounter handling costs over the energy yield of the resource, the handling cost for plant resources being composed of gathering and processing. Another type of cost which helps understand the proportions of resources in the diet is search time, closely linked to abundance. This model is used to predict the order in which resources will be added to or deleted from the diet. Several important predictions stem from the basic diet breadth model: i) high ranking resources will always be taken when they are encountered, ii) the inclusion of lower ranked resources in the diet will depend not on their abundance, but on the abundance of higher ranked items, iii) as the abundance of higher ranked items decreases, lower ranked items will be included in the diet. Conversely, as the abundance of higher ranked items increases, lower ranked items will be excluded, no matter how abundant they are.

The principal criticism against the diet breadth model has been that human subsistence is not only controlled by energy and resource abundance, but also by cultural practices, technology, cooking, eating habits and taboos (Bettinger 1987; Stahl 1989; Gremillion 2004). However, it is meant to use this kind of model not to address whether a behavior is optimal, but rather whether a particular hypothesis, based on specific constraints, describes the foraging behavior.

Preliminary Remarks on Plant Based Subsistence Reconstruction and Intersite Comparison

It is difficult to trace the subsistence strategy among prehistoric hunter-gatherer societies, for which we usually have only incomplete archaeological remains. Primary evidence for plant food from the fragile botanical remains is often highly biased by lack of recovery or poor preservation. In Near Eastern sites, most attention has been paid to the exploitation of small seeded grasses and wild cereals as a forerunner to agricultural practices. Regardless of the species involved, such a foraging strategy can be traced back to the Levantine Epipalaeolithic (Weiss et al. 2004) and was widespread during the Pre-Pottery Neolithic in all areas where wild cereals were abundant, including the Levant and northern Fertile Crescent (Willcox 1999; Savard this volume). However, traces of the plant subsistence base in the Upper and Epipalaeolithic are still scarce and it is likely that a greater variety of foraging patterns existed.

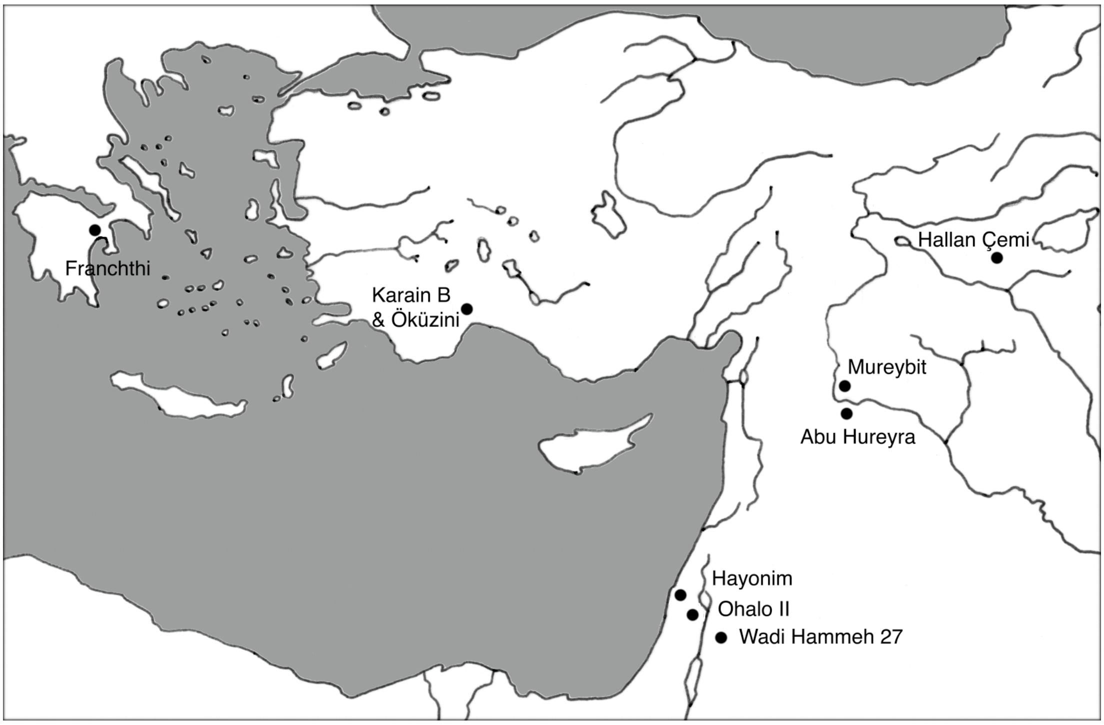


Figure 1. Location of the sites mentioned in the text. The site of Wadi Kubbaniya is not included in the map for reason of scale.

Our knowledge about the plant foods used in Upper and Epipalaeolithic sites in southwest Asia is based on a limited number of studies at sites geographically scattered over a huge area (Figure 1). Archaeobotanical records from these periods are highly biased by differential preservation, a problem that has been fully discussed elsewhere (Colledge 2001; Hillman, Madeyska, and Hather 1989). Moreover, the recovery methods (manual/machine flotation, sieving, mesh size), the contexts, kind of sites excavated (open-air or cave site; year-round or seasonal occupation) and sampling strategy (large scale, quantity of processed sediment) differ and are often difficult to reconstruct (cf Table 1). Differences in preservation of the plant remains can also influence their level of identification. Another problem consists in quantifying the use of the plants and their importance in prehistoric diets, based on the recovered macroremains (Popper 1988). Because of all these reasons, an intersite comparison is only possible at a low degree of precision.

Wadi Kubbaniya	**Franchthi II**	**Franchthi III-V**	**Ohalo II**	**Abu Hureyra I**	**Hayonim**
Late Palaeolithic	Upper Palaeolithic	Upper Palaeolithic/ Lower-Upper Mesolithic	Levantine Epipalaeolithic/ Kebaran	Epipalaeolithic	Epipalaeolithic/Early and Late Natufian
19000-17000 uncal BP	13000-11000 uncal BP	9500-7900 uncal BP	19000 uncal BP	11500-10000 uncal BP	12000 uncal BP
dry-sieving (1,7 and 0,9mm)	manual flotation (1,5mm)	manual flotation (1,5mm)	wet-sieving (2 and 0,5mm)	machine flotation (1mm)	wet-sieving and flotation
open-air site	cave site	cave site	open-air site	open-air site	cave site
seasonal occupation	seasonal occupation	seasonal or permanent occupation	seasonal occupation, maybe permanent		
arid environment with riverbank vegetation	woodland-open forest with steppic areas	open oak woodland interspersed with open patches of herbaceous vegetation	saline habitat, lakeshore habitat and mediterranean open park-like forest	terebinth-almond woodland steppe and riverine forest	
Hillman et al. 1989	Hansen 1991	Hansen 1991, Mason et al. 2002	Kislev et al 1992, Kislev and Simchoni 2002, Weiss et al. 2004	Hillman 2000	Hopf and Bar-Yosef 1987

Mureybit I-III	**Wadi Hammeh 28**	**Karain B**	**Öküzini**	**Hallan Çemi**
Epipalaeolithic/Natufian	Epipalaeolithic/Natufian	Epipalaeolithic	Epipalaeolithic	terminal Epipalaeolithic
10450-9550 uncal BP	12200-11900 uncal BP	≈15000 uncal BP	16500-12000 uncal BP	10600-9900 uncal BP
manual water flotation	bucket flotation (0,3mm)	manual flotation (0,5mm)	manual flotation (0,5mm)	machine flotation (1 and 0,35mm)
open-air site	open-air site	cave site	cave site	open-air site
permanent from phase II onward		seasonal occupation	seasonal occupation	permanent
steppe and river valley forest		forest-steppe and riverine forest	forest-steppe and riverine forest	riverine woodland and deciduous mixed oak forest
van Zeist & Bakker-Heeres 1984	Colledge 2001	Martinoli (accepted)	Martinoli (accepted)	Rosenberg et al. 1995, 1998

Table 1. Description of the Upper and Epipalaeolithic sites in southwest Asia and southeast Europe in which plant remains were recovered.

PLANT BASED SUBSISTENCE IN UPPER AND EPIPALAEOLITHIC IN SOUTHWEST ASIA AND SOUTHEAST EUROPE

Plant Based Subsistence at Öküzini and Karain B

With the excavation at Öküzini and Karain B caves in southwest Anatolia (Figure 1) in 1990-1999 and 1996-2001, a little light was shed onto plant exploitation during the Epipalaeolithic in this part of southwest Asia (Martinoli in press). Covering a stratigraphic sequence dated at 16500-12000 uncal BP in Öküzini and around 15000 uncal BP in Karain B, the sites were inhabited periodically at the end of the Late Glacial Maximum till the start of the Younger Dryas (Otte et al. 2003).

The caves were not very rich in botanical material, the bulk of the remains originating from the upper levels. Both assemblages yielded a very similar plant assemblage and little temporal patterning was evidenced. The principal plant foods appear to have been nuts and fruits complemented with underground storage organs like roots, bulbs or tubers. These included wild almonds (*Amygdalus graeca* or *orientalis*), wild pistachio (*Pistacia*), acorns (*Quercus*), wild pears (*Pyrus*), wild grapes (*Vitis vinifera* subsp. *sylvestris*), rosehips (*Rosa*), hawthorns (*Crataegus*) and hackberry fruits (*Celtis*). There were also a very small number of small pulses (Vicieae) and other small seeds (Table 2) at Öküzini. However, the Vicieae could represent, like the domestic cereal grains recovered, later contaminations as they often grow as cereal weeds (Martinoli in press). Evidence of an intensive use of the small seeds was absent, despite the appearance of grinding stones at 12500 uncal BP (Otte et al. 2003). These were not necessarily made for small seed processing, but could be used for various other plants, meat or minerals (Ertug 2002).

Undoubtedly, the composition of the plant assemblages reflects in part poor preservation of individual specimens, bias that cannot entirely be excluded, so that the missing small seeds could eventually represent so-called “missing foods” (Hillman, Madeyska, and Hather 1989; Hillman 2000). Nevertheless, the trivial role of small seeds was supported by several lines of evidence (Martinoli in press) others than the small number and very low frequency of the fossil seeds. If intensely used, small seeds would have been more abundant in the archaeobotanical record because i) most small seed species identified require roasting to become edible and would therefore have good preservation chances, ii) Öküzini cave, at least, bears traces of early summer occupation (Atıcı and Stutz 2002), a season which would show the availability of most small-seeded plants.

Over Regional Review of Plant-based Subsistence Strategies

In table 2, I have listed the presence and absence and estimate of the importance of the main plant food categories and species from the Upper and Epipalaeolithic settlements from southwest Asia and southeast Europe. The environments of the sites listed in table 1 were derived, when existent, from the authors’ descriptions based on macrobotanical, anthracological, in some cases also zoological data.

For the Upper Palaeolithic, only two sites have yielded botanical remains: Wadi Kubbaniya and Franchthi II. Wadi Kubbaniya, an Egyptian site where large scale recovery of plant remains was undertaken, produced a small number of vegetal remains among which the major plants consisted of tubers and rhizomes of taxa growing in riverine ecosystems, augmented with rare remains of fruits of the dom palm (*Hyphaena thebaica*) and club rush seeds (*Scirpus maritimus/tuberosus*). The presence of small seeds in apparent human faeces suggested their use as food. However, loose small seeds were not recovered but may have been lost during excavation or may not have been preserved (Hillman, Madeyska, and Hather 1989). The environment was arid but supported riverine vegetation.

In zone II at Franchthi in Greece, the edible species vetch (*Vicia*), lentil (*Lens*), almond (*Amygdalus communis*), pear (*Pyrus amygdaliformis*) and wild pistachio (*Pistacia* cf *lentiscus*) were the most numerous remains (Hansen 1991). Oat seeds (*Avena*) were probably also used for food, whereas the wild barley grains (*Hordeum vulgare* subsp. *spontaneum*) were considered as contaminants. The vegetation was suggested to consist of woodland or open forest with steppic areas.

In the Epipalaeolithic, the archaeobotanical data become slightly more numerous. In Franchthi zones III and IV, the most abundant species were pistachio (*Pistacia* cf *lentiscus*), almond (*Amygdalus communis*), pear (*Pyrus amygdaliformis*) and oats (*Avena*). Lentils (*Lens*), wild barley (*Hordeum vulgare spontaneum*) and a variety of legumes were also consistently present throughout most of the zones (Hansen 1991). New investigations evidenced, in some samples at least, considerable quantities of parenchyma presumably from “roots and tubers” (Mason, Hather, and Hillman 2002). The vegetation at this period had developed into open oak woodland interspersed with patches of herbaceous vegetation (Hansen 1991).

Ohalo II in Israel provided a large collection of charred plant remains preserved in wet conditions with the identification of 142 taxa (Kislev, Nadel, and Carmi 1992; Weiss et al. 2004). The principal plant foods appear to have been grass seeds and wild cereals, interpreted as staples, augmented with a variety of nuts (Mount Tabor oak acorns/*Quercus ithaburensis*, almonds/*Amygdalus*, pistachios/*Pistacia atlantica*) and fruits (wild olives/*Olea europaea*, hawthorns/*Crataegus*, wild fig/*Ficus* and wild grapes/*Vitis vinifera subsp. sylvestris*). A small quantity of pulses was also present. The surroundings mainly included an oak steppe forest with annual grasses among the trees and the small and saline nearby lake Kinneret (Kislev and Simchoni 2002).

		Wadi Kubbaniya	Franchthi II	Franchthi III-V	Ohalo II	Tell Abu Hureyra I	Hayonim	Mureybit I-III	Wadi Hammeh 27	Öküzini	Karain B	Hallan Çemi	
Hordeum	wild cereals		?	O	OO		O	O	O				barley
Triticum boeticum/Secale						OO							einkorn/rye
Triticum dicoccoides					O	O							emmer
Aegilops	wild grasses				O				cf				goat grass
Alopecurus					O								black grass
Avena			O	O	O	O							oat
Bromus					OO	O		O	cf				brome grass
Echinochloa								O					panic grass
Eremopyrum								O					wheat grass
Hordeum small					O	O		O					small barley
Lolium perenne/rigidum						O			O				ray-grass
Paniceae						O		O					paniceae
Poaceae												O	grasses
Puccinella					O								manna-grass
Stipa						OO							feather grass
Taeniatherum caput-medusae													medusahead
Cicer	pulses												chickpea
Lathyrus			O	O									vetchling
Lens			O	O	O	O		O	O			O	lentil
Lupinus pilosus							o						lupin
Pisum				O			cf	cf					pea
Large-seeded Vicieae						O		O	cf			O	large-seeded Vicieae
Vicia ervilia			O	O		O		O				O	bitter vetch
Cruciferae	small seeds					O							Cruciferae
Gundelia tournefortii												O	cardi
small-seeded Trifolieae						O		O	cf				small-seeded Trifolieae
small-seeded Vicieae					O			O		O		O	small-seeded Vicieae
Polygonum (corrigioloides)						OO		O					knot-grass
Scirpus maritimus/tuberosus						OO						OO	sea club-rush
Cyperus rotundus	roots/ bulbs/ tubers	O											sedge
Diverse parenchymous tissues		O		O						O	O		diverse parenchymous tissues
Scirpus maritimus/tuberosus		O											sea club-rush
Amygdalus/Prunus	nuts		O	O	O		O			OO	O	O	almond/plum
Pistacia atlantica/terebinthus					O	O		O	cf	O		O	pistachio
Pistacia lentiscus			cf	cf									lentisc
Quercus					O					O			oak
Celtis mineralised	soft fruits		O	O		O				O	O		hackberry
Crataegus					O								hawthorn
Ficus								O					fig
Olea europaea sylvestris					O								wild olive
Prunus						O						cf	plum
Pyrus			O	O	cf	O				OO	cf		pear
Rosa										O			rosehip
Vitis vinifera sylvestris			O		O					O			wild grape
Ziziphus spina-christi					O								christ's thorn

Table 2. Presence (more than 5 items) and absence of selected taxa from the major plant categories at Upper and Epipalaeolithic settlements from southwest Asia and southeast Europe. OO important in the assemblage, O present, cf uncertain identification, ? contamination. References same as for Figure 1.

Another site with a large plant assemblage was Abu Hureyra I in Syria, where more than 70 plant taxa were identified thanks to a large scale flotation strategy (Hillman 2000). Wild cereals (rye/*Secale*, einkorn/*Triticum boeticum/urartu* and emmer/*Triticum dicoccoides*), feather-grass/*Stipa*, sea-club rush/*Scirpus_maritimus/tuberosus* and knotgrass/*Polygonum corrigioloides* probably served as staples. Other small-seeded grasses (small barley/*Hordeum murinum*, etc.), pulses (lentils/*Lens* and large seeded vetches/Vicieae), small seeded legumes (Trifolieae), nuts (wild pistachios/*Pistacia*), fruits (hackberries/*Celtis*) and the carbohydrate rich seeds of goosefoots (Chenopodiaceae) have also been interpreted as food plants. The vegetation in the surroundings of the site was dominated by oak-terebinth-Rosaceae park woodland and steppe shaping a mosaic of woodland and open, grass dominated areas, and a riverine forest (Hillman 1996; Hillman 2000).

The Israeli site of Hayonim Cave in western Galilee yielded a limited amount of plant remains: wild cereals (barley/*Hordeum spontaneum*), wild pulses (possibly pea/cf *Pisum* and lupin/*Lupinus pilosus*) and nuts (almond/*Amygdalus communis*) (Hopf and Bar-Yosef 1987).

According to Hillman's model of vegetation (Hillman 1996), the landscape would have been dominated by steppe and a terebinth-almond woodland-steppe.

At Mureybit I-III, wild einkorn wheat (*Triticum boeticum*), wild barley (*Hordeum*), lentils (*Lens*) and peas (*Pisum*) served as human food, as well as seeds from a range of other wild small seeded taxa (van Zeist and Bakker-Heeres 1984/1986). Wild fruit trees and shrubs exploited by the inhabitants of the site included pistachios (*Pistacia*), figs (*Ficus*) and capers (*Capparis*). A steppe and river valley forest constituted the natural vegetation.

Wadi Hammeh 27, on the eastern margin of the Jordan rift valley, yielded only few plant remains despite large scale sampling: among them wild cereals and various grasses (barley/*Hordeum* and feather grass/*Stipa*), lentils (*Lens*) and pistachios (*Pistacia*) (Colledge 2001). The site was located in the terebinth-almond woodland-steppe (Hillman 1996).

In Hallan Çemi, the charred plant assemblages showed a paucity of grasses and near absence of wild cereals, but other wild plants like nuts (pistachios/*Pistacia*, almonds/*Amygdalus*) and wild pulses (lentils/*Lens*, bitter vetches/*Vicia ervilia*) were of great importance to the inhabitants of the site, as well as some other small seeds (e.g. *Gundelia tournefortii*) (Rosenberg et al. 1998; Savard this volume). Surrounding vegetation comprised a deciduous mixed oak forest and riverine woodland.

Synthesis

The overview of the plant subsistence base at the different sites shows some patterning (Table 2). The majority of the assemblages yielded small seeded plants in some proportion: wild cereals, wild grasses, legumes or other small seeds. Various species among these categories were abundant among the remains and were therefore interpreted as staples, e.g. at Ohalo II and Abu Hureyra. Exceptions to this pattern of small seed use seems to be Wadi Kubbaniya (where, however, small seeds have been reported from human faeces), Öküzini and Karain B. In the Levantine and Euphrates sites (Ohalo II, Hayonim, Wadi Hammeh, Abu Hureyra and Mureybit), the grasses, wild cereals and other small seeds, like knotgrass or sea club-rush, were present and most abundant. On the other hand, at Hallan Çemi and Franchthi, legume seeds were present and seemed to play an important role. Nuts and fruits were regularly present in the southwest Asian assemblages; however, they seem to have a main role in the Öküzini assemblage only, maybe also in Hallan Çemi. Sites like Hayonim, Wadi Hammeh and Mureybit are poor in nuts and fruits, what can probably be explained from their dry steppic environments.

Roots, bulbs or tubers were only recovered at four sites (Wadi Kubbaniya, Franchthi III-IV, Öküzini and Karain B). It must be noted that it is only since the work of Hather (Hather 1991, 1993) that the identification of parenchymous tissues from roots, bulbs or tubers is relevant. The absence of this kind of plant remain at most sites is possibly an absence of recognition. Nevertheless, there was a likely importance at Franchthi, Öküzini and Karain B of parenchymous root and tubers foods, especially when viewed in relation to small seed foods, which, on these sites, were not or very rarely recovered. The same pattern has been noticed for European hunter-gatherer sites, where small seeds are rare, nuts and parenchymous tissue more frequent (Mason, Hather, and Hillman 2002).

The main question arising from this review is: why are there comparatively so few small seeds at Öküzini and Karain B? In order to answer this question with the approach of optimal foraging theory, data on the cost of acquiring the main classes of plant resources are necessary.

Use of Optimal Foraging Theory as Explanatory Model

Ranking of the Main Classes of Food Plants

To apply models of optimal foraging to archaeological situations it is necessary to acquire data on the cost of exploiting aboriginally utilized resources, that means to acquire estimates handling time and ranking of the resources. The benefits of the resources are generally expressed in calories.

There are few ethnographic published data on the costs of acquiring plant resources, therefore some authors have devised on experimentations (Gremillion 2004; Simms 1987). These experimentations showed that data for groups of plant types with similar morphological characteristics can be seen as being similar. Ethnographic examples of root food are numerous in hunter-gatherer as well as agrarian societies, past and present (see for example (Kelly 1995; Ertug 2000, 2004; Kubiak-Martens 2002; Pokotylo and Froese 1983). These studies have shown that the preference for roots over seed foods is usually a product of the lower energy costs involved in processing them (Cane 1989). Lee and Devore (Lee and DeVore 1968), ethnographers intimately familiar with the practicalities of subsisting on wild resources, wrote: “our view is that vegetable food in the form of nuts, berries and roots were always available to man and were easily exploited by even the simplest of technologies”. Nuts and roots or tubers are generally considered plant foods with high return rates, but they can be quite variable depending mostly on processing requirements (Talalay, Keller, and Munson 1984; Smith and Martin 2001; Kelly 1995). Roots and tubers from wetland plants are particularly interesting, because they usually grow in large stands and many of them are edible (Smith and Martin 2001; Hillman, Madeyska, and Hather 1989).

The exploitation of small seeds, on the other hand, needs labour expensive processing. They vary widely in return rates, but in general are the lowest ranked resources. The resulting return rates are generally quite low in comparison to those obtainable from different nuts and acorns, for example (Gremillion 2004).

Predictions using Optimal Foraging Model

It seems that the main plant resources recovered at Öküzini and Karain B belonged to plant categories which usually require little time and labor to procure and process (Martinoli in press). The plant foods originated mostly from shrubs, trees or from underground plant storage organs, generally easy to gather and did not need intensive processing. According to the diet breadth model, the use mainly of high ranked plant foods reflects their good availability in the environment. It does however not imply the absence of grasses and pulses or other small seeds, but estimates that the resources nuts, roots/bulbs and tubers were privileged because they had better return rates and were sufficiently abundant for the human population present. The exploitation in the fall of nuts like the wild almond, a slightly lower ranked resource because of its need of detoxification, can tentatively be explained by risk management behavior. It is a storable and energy rich resource valued in prevision of the lean winter season. Moreover, almond wood was one of the main fuel resources throughout the sequence in Öküzini and Karain B (Thiébault 2002; Martinoli in preparation). The gathering of a plant resource for multiple uses can lower its exploitation cost.

Two important points emerged from encounter rates developed by computer simulations (Simms 1987): i) the search time for plant collecting is a relatively less important factor than handling time, ii) with increasing handling time (i.e. low ranked resources), abundance becomes less important in altering the procurement rate. That means that the abundance does not change the classification of the classes of plant resources, but rather accentuates the differences between the return rates. High ranked resources tend therefore to increase strongly their return rate when they become abundant, whereas low ranked resources increase only slightly their return rates even if abundant.

TEST OF THE PREDICTIONS OF OPTIMAL FORAGING THEORY

Late Glacial Environmental Reconstruction in southwest Anatolia and abundance of the different classes of plant resources

There is no way to confidently estimate the abundance of each plant type in the local environment of Öküzini and Karain B caves. However, the coincident use of pollen, charcoal and archaeozoological data, together with a good knowledge of the local topography and potential vegetation, enable an ecological modeling of the vegetation in past times (e.g. (Hillman 1996; Martinoli in preparation).

The mountains in southwest Anatolia served during the Late Glacial Maximum as a refuge for arboreal species, which, together with an increase in humidity, colonized the area from 14000 uncal BP onward (Kuzucuoglu and Roberts 1998). A sediment core taken in the plain in front of Öküzini cave with a phase dated at 14000 uncal BP showed that caducifoliate oak (*Quercus*), ash (*Fraxinus*), wild pistachio (*Pistacia*) and juniper (*Juniperus*) were already present, although the non-arboreal species dominated the pollen record (Kuzucuoglu et al. 2002). However, insect pollinated species like almond (*Amygdalus*) and pear trees (*Pyrus*) are usually missing in pollen records, so that the overall rate of arboreal pollen is underestimated (Woldring and Bottema 2001/2002). Riverside associations were also present at 14000 uncal BP with pollen from aquatic and semi-aquatic plants (Kuzucuoglu et al. 2002). This correlates well with the existence of an ancient lake in the plain in front of the caves (Pawlikowski 2002).

Anthracological analyses made at Öküzini cave showed the presence of a forest steppe from 14500 BP uncal to 12200 BP uncal, in which the almond tree played an important role (Thiébault 2002). Other woody steppic species identified were wormwood (*Artemisia*), pine (*Pinus*) and wild pistachio (*Pistacia*). However, and from the base of the sequence, the presence of mesophilous species such as caducifoliate oaks (*Quercus*), maple (*Acer*), plums (*Prunus*), boxwood (cf. *Buxus sempervirens*) and whitebeam/hawthorn (*Sorbus/Crataegus*), or of more thermophilous species such as sclerophilous oaks (*Quercus*) and olive tree (cf. *Olea*) were noted. A riverside forest was also present, composed of tamarisk (*Tamarix*), ash (*Fraxinus*) and (*Salix/Populus*) (Thiébault 2002).

The archaeozoological record showed hunting of mainly ovicaprines (sheep and goats) and fallow deer and roe deer, the latter increasing during time, what was correlated with an increasingly forested environment from 16000-12000 uncal BP (Lopez Bayon, Léotard, and Kartal 2002).

All data conclude to the presence of a forested area rich in nuts and fruits, however its cover and density are difficult to estimate precisely. Öküzini and Karain B were situated at the junction between a plain and a mountain range, a topography that offers a high variety of ecological niches. The environment was therefore varied, with the more mesic tree species probably growing in protected valleys, the thermophilous species on the exposed foothills, the steppic bushes on dry, rocky mountain flanks, and the riverine trees and semi-aquatic and aquatic species in the wet areas and marshes in the plain. Archaeological survey in the province of Antalya showed that the area supported small mobile groups (Kayan, Minzoni-Déroche, and Yalçınkaya 1987). It is therefore quite possible that the forest and wetland high ranked plant resources like the nuts and underground organs were sufficiently abundant for the subsistence of the inhabitants of Öküzini and Karain B, without resorting to the exploitation of the low ranked small-seeds. Moreover, both settlements are interpreted as seasonal camps, and therefore the inhabitants had the possibility to shift to another place when high ranked resources decreased (both animal and vegetal), rather than to appeal to low ranked resources.

A detailed exam of the local environments of all the sites mentioned in the text is beyond the scope of this paper. It seems however that, wherever present, even in small amounts, high ranked resources like nuts have constantly been used. On the other hand, populations of sites situated in open steppic woodland vegetation have always exploited low ranked resources like small seeds (grasses, wild cereals, legumes and others), even when wetlands rich in root food, i.e. higher ranked resources, were present nearby (e.g. Hallan Çemi, Ohalo). In these cases, factors like the storability, nutritional contents, dependability on a resource, technological skills developed, etc… were probably as important as the energy provided. This is in contradiction with the predictions of optimal foraging theory and it would be challenging to find ways to test these hypotheses.

CONCLUSIONS

The use of optimal foraging theory at ÖK and KB as an interpretative model to understand why there are nearly no small seeds at these sites seem fruitful in that the importance of nut and root food in relation to small seed food reflects not only a mere preservation pattern, its explanation is likely to be found in their high return rates and good availability in the area, together with a low human population. However, it must be kept in mind that there is no diet composed solely of nuts, roots or seeds, it is always a variety of resources that are consumed. This is a simplification made for the purpose of this study.

These first results encourage the pursuit of a more detailed investigation exploring the relation between subsistence and environment in more complexity. One way would be to estimate more precisely the ranking of the plants recovered archaeologically with the help of experimentation. However, as long as we are unable to identify specifically the plant remains (in particular the parenchymous tissues) and to understand how they were processed, we will be unable to estimate precisely their return rates. A better understanding of the connection between subsistence and environment will also be possible only with cautious modeling of the local environment in the surroundings of a site, process which beneficiates greatly from pluridisciplinary approaches. To conclude, much more experimentation and regional investigations are needed to better document the subtle relationship between plant food exploitation and environment, and hence the foraging behavior of prehistoric societies.

ACKNOWLEDGEMENTS

I would like to thank G. Hillman and M. Nesbitt for initiating me to Near Eastern archaeobotany and handing me the plant material over from Öküzini and Karain B, as well as the excavation directors I. Yalcınkaya and M. Otte and their team, for their collaborative work. I wish to thank S. Jacomet, M. Nesbitt and M. Savard for their critical review of the manuscript. This research has been possible with the support of S. Jacomet and colleagues from the IPAS, and the financial support of the Swiss National Science Foundation (project number 1214-64974.01 and 101312-101585/1).

BIBLIOGRAPHY

Atıcı, L. and A. Stutz. 2002. Analysis of the ungulate fauna from Öküzini: a preliminary reconstruction of site use, seasonality, and mortality pattern. In *Öküzini: final paleolithic evolution in southwest Anatolia*, edited by I. Yalçınkaya, M. Otte, J. Kozlowski and O. Bar-Yosef. Liège: Eraul.

Bettinger, R. L. 1987. Archaeological approaches to hunter-gatherers. *Annual Review of Anthropology* 16:121-142.

Cane, S. 1989. Australian aboriginal seed grinding and its archaeological record: a case study from the Western Desert. In *Foraging and Farming. The evolution of plant exploitation*, edited by D. R. Harris and G. C. Hillman. London: Unwin Hyman.

Colledge, S. 2001. *Plant exploitation on Epipalaeolithic and Early Neolithic sites in the Levant*. Vol. S986. Oxford: BAR International series.

Ertug, F. 2000. An Ethnobotanical Study in Central Anatolia (Turkey). *Economic Botany* 54 (2):155-182.

———. 2002. Pounders and grinders in a modern central anatolian village. In *Moudre et broyer. L'interprétation fonctionnelle de l'outillage de mouture et de broyage dans la Préhistoire et l'Antiquité*, edited by H. Procopiou and R. Treuil. Paris: Edition du CTHS.

———. 2004. Wild edible plants of the Bodrum area (Mugla, Turkey). *Turkish Journal of Botany* 28:161-174.

Gremillion, K. J. 2004. Seed processing and the origin of food production in Eastern North America. *American Antiquity* 69 (2):215-233.

Hansen, J. 1991. *The palaeoethnobotany of Franchthi Cave.* Vol. 7, *Excavations at Franchthi Cave, Greece*. Bloomington, Indianapolis: Indiana University Press.

Hather, J. G. 1991. The identification of charred archaeological remains of vegetative parenchymous tissue. *Journal of Archaeological Science* 18:661-675.

———. 1993. *An archaeobotanical guide to root and tuber identification. 1. Europe and South West Asia.* Vol. 28. Oxford: Oxbow Monograph.

Hillman, G. C. 2000. Abu Hureyra I: The Epipalaeolithic. In *Village on the Euphrates. From foraging to farming at Abu Hureyra.*, edited by A. M. T. Moore, G. C. Hillman and A. J. Legge. Oxford: Oxford University Press.

Hillman, G. C., E. Madeyska and J. G. Hather. 1989. Wild plant foods and diet at late palaeolithic Wadi Kubbaniya: the evidence from charred remains. In *The prehistory of Wadi Kubbaniya. Stratigraphy, palaeoeconomy and environment*, edited by F. Wendorf, R. Schild and A. Close. Dallas: Southern Methodist University Press.

Hillman, G. H. 1996. Late Pleistocene changes in wild plant-foods available to hunter-gatherers of the northern Fertile Crescent: possible preludes to cereal cultivation. In *The origins and spread of agriculture and pastoralism in Eurasia*, edited by D. R. Harris. London: UCL Press.

Hopf, M. and O. Bar-Yosef. 1987. Plant remains from Hayonim cave, western Galilee. *Paléorient* 13 (1):117-120.

Kayan, I., A. Minzoni-Déroche and I. Yalçınkaya. 1987. Prospection préhistorique dans la région d'Antalya. Notices préliminaires. *Anatolia Antiqua (Varia Anatolica)* I:9-13.

Kelly, R. L. 1995. *The foraging spectrum. Diversity in Hunter-Gatherer lifeways*. Washington, London: Smithsonian Institution Press.

Kislev, M., D. Nadel and I. Carmi. 1992. Epipalaeolithic (19000 BP) cereal and fruit diet at Ohalo II, sea of Galilee, Israel. *Review of Palaeobotany and Palynology* 73:161-166.

Kislev, M. E. and O. Simchoni. 2002. Reconstructing the palaeoecology of Ohalo II, an Early Epipalaeolithic site in Israel. In *Hunter-gatherer archaeobotany. Perspectives from the northern temperate zone*, edited by S. L. R. Mason and J. G. Hather. London: Institute of Archaeology, University College London.

Kubiak-Martens, L. 2002. New evidence for the use of root foods in pre-agrarian subsistence recovered from the late Mesolithic site at Halsskov, Denmark. *Vegetation History and Archaeobotany* 11:23-31.

Kuzucuoglu, C., A. Emery-Barbier, M. Fontugne and S. Kunesh. 2002. The Öküzini marshes: a new Upper Pleistocene record on the anatolian mediterranean coast. In *La grotte d'Öküzini: évolution du Paléolithique final du sud-ouest de l'Anatolie*, edited by I. Yalcınkaya, M. Otte, J. K. Kozlowski and O. Bar -Yosef. Liège: Eraul.

Kuzucuoglu, C. and N. Roberts. 1998. Evolution de l'environnement en Anatolie de 20000 à 6000 BP. *Paléorient* 23 (2):7-24.

Lee, R. and I. DeVore. 1968. *Man the hunter*. Chicago: Aldine.

Lee, R. B. 1968. What hunters do for a living, or, how to make out on scarce resources. In *Man the hunter*, edited by R. B. Lee and I. DeVore. chicago: Aldine Publishing Company.

Lopez Bayon, I., J.-M. Léotard and M. Kartal. 2002. Séquence stratigraphique de la grotte d'Öküzini. Remplissage naturel et remplissage anthropique. In *La grotte d'Öküzini: évolution du Paléolithique final du sud-ouest de l'Anatolie*, edited by I. Yalçınkaya, M. Otte, J. Kozlowski and O. Bar -Yosef. Liège: Eraul.

Martinoli, D. 2002. Les macrorestes botaniques de la grotte d'Öküzini. In *La grotte d'Öküzini: évolution du Paléolithique final du sud-ouest de l'Anatolie*, edited by I. Yalçınkaya, M. Otte, J. K. Kozlowski and O. Bar -Yosef. Liège: Eraul.

———. in preparation. Use of firewood at two Epipalaeolithic cave sites in southwest Anatolia (Turkey) and reconstruction of the local woodland vegetation.

———. in press. Plant-food use, temporal changes and site seasonality at Epipalaeolithic Öküzini and Karain B caves, southwest Anatolia, Turkey. *Paléorient*.

Martinoli, D. and S. Jacomet. 2004. Identifying endocarp remains and exporing their use at Epipalaeolithic Öküzini in southwest Anatolia, Turkey. *Vegetation History and Archaeobotany* 13:45-54.

Mason, S., J. G. Hather and G. C. Hillman. 2002. The archaeobotany of European hunter-gatherers: some preliminary investigations. In *Hunter-Gatherer Archaeobotany. Perspectives from the northern temperate zone*, edited by S. L. R. Mason and J. G. Hather. London: Institute of Archaeology University College London.

Otte, M., I. Lopez Bayon, P. Noiret, O. Bar-Yosef, I. Yalçinkaya, M. Kartal, J.-M. Léotard and P. Pettitt. 2003. Sedimentary deposition rates and carbon-14: the Epi-paleolithic sequence of Öküzini cave (southwest Turkey). *Journal of Archaeological Science* 30:325-341.

Pawlikowski, M. 2002. Ancient lake near Öküzini and Karain caves (southern Turkey). In *Öküzini: final paleolithic evolution in southwest Anatolia*, edited by I. Yalçinkaya, M. Otte, J. Kozlowski and O. Bar-Yosef. Liège: Eraul.

Pokotylo, D. L. and P. D. Froese. 1983. Archaeological evidence for prehistoric root gathering on the southern interior plateau of British Columbia: a case study from upper Hat Creek Valley. *Canadian Journal of Archaeology* 7 (2):127-157.

Popper, V. S. 1988. Selecting quantitative measurements in plalaeoethnobotany. In *Current Paleoethnobotany. Analytical methods and cultural interpretations of archaeological plant remains*, edited by C. A. Hastorf and V. S. Popper. Chicago: The University of Chicago Press.

Rosenberg, M., M. R. Nesbitt, R. W. Redding and B. L. Peasnall. 1998. Hallan Çemi, pig husbandry, and post-Pleistocene adaptations along the Taurus-Zagros arc (Turkey). *Paléorient* 24 (1):25-41.

Savard, M. this volume. Archaeobotanical Evidence of Late Epipalaeolithic/Early Aceramic Neolithic Subsistence and Environment in the Northern Fertile Crescent.

Simms, S. R. 1987. *Behavioral Ecology and Hunter-Gatherer Foraging. An Example from the Great Basin*. Vol. S381. Oxford: BAR International Series.

Smith, C. S. and W. Martin. 2001. Sego lilies and prehistoric foragers: return rates, pit ovens, and carbohydrates. *Journal of Archaeological Research* 28:169-183.

Stahl, A. B. 1989. Plant-food processing: implications for dietary quality. In *Foraging and Farming. The Evolution of Plant Exploitation*, edited by D. R. Harris and G. C. Hillman. London: Unwin Hyman.

Talalay, L., D. R. Keller and P. J. Munson. 1984. Hickory nuts, walnuts, butternuts, and hazelnuts: observations and experiments relevant to their aboriginal exploitation in Eastern North America. *Prehistory Research Series* VI (2):338-359.

Thiébault, S. 2002. Approche de l'environnement végétal du site d'Öküzini (Turquie) au Tardiglaciaire par l'analyse anthracologique. In *Öküzini: final paleolithic evolution in southwest Anatolia*, edited by I. Yalçınkaya, M. Otte, J. Kozlowski and O. Bar-Yosef. Liège: Eraul.

Weiss, E., W. Wetterstrom, D. Nadel and O. Bar-Yosef. 2004. The broad spectrum revisited: evidence from plant remains. *Proceedings of the National Academy of Science* 101 (26):9551-9555.

Willcox, G. 1999. Agrarian change and the beginnings of cultivation in the Near East: evidence from wild progenitors, experimental cultivation and archaeobotanical data. In *The Prehistory of Food*, edited by C. Gosden and J. Hather. London, New York: Routledge.

Winterhalder, B. and E. A. Smith. 1981. *Hunter-Gatherer Foraging Strategies. Prehistoric Archeology and Ecology*. Chicago: The University of Chicago Press.

Woldring, H. and S. Bottema. 2001/2002. The vegetation history of East-Central Anatolia in relation to archaeology: the Eski Acıgöl pollen evidence compared with the Near Eastern environment. *Palaeohistoria* 43/44:1-34.

van Zeist, W. and J. A. H. Bakker-Heeres. 1984/1986. Archeobotanical Studies in the Levant. 3. Late-Palaeolithic Mureybit. *Palaeohistoria* 26:171-199.

4. Synthesis of the main results

4.1. Identification of plant macroremains

As previously mentioned (§ 1.3.), the identification of plant macroremains recovered in Anatolia and as ancient as those found in Öküzini and Karain B caves is difficult because of the high botanical diversity and the predominantly bad preservation that occur here. During this study, we were confronted with the identification of two particular classes of plant remains: the „nutshells” and the „amorphous“ objects. We will synthesise in the following the experiments undertaken and the identification levels we were able to reach, and suggest future ways of investigation.

4.1.1. The „nutshells“

While the identification of entire nuts or hard shelled fruits are usually possible with the help of their morphology, the matter becomes much more challenging when one deals only with fragments, as it was the case in Öküzini and Karain B. The features present are usually restricted to the thickness of the „shell“, the inner and outer ornamentation, the shape or any particular character one fragment happens to bear. A number of potential species were selected from the modern reference collection housed at University College London and were charred under controlled conditions. These were *Prunus domestica* sbsp. *domestica*, *Prunus domestica* sbsp. *insititia*, *Prunus divaricata* sbsp. *ursina*, *Prunus spinosa*, *Cerasus avium*, *Cerasus vulgaris, Amygdalus communis*, *Amygdalus orientalis*, *Pinus pinea*, *Pistacia atlantica*, *Crataegus monogyna* and *Crataegus orientalis* (nomenclature according to Davis & al., 1965-1988). The exam of the anatomical structure of the „shell“ with the help of scanning electron microscopy (SEM) showed that the transverse section and the inner structure can be useful to separate groups of potential nuts and fruits. In that way, a Prunoideae group (grouping the genus *Prunus*, *Cerasus* and *Amygdalus*), a *Crataegus* group, a *Pinus* group and a *Pistacia* group could be recognised. *Prunus*, *Cerasus* and *Amygdalus* showed a more or less distinct vacuolated inner surface composed of many elongated cells, while the cross section was composed of 2 to 3 layers of round or elongated sclerified cells (Plate 6 & 7). The inner side of *Crataegus* was smooth and made of elongated cells disposed in parallel rows, while the cross section was almost homogeneous with large sclerified cells (Plate 7 : 2). *Pinus* had a very dense „shell“, the sclerified cells showed almost no lumen and were strongly fused together (Plate 7 : 3). The inner side of the shell presented a rough surface without clear pattern. *Pistacia*’s „shell“ was far thinner and its cross section, with a layer of palissadic cells on the inner side, was typical (Plate 2 : 7). The number of potential species examined was far from being exhaustive and this classification will need more investigation in the future. However, these observations could be repeated on experimentally charred and subfossil plant remains with the use of SEM and incident light microscope at a magnification of up to 500X. After the exam of the plant remains from Öküzini and Karain B, it was fairly clear that we were dealing in majority with remains belonging to the Prunoideae group.

In looking more closely to the transverse section of the experimentally charred *Prunus*, *Cerasus* and *Amygdalus* endocarps, it seemed possible to make a distinction between the genus according to the arrangement of the layers and the shape of the cells which composed them. However, the intensity these features vary according to, for example, the location of the cross-section, the maturity of the fruits and the variations of these anatomical features between populations of the same species need additional exploration.

In archaeological specimens, the preservation state rarely allows a complete and well-preserved cross-section: the cells on the inside and outside layers were often eroded. The only possibility to refine the identification was to use features from the shape and ornamentation, when preserved on the fossil plant remains, and to compare them to the entire endocarps of the potential species. This procedure was detailed in the first research paper (§ 3.1.) and resulted in the identification of the „nutshells“ as *Amygdalus graeca* or *A. orientalis*, and in the possible presence among them of *Prunus divaricata*. Because of space limit, we could not include the descriptions and illustrations of the various *Amygdalus* endocarps we came across in the course of that study. As these species are rarely found in botanical reference collections, although remains potentially belonging to these plants are frequent in archaeobotanical assemblages, we would like to include their description here (§ 8.4. and plate 8 to 17).

One could argue that the identification of the botanical macroremains as belonging to genus *Amygdalus*, or even the family *Prunoideae*, would represent a sufficient identification level. We think that the precision gained through the identification of the possible species offered us the opportunity to have a better understanding of the role of the plants in the diet, their season of availability and the environment of the sites.

To conclude, it is important in the study of very old plant macroremains not to neglect any features to attempt identification, even if this is difficult and time consuming. The study of modern reference material is of outstanding importance, especially considering the accelerated rarefaction or even extinction of living species. The preservation conditions represent however an ultimate limit for an identification based on morphological and anatomical features. The resort to chemical analysis, which has already given promising results (McLaren, 1995), might represent an alternative.

4.1.2. The „amorphous“ objects

The remains designated „amorphous“ objects group fragments supposed, on the base of their anatomical structure, to belong to underground storage organs (vegetative parenchymous organs). The state of preservation of these fragments (small size and sometimes vitrification), as well as the lack of an exhaustive reference collection for this type of remains, hindered any further identification. Macroremains of underground storage organs are sparse, in spite of the important role roots and tubers are thought to have played in prehistoric subsistence due to their high concentration of starch. Even if it was not possible to identify these remains, their presence was already informative.

Despite the efforts undertaken up till now to allow the identification of this kind of remains with the help of morphological and anatomical features (Hather, 1991; Hather, 1993), more efforts are still needed to reach a better identification of such remains. An incontrovertible prerequisite for the study of such remains is the access to a complete reference collection. A promising technique represents the starch grain analysis, although it seems that starch grain structure is not often preserved in charred root specimens (Pearsall, 2000). The mention of the presence of such remains at a site is important, even if it seems that their identification will have to wait.

4.2. Diet and plant based subsistence

In the case of Öküzini and Karain B, the botanical macroremains were clearly anthropogenic, being recovered in caves, and were presumably the result of deliberate collecting. Thirteen taxa were positively identified in both caves, all levels together, mostly in carbonised state, sometimes mineralised. Two were only of uncertain identification (*cf*). Beside them, at least five identification categories, which comprise items grouped on the basis of similar morphology, were recognised. Among the remains from Öküzini, *Amygdalus graeca/orientalis* (wild almond), cf. *Amygdalus* and the category „nutshell fragments 0,8-1mm thick“ probably represent remains of wild almonds at different stages of preservation. Other „nuts“ recovered was wild pistache (*Pistacia)* and acorns (*Quercus*). Fruits were more diverse with *Pyrus* (wild pear), *cf. Pyrus* and the category „fruit flesh/ fruit flesh with testa/ fruit flesh with seed imprints“, all probably representing pear remains, *Vitis sylvestris* (wild grape), *Rosa* (rosehip) and *Crataegus* (hawthorn). Small seeded Vicieae (small legumes), as well as seeds and fruits of *Rumex* (dock), *cf. Zygophyllum* (a small shrub), Trifolieae (clover-like plants), *Galium* (a cleaver), *cf. Sparganium* (bur-reed), Cyperaceae (sedge family), *Scirpus* (sedge), Poaceae (grass) and *Bromus* (brome grass) were recovered in insignificant number. The large sized grains of legumes and cereals were identified as intrusions from later levels, what was later attestet with AMS datation. Among the identification categories, the „amorphous objects“ and the not nearer identifiable „amorphous objects/fruit flesh“ were recovered. Additionally a number of unidentified seeds and nutshells were present. The mineralised remains belonged to *Celtis* (hackberry), *Alkanna*, *Pistacia* and *Vitis*. In Karain B, the range of taxa and categories were restricted to those that dominated the Öküzini assemblage: *cf. Amygdalus*, *cf. Pyrus*, „nutshell fragments 0,8-1mm thick“, „amorphous objects“, „fruit flesh“ and „amorphous objects/fruit flesh“. *Celtis* and *Alkanna* were found in mineralised state. Similarly to Öküzini, several seeds of pulse and cereals, later in date, were found.

Remains belonging to the *Amygdalus* group and *Pyrus* group (which put together all the remains thought to belong to the genus mentioned, but at different preservation stages) and to the „amorphous objects/fruit flesh“ were dominant in terms of ubiquity in each archaeological unit dated to the Epipalaeolithic in both caves. Other plant remains like *Vitis*, *Pistacia* and *Quercus*, had moderate presence scores and appeared only in the later archaeological units. We therefore concluded that a limited range of nuts, fruits and roots, bulbs or tubers appeared regularly in the Epipalaeolithic assemblages and represented the main plant resources exploited.

The uses and role of the plants recovered were analysed in terms of ethnographic record of use and nutrient contents. The nutty seeds from wild almonds and pistachios represented the most concentrated resources for vegetal fat and could contribute appreciably to the diet. Almond seeds have valuable nutritional properties, being rich in fat, especially in mono-unsaturated oleic fatty acids. However, almost all wild almonds have bitter nuts, due to the presence of hydrocyanic acid, a toxic substance liberated through the crushing of the seeds. The degree of bitterness differs between almond species and populations (Grasselly, 1976; Grasselly & Crossa-Raynaud, 1980) and sweet type may occur in the nature, but seemingly in low frequency. The toxicity of wild almonds is overcome by careful processing: simple grinding and drying is usually sufficient (Jones, 1998). Wild almonds are still consumed and appreciated in different parts of their distribution area as greens, for the production of oil or roasted. Reliance on food plants containing cyanogenic glucosides is not rare, the best-known example being the consumption of the cassava root (*Manihot esculenta*) by large populations living in the Amazon. Nutritional studies showed that even if the detoxification did not eliminate all the hydrocyanic acid, when cyanogenic plants are eaten slowly or over a period of time, there might be no symptoms of cyanide poisoning. On the other hand, a diet rich in protein seems to have an antagonist effect to the toxic hydrocynnic acid. The fruits of *Pistacia* are also very nutritious and are still used as food in Turkey and the Near East, where they are usually eaten with the shell after roasting.

The fruits from *Celtis*, *Crataegus*, *Pyrus*, *Rosa*, *Vitis* and probably other fruits provided several key nutrients and fibres that animal products either lack or provided in low quantities, and added diversity to the diet. The *Celtis* fruits have an oily seed and a drupe rich in vitamin C. Their use in present times has also been documented (Ertug-Yaras, 1997).

The vegetative underground organs would have been the main resources for carbohydrates. Roots, bulbs and tubers have numerous uses as food when eaten raw or cooked and belong still today to the traditional wild plants exploited in Turkey (Ertug-Yaras, 1997). Their gathering and processing is generally not labour intensive. The acorn, another plant resource rich in starch, has often been used for human food, although its variable tannin content needed sometimes processing. Its record remains however rare, as well as its importance among the wood charcoals (§ 3.3.), and we considered therefore its contribution to the diet as low. Several of the small-seeded plants recovered have valuable nutritional properties, being rich in starch and sometimes in proteins. We interpreted their little importance in the assemblages as a mark of low importance in the diet.

The proteins necessary for a balanced diet were mostly provided through animal resources (mainly ovicaprines, fallow deer, roe deer, red deer and wild boar) (Lopez Bayon, Léotard & Kartal, 2002), various birds, reptiles and fishes. Insects, especially larvae, often exploited by foraging societies, could also have been used, but left no traces.

It appears that the main plants recovered consisted in a variety of wild „nuts“, wild fruits and underground storage organs. Data on the cost of acquisition, that is the estimate handling time (gathering and processing) over the energy yield of the resources, are rare for wild resources. Through experimentation, it was shown that the results for groups of plants with similar morphological characteristics could be seen as similar. Nuts and roots, bulbs or tubers are generally considered as plant foods with high return rate, i.e. high ranked, although their processing requirements can be quiet variable. Small seeds, on the other hand, require labour-intensive processing in order to render them edible and physiologically assimilable, and have therefore a low return rate. Fruits have little calorific significance, their importance lies on their micronutrient content. Overall, the plant resources with high energetic return exploited during the Epipalaeolithic at Öküzini and Karain B required little time and labour to procure and process, apart perhaps the wild almonds.

No chronological trends could be evidence among the plant assemblages recovered. We concluded therefore that there was no apparent subsistence change and no traces of intensification of the plant based subsistence at Öküzini and Karain B during the Epipalaeolithic.

Several artefacts could be connected with plant gathering or processing, unfortunately their use is far from being specific. In this field, a meticulous exam of the tools, in particular the search for and analyses of starch grains could be particularly interesting, as it enabled good results at other sites (E. Weiss pers. communication).

4.3. Seasonality and settlement pattern

The identification of the season during which the caves were used and the mode of occupation (year-round or seasonal) were difficult because the period of availability and gathering of plant food and the season of occupation do not inevitably overlap. Additionally, the botanical remains recovered were accumulated in the caves over several hundreds of years and are therefore no precise indicators for the pattern of use of the caves.

The plant resources energetically the most important for the diet of the foraging populations of southwest Anatolia, i.e. the roots, bulbs and tubers and the nuts, would have been most accessible in winter and spring for the first, in late summer and autumn for the latter (§ 3.2.). Interestingly, the seasonality indicated by the plant remains matches the results from the analyses of the ungulate fauna (Atici & Stutz, 2002). We assume that the communities, which left their traces in Öküzini and Karain B, were nomads or semi-nomads, which occupied the caves intermittently during different seasons. The small size of the settlements suggests that the number of residents comprised a few dozens people at most, and the numerous traces of prehistoric presence in the surroundings could reflect a mobile and dispersed population. The anthracological study indicated that the wood used for fuel originated from the local vegetation and even that the differences in secondary taxa between the caves could reflect wood gathering in the direct surroundings of the caves (§ 3.3.). This would speak in favour of rather short episodes of occupation.

Ethnographic examples showed that mobility is flexible and widely diverse: many modern hunter-gatherers groups switch from one mode of mobility to another according to need and season (Akkermans & Schwartz, 2003). Moreover, modern band-organized people exhibit pattern of concentration and dispersion: rather than living in uniformly sized groupings throughout the year, band societies tend to spend part of the year dispersed into small foraging units and another part of the year aggregated into much larger units (Lee & Daly, 1999). The absence of other excavations and systematic survey of the region makes any hypotheses about the mobility pattern of these Epipalaeolithic communities difficult. The extent of the territories exploited by the hunter-gatherers from Öküzini and Karain B is unknown, but in order to meet the long-term needs of survival it must have been extensive, depending on the distribution of natural resources, the character of the landscape and the density of population.

4.4. Vegetation reconstruction

The Öküzini charcoal assemblages from the lower Epipalaeolithic (archaeological units I and II; between 16.500 and 14.500 uncalBP) comprised a total of 14 taxa, whereas in Karain B, 9 taxa were present. The commonest taxa in Öküzini in all horizons were clearly *Acer* (maple) (100% occurrence), *Amygdalus* (almond) (between 100-50% occurrence) and *Fraxinus* (ash) (between 100-63% occurrence). Maloideae and *Rhamus/Phillyrea* (buckthorn/mock privet), *Prunus* (wild plum) and *Quercus* (oak) were regularly recorded with small scores, *Acer* (R 2-3), cf. *Pistacia* (terebinth), *Olea* (olive tree) and *Salix* (willow) were only sporadically present. *Tamarix* (tamarisk) and Coniferae (coniferous wood) gave only a single fragment each. In Karain B, the same *Acer*, *Amygdalus* and *Fraxinus* (100% occurrence each) were clearly the most common taxa. *Acer* (R 4-5-6), *Prunus*, *Quercus* and *Rhamnus/Phillyrea* were regularly present with smaller scores. Maloideae and Coniferae were quiet common. In terms of percentage fragments counts, *Acer,* followed by *Amygdalus* and *Fraxinus,* were the most abundant taxa in all levels in Öküzini and amply dominated the charcoal assemblages (representing between 89 and 95% of the charcoals). There were no chronological changes visible. In Karain B, the dominance of the 3 taxa *Acer*, *Amygdalus* and *Fraxinus* was even stronger than in Öküzini (between 97 and 93%). The only chronological change was the greater importance of the coniferous wood in the younger phase (PI.1).

To determine the taphonomic influences on the charcoal assemblages, the estimate density, percentage of *indeterminata* (= preservation indices) and diversity were used. The density was obviously lower in Öküzini than in Karain B, the percentage of *indeterminates* was higher in Öküzini, and the diversity was similar (average 8,2 taxa in Öküzini, 9 in Karain B) when archaeological units (AU) are compared. The differences in densities and preservation indices reflect overall bader preservation conditions in Öküzini. This was tentatively explained by the excavation of distinct zones: the centre of the cave in Öküzini, which was a zone of high activity, and a marginal, „midden“ zone in Karain B. Although the representativity of the samples analysed is insufficient in Öküzini but good in Karain B, charcoal assemblages from Öküzini was as diverse or more diverse as that from Karain B. We can therefore suppose that the inhabitants from Öküzini used a larger spectrum of wood taxa that those from Karain B.

The coherence between the charcoal assemblages from all levels and both sites suggested that broadly the same main firewood species were exploited at both sites throughout the Epipalaeolithic and that it probably reflects the availability within the site catchment's area. However, differences appeared between the caves when the composition of the secondary taxa was considered. This was partly attributed to the different representativity of the assemblages, but reflected more probably differences in taxa composition of the procurement areas. The Öküzini inhabitants collected their fuel at the foothills and lower zones of the mountains, where a higher diversity of plants could grow, whereas those from Karain B gathered wood on the mountain flanks. This involves fuel collecting from the nearest resources in an opportunistic manner. This also coincides with the prevalence in the archaeozoological assemblages from

Öküzini of resources, which point to principal use of the plain and lower mountains, whereas at Karain B, the dominance of sheep and goat indicate a preference for montane resources (Lopez Bayon, Léotard & Kartal, 2002).

The reconstruction of the local vegetation at around 16.000 uncalBP according to the pollen and charcoal gave the following image. The plain was presumably a dry area colonised by dwarf shrubs and grasses, traversed in places by streams and rivulets with their hydrophytic vegetation (*Salix*, *Tamarix* and *Vitis*). Only the foothills and protected valleys would allow the growing of mesophillous taxa like the olive tree (*Olea*). The karstic mountain slopes underwent dry and harsh conditions. *Acer*, caducifoliate *Quercus*, *Amygdalus* and *Fraxinus* would have been the main woody taxa colonising the lower mountain flanks, mingled with Maloideae, *Pyrus, Pistacia* trees and bushes like *Crataegus*, *Rosa*, *Rhamnus* or *Phillyrea*. The coniferous trees, more resistant, settled probably on rocky outcrops on the mountain slopes, extending to the higher zones. The presence of tension wood in most of the coniferous charcoals fits well with their probable location. Most of the species attested are light demanding and therefore constituted very open vegetation.

The charcoal assemblages dated from ca. 16.500 to 14.500 uncalBP did not show important changes; therefore we can conclude that the foraging populations of this area exerted little pressure on the local vegetation. Major changes appeared only at ca. 12000 uncalBP with a decrease of *Amygdalus* and an increase of caducifoliate *Quercus* and *Fraxinus*, and was attributed to climatic changes (Thiébault, 2002).

4.5. Comparison with other sites

During the last decades, more and more Late Pleistocene hunter and gatherer sites had plant remains preserved, as long as adapted recovery techniques were used (§ 3.4.). These archaeobotanical records represent indices for a substantial contribution of plants to the diet of prehistoric societies, although the evidence is still meagre owing to matters of preservation.

A comparison between archaeologically known foraging sites is difficult due to preservation biases, differences in the recovery methods, in the kinds of sites excavated and in the scale of the investigations. These differences allow only a comparison with qualitative, sometimes semi-quantitative data. For ease of comparison, we have assumed that the importance of the recovered plant remains was proportional to their importance in the prehistoric diet. The majority of the Epipalaeolithic sites yielded small seeded plants in some proportion: wild cereals, wild grasses, legumes or other small seeds. Among these resources, several species were interpreted as staples due to their abundance. Two geographical trends seem to appear: in the Levantine and Euphrates sites, the wild cereals and other small seeds like *Polygonum* (knotgrass) and *Scirpus* (sea club-rush) seem to dominate, whereas in south east Anatolia and Greece, legume seeds are more varied among the small seeds. Nuts and fruits were regularly present in most of the sites. Roots, bulbs and tubers were only recovered in Wadi Kubbaniya, Franchthi III-IV, Öküzini and Karain B. Simultaneously, Wadi Kubbaniya, Öküzini and Karain B showed very little importance of small seeded resources. The absence of roots, bulbs and tubers at most sites possibly reflects an absence of recognition, but interestingly, the sites where this category of remains was recognised were the same than those in which the small seeds were absent or less important.

4.6. Subsistence and environment

The optimal foraging models were developed within human behavioural ecology to understand the factors and environmental features affecting resource selection: it was assumed that foragers make choices that maximise their foraging efficiency and therefore fitness. Among the different models, the diet breadth model or optimal diet model predicts that the resources a forager chooses from an available set of resources depends on their efficiency rank and abundance in the environment. The analyses of the botanical macroremains from Öküzini and Karain B showed that nuts, fruits as well as roots, bulbs or tubers played an important role among the food plants of the Late Glacial foragers settling at Öküzini and Karain B. These are plants which are generally easy to gather and to process. According to the diet breadth model, the use mainly of high-ranked plant foods reflects their good availability in the environment. It does however not imply the absence of small seeded plants in the environment, but estimates that the resources nuts, roots, bulbs and tubers were privileged because they had better return rates and were sufficiently abundant for the human population that settled in the area. The exploitation in the autumn of the wild almonds, a lower ranked resource because of its need of detoxification, was tentatively explained by risk management behaviour.

The use of the diet breadth model gave rise to the hypothesis that the plant subsistence base of these societies was related to a sufficiently good availability and abundance in the environment of high ranked plant resources. However, although these populations seem to have exploited fuel wood from the available trees and shrubs in an opportunistic way, without traces of shortage, environmental data did not show the existence of a particularly rich vegetal environment. Therefore, it seems that even in a relatively poor environment, the populations did not suffer from scarcity, or did not respond in exploiting less valuable and more labour demanding resources, but rather in moving their camp. The notion of abundance and scarcity of plant resources should be used with caution, as it is related to the duration of an occupation or the density of population, or a combination of both. Even in a poor environment, small and mobile groups can find plenty of resources.

5. Conclusion and perspectives

The study of the plant remains from Epipalaolithic sites might not always be spectacular in the variety and quantities of plant remains recovered, but allows beside the study of their material culture, another approach to the living of early foraging populations. The Anatolian coast has environmental characteristics that differ greatly from most other areas of the Near East that hosted wild ancestors of the earliest domesticates. We have local hunter-gatherer communities underwriting their own distinctive brand of nomadic or semi-nomadic behaviour by exploiting nuts, fruits, underground storage organs, wild mammals and probably fish and birds in a manner that forms a notable contrast to the Late Pleistocene and Early Holocene Levant. However, this investigation has no counterpart in Anatolia and suffers enormously from the lack of comparative studies at a regional scale.

This kind of investigation is very laborious and time consuming owing to the difficulty of recovery and identification of the botanical remains. Beside the improvement of the identification methods, future research will have to focus on the elaboration of interpretation tools. For the modelling of the subsistence strategy, quantitative data on processing cost and nutrient composition of wild plant resources are necessary, implying more experimental work. For a better understanding of the relation between subsistence and environment, the exploitation of the ethnographic literature would be an interesting way to explore. In this respect, we agree with Akkermans's view that „Cautious in the use of modern analogies is required because foragers are immensely varied and their strategies are the results of specific historical and environmental circumstances. However, if we wish to identify general patterns in the forager lifestyle beyond the mere description of material culture, analogy is necessary, and the concerns about the dangers of using ethnographic analogies have not yet led to a credible alternative" (Akkermans & Schwartz, 2003).

We hope that despite these difficulties, archaeobotanical studies will be systematically included in the archaeological excavation of early pre-agrarian sites. Future research can only enrich the picture that is now beginning to emerge.

6. Summary

Located in southwest Turkey, not far from the seacoast, the natural caves of Öküzini and Karain B were inhabited by prehistoric populations during the Late Glacial and beyond. The Epipalaeolithic populations left traces of different occupation phases dated between 16.560 ±180 uncal BP (18.200-17.400 cal BC) to 12.130 ±100 uncal BP (14.400-11.800 cal BC) in Öküzini, around 15.000 uncal BP in Karain B. The topic of this research was to examine the macrobotanical remains associated with the Epipalaeolithic occupations, with the underlying aims to acquire insights about the economy of these communities and their use of the environmental resources.

A first research paper addresses the issue of plant macroremain identification, in particular the identification of „thick shelled“ plant remains. Morphological comparison with the range of potential species and present geographical distribution made it possible to refine the determination to a double species: *Amygdalus orientalis* or *A. graeca*. These plants could grow in the surroundings of the sites on rocky slopes or sandy hills and had to be collected during late summer. All wild *Amygdalus* seeds are toxic, so that their use as food can be disputed. However, through examination of the detoxification possibilities, nutritional properties and ethnographic analogies for the use of wild almonds, we came to the conclusion that the seeds probably played a notable role in the diet of the Epipalaeolithic population of southwest Anatolia. A comparison with further published prehistoric "nutshell" finds from the Near East supports a long and widely distributed tradition of wild almond use.

The analyses of the whole plant macroremain assemblages (excluding wood charcoals) identified at least 18 taxa and "categories" of remains, mainly carbonised. The importance and the role of the plants – particularly in the diet and their bearing on the seasonality of occupation of the sites – have been evaluated with quantitative and qualitative data. Nuts (principally *Amygdalus*, wild almond), fruits (principally *Pyrus*, wild pear), bulbs, roots or tubers (underground storage organs) seem to have occupied a particularly important place in these communities during all Epipalaeolithic phases, at the expense of small-seeded plants. The attested plants would have provided carbohydrates, lipids and micronutrients complementing well the meat diet. The cost of acquisition of the major plant resources was estimated: nuts and underground storage organs were generally considered as high ranked resources, providing a resource easy to gather and to process for a high calorific return. The almonds had a higher cost of acquisition. Their richness in fats and their availability at the onset of the winter season however could justify the additional work required for their detoxification. Judging from the seasonality indices of the plants and ungulate fauna at Öküzini, the cave could have been inhabited periodically in all seasons, but particularly in spring and autumn.

A third paper presented the use of firewood and palaeoenvironmental reconstruction using anthracological and other environmental data. The diversity of fuel wood used was moderate and at both sites *Acer* (maple), *Amygdalus* (wild almond) and *Fraxinus* (ash) were the most common and important taxa. Secondary taxa were composed of Maloideae, *Pyrus* (wild pear), *Prunus* (wild plum), *Quercus* (cadufoliate oak), and *Rhamnus*/*Phillyrea* (buckthorn/mock privet). No chronological changes were observed. The major difference between both caves was the presence of hygrophilous and mesophillous taxa in Öküzini, whereas Coniferous wood was more common in Karain B, leading to the interpretation of an opportunistic exploitation of the surroundings of each site. Despite the poverty of the Late Glacial vegetation, there was no indication of use of alternative fuel material. These Epipalaeolithic populations seem to have responded to shortages rather through mobility than intensification. The anthracological results have been integrated to present-day knowledge of the environment of southwest Anatolia in an attempt to reconstruct the local vegetation.

Among the different models of optimal foraging, the diet breadth model predicts that the resource a forager chooses from an available set of resources depends on their efficiency rank and abundance in the environment. Knowing from former investigations what plant resources were collected by the Epipalaeolithic populations from Öküzini and Karain B, we used this model to estimate the richness of the various classes of plant resources in the environment of the sites. An exploitation of high ranked plant resources, the nuts and the roots, bulbs or tubers, instead of small seeds, probably reflected their good availability in the environment. On the other hand, although the pattern of fuel use did not show any indices of wood scarcity, the reconstruction of the vegetation resulted in an environment not particularly rich in plant resources. The density of population being low, we suppose that the Epipalaeolithic populations living in this region adapted to their natural conditions in moving regularly their camps.

7. Bibliography

Akkermans, P.M.M.G. & Schwartz, G. 2003. *The archaeology of Syria. From complex hunter-gatherers to early urban societies (ca. 16000-300 BC).* Cambridge: Cambridge University Press

Atici, L. & Stutz, A. 2002. Analysis of the ungulate fauna from Öküzini: a preliminary reconstruction of site use, seasonality, and mortality pattern. In I. Yalçinkaya, M. Otte, J. Kozlowski & O. Bar-Yosef (eds), *Öküzini: final paleolithic evolution in southwest Anatolia.* Liège: Eraul. 101-108

Bar-Yosef, O. 2002. Öküzini cave - a view from the Levant. In I. Yalçinkaya, M. Otte, J. Kozlowski & O. Bar -Yosef (eds), *La grotte d'Öküzini: évolution du Paléolithique final du sud-ouest de l'Anatolie.* Liège: Eraul. 375-379

Butler, A. 1989. Cryptic anatomical characters as evidence of early cultivation in the grain legumes (pulses). In D.R. Harris & G.C. Hillman (eds), *Foraging and farming. The evolution of plant exploitation.* London: Unwin Hyman. 390-407

Colledge, S. 1988. Scanning electron studies of the cell patterns of the pericarp layers of some wild wheats and rye. Methods and problems. In S. Olsen (eds), *Scanning electron microscopy in archaeology.*

Colledge, S. 2001. *Plant exploitation on Epipalaeolithic and early Neolithic sites in the Levant.* Oxford: BAR International series

Davis, P.H. & al., e. 1965-1988. *Flora of Turkey and the East Aegean Islands. Vol. 1 (1965); Vol. 2 (1967); Vol. 3 (1970); Vol. 4 (1972); Vol. 5 (1975); Vol. 6 (1978); Vol. 7 (1982); Vol. 8 (1984).* Edinburgh: Edinburgh University Press

Ertug-Yaras, F. 1997. *An ethnoarchaeological study of subsistence and plant gathering in central Anatolia.* Washington University

Grasselly, C. 1976. Les espèces sauvages d'amandiers. *Options Méditerranéennes* 32, 28-43

Grasselly, C. & Crossa-Raynaud, P. 1980. *L'amandier.* Maisonneuve et Larose

Hather, J.G. 1991. The identification of charred archaeological remains of vegetative parenchymous tissue. *Journal of Archaeological Science* 18, 661-675

Hather, J.G. 1993. *An archaeobotanical guide to root and tuber identification. 1. Europe and South West Asia.* Oxford: Oxbow Monograph

Hillman, G.C. 1989. Late Palaeolithic plant foods from Wadi Kubbaniya in Upper Egypt: dietary diversity, infant weaning, and seasonality in a riverine environment. In D.R. Harris & G.C. Hillman (eds), *Foraging and Farming. The Evolution of Plant Exploitation.* London: Unwin Hyman. 207-239

Hillman, G.C., Wales, S., McLaren, F., Evans, J. & Butler, A. 1993. Identificating problematic remains of ancient food: a comparison of the role of chemical, histological and morphological criteria. *World Archaeology* 25, 94-121

Jones, D.A. 1998. Why are so many food plants cyanogenic? *Phytochemistry* 47, 155-162

Kartal, M. 2003. Anatolian Epi-Paleolithic Period Assemblages: Problems, Suggestions, Evaluations and Various Approaches. *Anadolu/Anatolia* 24, 45-61

Kelly, R.L. 1995. *The foraging spectrum. Diversity in Hunter-Gatherer lifeways.* Washington London: Smithsonian Institution Press

Kislev, M.E. 1984. Pre-domesticated cereals in the pre-pottery neolithic A period. In I. Hershkovitz (eds), *Man and culture in change.* BAR International Series. 147-236

Kubiak-Martens, L. 1996. Evidence for possible use of plant foods in Palaeolithic and Mesolithic diet from the site of Calowanie in the central part of the polish plain. *Vegetation History and Archaeobotany* 5, 33-38

Lee, R. & DeVore, I. 1968. *Man the hunter.* Chicago: Aldine

Lee, R.B. & Daly, R.H. 1999. *The Cambridge Encyclopedia of hunters and gatherers.* Cambridge: Cambridge University Press

Lopez Bayon, I., Léotard, J.-M. & Kartal, M. 2002. Séquence stratigraphique de la grotte d'Öküzini. Remplissage naturel et remplissage anthropique. In I. Yalçinkaya, M. Otte, J. Kozlowski & O. Bar -Yosef (eds), *La grotte d'Öküzini: évolution du Paléolithique final du sud-ouest de l'Anatolie.* Liège: Eraul. 25-39

Mason, S.r.L., Hather, J.G. & Hillman, G.C. 1994. Preliminary investigation of the plant macro-remians from Dolni Vestonice II, and its implications for the role of plant food in Palaeolithic and Mesolithic Europe. *Antiquity* 68, 48-57

McLaren, F.S. 1995. Plums from Douara Cave, Syria: the chemical analysis of charred stone fruits. In H. Kroll & R. Pasternak (eds), *Res Archaeobonaticae. International Workgroup for Palaeoethnobotany. Proceeding of the 9th Symposium Kiel 1992.* Kiel: 195-218

Nesbitt, R.M. 1997. *Archaeobotanical identification of Near Eastern grass caryopses.* PhD Thesis, University College London

Özdogan, M. 1997. The beginning of Neolithic economies in southeastern Europe: an Anatolian perspective. *Journal of European Archaeology* 5, 1-33

Özdogan, M. 1998. Anatolia from the Last Glacial Maximum to the Holocene climatic optimum: cultural formations and the impact of the environmental setting. *Paléorient* 23, 7-24

Panter-Brick, C., Layton, R.H. & Rowley-Conwy, P. 2001. *Hunter-gatherers an interdisciplinary perspective.* Cambridge: Cambridge University Press

Pearsall, D.M. 2000. *Paleoethnobotany. A Handbook of Procedures. Second Edition.* San Diego: Academic Press

Shiva, V. 1993. *Monocultures of the mind.* London: Zed Books

Thiébault, S. 2002. Approche de l'environnement végétal du site d'Öküzini (Turquie) au Tardiglaciaire par l'analyse anthracologique. In I. Yalçinkaya, M. Otte, J. Kozlowski & O. Bar-Yosef (eds), *Öküzini: final paleolithic evolution in southwest Anatolia.* Liège: Eraul. 95-99

Yakar, J. 1991. *Prehistoric Anatolia. The Neolithic Transformation and the Early Chalcolithic Period.* Tel Aviv: Monograph Series of the Institute of Archaeology Tel Aviv University

8. Catalogue

See § 3.1. for the cited bibliography.

Site abbreviations

ÖK	Öküzini
KB	Karain B

Measurements of the plant remains

L	Length
B	Breadth
T	Thickness
LS	Stalk length
PCH	Chalaza position

The plants are listed in systematic order according to the Flora of Turkey and the East Aegean Islands (numbers between brackets), Davis (1965-1988)

Photographs of the plant macroremains by Georges Haldimann. SEM photographs Zentrum für Mikroskopie Universität Basel and University College London. Photographs of the modern almond species and drawings by Danièle Martinoli.

8.1. Taxa

Alkanna TAUSCH (87.30.)

Preservation state: mineralised

Site: ÖK

Measurements: (n = 6) L = 2.15mm (1.7 – 2.5); B = 2.15mm (1.9 – 2.6); T = 1.6mm (1.4 – 1.8).

One extremity was elongated-pointed, bordered on each side with two smaller tips; the other end bore a round hilum scar surrounded with a bold rim. The nutlets were bent and had a hard, siliceous testa, beige to rust coloured. The surface was sparsely covered with small and round pustules in an unsteady pattern.

Because of their hard shell, the uncarbonised *Alkanna* nutlets survive well in the archaeological sediments and tend to be overrepresented.

There are more than thirty *Alkanna* species in Turkey. No attempt has been made to identify the fossil remains to species level. The ecology and fruiting season of the various *Alkanna* plants vary a lot, but they grow mostly in dry environments.

Amygdalus graeca LINDLEY/*orientalis* MILLER and cf. *Amygdalus* L. (46.9.6/7)

Preservation state: carbonised endocarp fragments

Site: ÖK

Measurements: (n = 10) L = 4.71mm (3.3 – 7.1), B = 3.94mm (2.5 – 6.8), T = 1.0mm (0.8 – 1.2)

Plate 1, 1 & 2

The fragments were of various shapes according to the parts of the endocarp they originated. The ones coming from the surroundings of the hilum plate bore deep and more or less thick grooves. They were curved, reflecting a rounded, though laterally slightly flattened, hilum apex. Some of them held parts of the round elongated hilum plate. Other fragments comprised segments of the ventral keel, which was well individualised and sharp. A strong main groove delimited the keel on each side, bordered by one, sometimes two, weaker grooves incising the lips. In cross-section, the cavity of the main vascular bundle was visible in the centre of the keel or slightly displaced to the inner side. Many fragments came from the flanks of the endocarps and differed only through their ornamentation, which could be longitudinally grooved, reticulate or smooth. Some pieces came form the basal extremity: they were laterally flattened and pointed. After a review of the morphological features of the *Amygdalus* and *Prunus* endocarps and of their present-day geographic distribution, the most probable identification resulted in the two closely related species *Amygdalus graeca* Lindley and *Amygdalus orientalis* Miller (Martinoli & Jacomet, 2004). Additional fragments without characteristic identification features have been identified as cf *Amygdalus*. They were generally small and eroded, occasionally weakly grooved. The characters they shared were a 1mm thick shell with a similar histological arrangement in transverse section. These fragments presumably also belonged to *Amygdalus*.

Amygdalus graeca is a shrub or small tree between 1 and 4 m and grows on limestone rocks in phrygana, between 10 and 500m. It is a xerophytous and low altitude plant. *Amygdalus orientalis* is a shrub, 0.5 to 3m tall, growing in open sunny niches such as sandy hills covered with steppe or steppe forest, on limestone cliffs or on rocky calcareous slopes, between 600 and 1500m (Browicz, 1972a; Browicz, 1972b; Browicz & Zohary, 1996; Davis & al., 1965-1988).

***Bromus* L. (145.23.)**

Preservation state: carbonised seed

Site: ÖK

Measurements: L = 3mm, B = 0.9mm, T = 0.42mm

The fruit was oblong and plane. In cross-section, the dorsal side was domed; the ventral side was more or less flat to hollow. The basal end was tapering, but the embryo was broken off. The linear hilum did not reach the apex of the fruit. The surface was longitudinally shrivelled and the wrinkles followed the curved apex.

A great number of *Bromus* species were reported from Turkey (Davis & al., 1965-1988). For lack of sufficient seed reference material, it was not possible to reach at a more accurate identification.

***Celtis* L. (110.3.)**

Preservation state: mineralised endocarps (whole, halves and fragments)

Site: ÖK

Measurements: (n = 10) L = 6.22mm (5.44 – 7.2); B = 5.57mm (4.96 – 6.08); T = 5.70mm (5.12 – 6.56).

Plate 2, 3

The mineralised endocarps were nearly spherical and composed of two symmetric and empty halves, with a somewhat protuberant median suture. The endocarp was slightly tapering progressively at one end, forming a small appendix curved over the suture. The base of the endocarp was often somewhat flat. The testa colour varied from grey, beige to red, was hard and about 0.5 mm thick. The rugulose surface was covered with a coarse reticulate pattern, but this ornamentation was sometimes eroded. The *Celtis* endocarps were always preserved in a mineralised state but as these fruits are very rich in calcium carbonate (approx. 70% weight in fresh specimens), they are very resistant to degradation. It is the reason why the antiquity of *Celtis* endocarps found in archaeological excavations is questionable. In the case of a cave site, most of the botanical remains are anthropogenic, natural contaminations are unlikely. Even an intrusion by animals seems dubious, on account of the deepness of the sequence (over 3 m).

Four species of *Celtis* grow in Anatolia today (Davis & al., 1965-1988). They have quiet similar pericarps, sometimes overlapping forms, so that species identification is difficult. However, *Celtis tournefortii* and *C. australis* have the most resembling endocarps and represent therefore a credible identification. *Celtis australis* is a 20 to 25m tree and grows on open rocky slopes and in thickets, rarely in forests. *Celtis tournefortii* grows as a shrub or a small tree up to 6 m in open rocky places.

***Crataegus* L. and cf. *Crataegus* L. (46.27.)**

Preservation state: carbonised seeds (whole and fragments)

Site: ÖK

Measurements: L = 7.0mm, B = 6.6mm, T = 4.2mm

Plate 2, 4

The pyrenes were hemispherical to three faced, almost as broad as large. Apex and bottom were blunt. The domed dorsal side bore 2 to 3 broad longitudinal ridges. The ventral side was flat to roof-shaped. The latter bore the hilum in the middle, at approximately 1/3 from the apex. The surface of the pyrene was rough. A very characteristic feature was the thick pyrene wall (between 0.7 and 1.2mm), composed, in transverse section, of isodiametric sclerified cells. The inside of the pyrene was smooth and shiny. One whole pyrene and two fragments too small to allow secure identification were found. The shape of the former indicated that it belonged to a two-seeded fruit.

According to (Davis & al., 1965-1988), seven species occur in Turkey with 1-2 or 2-3 pyrenes per fruit. These are deciduous, usually thorny trees or shrubs. Their ecology varies between steppe, oak forest, calcareous hills and rocky slopes.

Cyperaceae (144.)

Preservation state: carbonised fruit fragment

Site: ÖK

Measurements: L = 1.74mm, B = 1.2mm

The fruit was a bilateral compressed nutlet, ovate in outline and tapering at the apex. The base was mucronate. The typical Cyperaceae surface ornamentation was preserved: it consisted in small quadrangular cells oriented in longitudinal rows. The interior of the nutlet (the seed) was preserved.

This family groups perennial, biennial or annual herbs with varied ecologies.

***Galium* L. (118.6.)**

Preservation state: carbonised seed

Site: ÖK

Measurements: D = 2.3mm, T = 1.6mm; D = 2.8mm, T = 2.0mm

The fruit was hemispherical, with a round cavity dug on the flat side. The surface pattern was eroded in one specimen, composed of small rectangular cells in an other. No attempt was made to identify the fruits to species level.

***Indeterminata* seeds/fruits**

Preservation state: carbonised seeds (whole and fragments)

Site: ÖK

This category comprises badly preserved and mostly fragmented seed and fruit remains not nearer identifiable.

***Pistacia* L. (43.3.)**

Preservation state: carbonised and mineralised endocarps (whole and fragments)

Site: ÖK

Measurements: ÖK (n=21): L = 3.65mm (2.8-4.2); B = 3.5mm (2.8-4.7); T = 2.4mm (1.7-2.9)

Plate 2, 5 & 6

The nutlets were globular, slightly longer than broad, laterally more or less compressed and varied in size. They had a flat base (hilum plate) and a rounded apex tapering in a small point. The surface was smooth and in a few cases partially covered by the remnants of the receptacle. The endocarp shell was approximately 0.2 to 0.3mm thick. It presented a characteristic transverse section when seen at high magnification (400x): the inner side was bordered with one layer of elongated palissadic cells. Even small fragments could still be identified when this feature was present. Doubtful identifications due to bad preservation were attributed to *cf. Pistacia*.

Five wild pistachio species grow in Turkey. Two of them (*P. lentiscus* L., small and flat endocarps; *P. eurycarpa* Yalt., large and globular endocarps) can be eliminated from the identification possibilities on morphological grounds. *P. khinjuk* Stocks is probably unlikely according to its modern geographic distribution exclusively in southeast Turkey. The two species left, *Pistacia atlantica* Desf.and *P. terebinthus* L., produce very similar nutlets fitting well with the fossil remains. Hence, both species represent possible identifications. *P. atlantica* Desf. is a deciduous tree up to 7m. It grows at present on dry hillsides, cemeteries, field edges and roadsides, from see level to 1500m. This tree often occurs as a vestige of destroyed forest. *P.terebinthus* L. is a shrub of 2 to 3m, or a small tree up to 6m. It grows on rocky slopes from 50 to 1500m and is a component of macchie, pseudo-macchie and *Pinus brutia* forest.

Poaceae (145.)

Preservation state: carbonised seed

Site: ÖK

Measurements: L = 3mm, B = 1.02mm, T = 0.72mm

The seed was oblong, dorso-ventrally compressed with flat ventral side and domed dorsal face. The greatest width was in the middle of a caryopse slightly tapering towards the upper and lower ends. The ventral side and both extremities were damaged.

Pyrus L. and cf. *Pyrus* L. (46.34.)

Preservation state: carbonised seed and almost whole fruits and fruit fragments, in some cases with seeds included.

Site: ÖK

Measurements: seed (n = 1) L = 6.0mm, B = 3.6mm, T = 2.6mm. The estimate size of the fruits is 10mm in diameter; the fragments measuring between 3 x 5mm and 10 x 10mm.

Plate 3, 6-10

The seed was drop-shaped with a pointed tip. One side was flat, the other convex. The surface was covered with a thin, longitudinal cell pattern. Pear seeds are very difficult to differentiate from apple, but because of the positive identification of pear and absence of apples, the seed was identified as cf *Pyrus*.

The fruits were globose to subglobose, all of them partially damaged. Several specimens were squashed, but it was difficult to tell if that happened before or after charring. The peduncle zone was always convex. The well-preserved fruits often displayed a faint concavity on one side, in which the calyx scar was still visible. The *Pyrus* fruit fragments originated from various parts of the fruit and, therefore, they owned different features. Their main identification features were the presence of clusters of stone cells, the structure of the testa, the morphology of the calyx remains and the shape of the seeds. A secure determination relied on the simultaneous presence of stone cells together with another feature. When only one isolated feature could be observed, we identified the plant remain as *confer (cf) Pyrus.* The fruit testa was composed of small hexagonal to rounded, convex cells. Where the testa was damaged, the granular and coarse texture of the fruit flesh appeared. This resulted from the presence of clusters of sclerotid cells (called stone or grit cells). The stone cells formed small or large clusters (between 0.2 to 1.2mm in diameter) surrounded by radiating parenchyma cells (Plate 3, 9), and were particularly numerous at proximity of the peduncle and calyx zones and around the seed cavity. The calyx remains were composed of a circle of 1.7 to 3.2mm diameter of 5 sepal remains, bordered on the inside with the stalklet like remains of the stamens. Up to 5 style bases were in some cases preserved in the centre of the circle. Several fragments of wild pear contained the seeds still *in situ,* radiating around the central axis.

Nine species of *Pyrus* grow in Turkey and hybridisation is widespread. By the size of the fruits, a single species would be an appropriate candidate, that is *Pyrus boissieriana* Buhse. However, it is hazardous to base the identification solely on the size, which can vary and be biased through carbonisation or human selection. According to the modern distribution of the wild pears (Browicz, 1982-1992; Davis & al., 1965-1988), five species (including *Pyrus boissieriana*) are improbable. The four remaining species (*Pyrus communis* L. (subsp. *communis* and subsp. *caucasica*), *P. amygdaliformis* Vill., *P. syriaca* Boiss. and *P. eleagnifolia* Pallas) have all been observed in southwest Anatolia today, but have large fruits up to 2 or 3 cm. Consequently, we could not state which species corresponds to the fossil remains. It is also conceivable that more than one species was represented in the assemblage. Wild pears grow in various environments, from field edges, stream banks, dry stony slopes, macchie and deciduous or coniferous forests, from see-level up to 2000 m.

Quercus **L. and cf** ***Quercus*** **L. (113.3.)**

Preservation state: carbonised endocarp fragments

Site: ÖK

Measurements: fragments between approximately 20 x 10.4mm and 3 x 3mm.

The acorn fragments had a smooth surface, longitudinally slightly grooved. One can catch a glimpse of the original ovate shape from the largest fragments. The texture of the acorns was dense, scattered with small radial splits resulting from the carbonisation.

Oaks are deciduous or evergreen trees or shrubs. They represent an extremely important genus, with a high number of species, widespread hybridisation and introgression.

Rosa **L. (46.23.)**

Preservation state: carbonised fruitlets (whole and fragments) and a pseudocarp fragment

Site: ÖK

Measurements: seeds L = 3.6mm, B = 2.8mm, T = 1.7mm; L = 3.3mm, B = 2.4mm, T = 2.0mm; fruit L = 8.5mm, B = 6.5mm, T = 3.0mm; L = 10.9mm, B = 4.5mm, T = 2.7mm.

Plate 4, 10 & 11

The achenes had the shape of a croissant presenting a triangular cross-section. The largest face was convex, the two flanks were flat to slightly convex and of similar size. The size and shape of the achenes varied a little, presumably depending on their position in the "fruit". The surface pattern consisted in longitudinal compact ridges. Additionally, transverse oscillations appeared on the lateral sides. One extremity of the fruitlets was pointed, the other was blunt and bore the triangular-rounded hilum scar. The achenes shell were approximately 0.25mm thick. The achenes had a single cavity with a shiny inner side presenting a weak pattern of transverse lines.

Two fragments of an ovoid "false-fruit (pseudocarp) were identified, partly covered with a wrinkled testa. In the genus *Rosa*, the pseudocarp consists in a fleshy and often coloured thickening of the hypanthium. At high magnification (100x), the testa showed small and weakly protruding pustules. The fleshy part of the false fruit measured approximately 0.8 to 1mm thick. It was composed of rather small vacuoles. The interior of the false fruit revealed a cavity covered with a dense network of long and thick bristles, shaping several niches where the fruitlets originally took place. The remains of small peduncles were set at the base of each of these cavities.

Twenty-four *Rosa* species are present in Turkey with highly similar fruits and fruitlets, so we made no attempt to identify the remains further than genus level. These deciduous shrubs grow in variable environments.

Rumex L. (15.7.)

Preservation state: carbonised fruit

Site: ÖK

Measurements: L = 1.74mm, B = 1.02mm, T = 1.02mm

The fruit was obovate, triangular in cross-section, with an acuminate apex. The fragments of a smooth testa adhered at the base of the nutlet, and showed the presence of sharp edges. A furrow, representing the original embryo position, carved longitudinally the middle of one side.

A specific identification was not attempted. This genus includes 23 species in Turkey, annual or perennial herbs with diverse ecologies.

Bolboschoenus maritimus **(L.) Pallas and cf.** ***Bolboschoenus*** **(L.) Pallas (syn.** ***Scirpus maritimus*** **L.) (144.11.1.)**

Preservation state: carbonised fruits and fragments of fruit

Site: ÖK

Measurements: L = 1.8mm, B = 1.32mm, T = 0.96mm; L = 1.38mm, B = 1.38mm, T = 1.02mm.

The fruit was ovate in outline. The ventral side was more or less flat, while the dorsal side was roof-shaped with a rounded median ridge. At the pointed apex, the three edges became sharp and the shell was somewhat parted. The bottom bore a small scar. The eroded surface was slightly striated. According to the preservation state, it was possible to make a more or less (*cf.*) secure identification.

This species is widespread today in Turkey. It grows in freshwater or saline marshes, stagnant swamps, water meadows and by streams and rivers.

Cf. ***Sparganium*** **L. (141.1.)**

Preservation state: carbonised seed

Site: ÖK

Measurements: approximately 1.5mm in diameter

The fruit was subglobular. A circular cavity was situated on a somewhat flattened side. The surface presented indistinct longitudinal strips.

Sparganium are perennial aquatic or semi-aquatic herbs, growing in lakeshores, riverbanks, marshes or wet soils. Three species are found in Turkey.

Trifolieae

Preservation state: carbonised seed

Site: ÖK

Measurements: L = 1.08mm, B = 1.44mm, T = 1.2mm

The seed was poorly preserved. It was subspherical in shape, with a small radicle bent along 1/4 of the surface. The testa, smooth, had almost entirely disappeared. The interior of the seed consisted of large vacuoles.

The Trifolieae tribe groups an important number of species with very diverse ecology.

Vicieae small-seeded

Preservation state: carbonised seeds (badly preserved) and seed fragments

Site: ÖK

Measurements: L = -, B = 2.2mm, T = 2.3mm; fragment’s average diameter 2.15mm (between 1.9 and 2.3mm).

The seeds were spherical and subspherical, composed of two cotyledons. Fragments of the smooth seed coat were occasionally preserved, but the hilum was always missing. The radicle, preserved in some cases, was bent over a somewhat flattened side. These remains were attributed to small-seeded, wild *Vicieae.* Their ecology could not be specified.

Vitis sylvestris GMELIN (38.40.1.)

Preservation state: carbonised and mineralised pips (whole and fragments); carbonised fruit flesh, some with pips included

Site: ÖK

Measurements: ÖK seeds (n = 36, carbonised): L = 3.89mm (2.6-5.2), B = 3.13mm (2.1-3.8), LS = 0.48mm (0.2-0.8), PCH = 1.60mm (0.6-2.3); ÖK (n = 4, mineralised): L = 4.62mm (4.5-4.8), B = 3.62mm (3.0-4.1), LS = 0.32mm (0.2-0.5), PCH = 1.9mm (1.8-2.0).

Plate 4, 12 & 13

The pips were subglobose to heart-shaped and varied in size. They bore a short stalklet at one extremity of the pip, a round or slightly oval structure called chalaza on one side, and two deep and almost parallel grooves incised the opposite face. The characteristic shape of the pips together with the structure of the transverse section of the testa authorised the identification even of small fragments. The testa present 2 zones viewed in transverse section at high magnification (100x): an aerated parenchyma with isodiametric thin-walled cells on the outside, a dense tissue made up of radially elongated stone cells in the inner part. Occasionally, the fossil specimens had the negative shape from the interior, hollow space, of the seed.

Nearly whole and fragments of grape berries were found. The fruits were globular to oval and measured approximately 8 to 10mm in diameter. The surface of the berry was often wrinkled. When preserved, the testa showed a smooth structure composed of faint isodiametric and convex cells. The fruit flesh was made of large, thin-walled vacuoles. A secure identification was possible with the help of the presence of seed fragments embedded in the fruit flesh, the structure of the testa and the hexagonal shape of the peduncle scar.

Vitis sylvestris is a woody climber that grows in deciduous forests on mountainsides and valleys, often near rivers or streams, from sea level to 1600m.

Cf. *Zygophyllum fabago* L. (34.1.1.)

Preservation state: carbonised

Site: ÖK

Measurements: L = 4.91mm, B = 2.27mm

One half of the longitudinal seed was preserved. It was oval and elongated in shape with a strongly curved rim, pointing to a very flat whole seed. The surface bore a characteristic ornamentation consisting of small, regularly arranged, *papillae*. The hilum, which was set in the modern seed on one fringe, was not preserved in the fossil specimen.

Two *Zygophyllum* species are present in Turkey: *Z. fabago* L. has seeds similar in size, shape and surface pattern to the fossil remain, *Z. album* L. has much smaller seeds. The first is an Irano-Turanian perennial herb growing on waste places or in steppes between 50 and 1000m, and on alluvial plains in desert region.

8.2. Identification categories

Amorphous objects indeterminata

Preservation state: carbonised fragments

Site: ÖK

Measurements: various sizes

Plate 5, 14-16

These charred amorphous objects consisted in rounded fragments made of a dense structure, with a distinct organisation. Some of them were observed at high magnification (Scanning Electron Microscopy). They often contained elements of vascular tissue, like vessels with spiral thickenings, surrounded with a highly silicified tissue carved with an irregular pattern of cavities. The original external surface had usually disappeared, apart from two specimens resembling to small bulbs. It was not possible to identify any of these objects, but it consists most probably in underground organs like roots, bulbs or tubers.

Amorphous objects/fruit flesh indeterminata

Preservation state: carbonised fragments

Site: ÖK

Measurements: various sizes

This category groups amorphous objects with a vacuolated, often badly preserved (silicified) structure. These remains were not suitable for further identification. They comprised also small fragments, which could not be attributed with certainty to any other identification category. These remains can result from the carbonisation of fruit flesh or parenchymous tissue of underground organs.

cf. *Faeces*

Preservation state: carbonised

Site: ÖK

Measurements: approximately between 3 - 4mm long, 2 – 3mm broad, 1.5-2mm thick

Plate 5, 17

The fragments are of different shape and size. A widespread form was a flat half moon with rounded borders. The structure comprised oval elongated items included in a matrix, which reminded us insect eggs and raised the possibility that the cf.faeces remains represent bat pellets.

Fruit flesh/fruit flesh with testa/ fruit flesh with seed imprints indeterminata

Preservation state: carbonised fruit flesh fragments

Site: ÖK

Measurements: various sizes

This category groups tissues with an irregularly and thin-walled vacuolated structure. No stone cells were observed. There are three kinds of remains: 1) those without any other feature 2) those with a fragment of testa, but eroded or undifferentiated and 3) those with “seed” imprints or pericarp remains, but small and not characteristic.

These fragments could belong to various fruits, including pear and apple, but the identification features are missing.

***Indeterminata* type g**

Preservation state: carbonised fragments

Site: ÖK

Measurements: various sizes

This category groups fragments with a rather smooth surface, and a dense and compact structure. The shape is often laterally flattened, sometimes like a croissant, with rounded borders. The fragments bore sometimes several lines parallel to concave border.

”Nutshells” 0.8-1mm thick *indeterminata*

Preservation state: carbonised fragments

Site: ÖK

Measurements: approximately between 4 x 4mm to 2 x 2mm

This category groups “nutshell” fragment of various size, 0.8 to 1mm thick. These fragments were small and eroded; the surface ornamentation or other features were absent. However, the transverse section was similar to the remains identified as *Amygdalus graeca/orientalis* and *cf. Amygdalus*. Since this anatomical structure is analogous and distinctive in *Amygdalus* and *Prunus* endocarps, the *Indeterminata* “nutshells” 0.8-1mm thick belong presumably to one or the other genus, although the features for a secure identification are missing.

“Nutshell” < 0.5mm thick *indeterminata*

Preservation state: carbonised fragments

Site: ÖK

Measurements: various sizes

This category groups very small and thin (between 0.25 and 0.5mm thickness) shell fragments. The shape, surface structure or transverse section showed no feature allowing any identification. Different taxa could be represented here.

8.3. Suspected contaminants omitted from the analyses

Vicia ervilia WILLD. (45.40.23.)

Preservation state: carbonised seeds

Site: ÖK

Measurements: L = 3.4mm, B = 3.4mm, T = 3.6mm; L = 3.0mm, B = 2.9mm, T = 2.4mm; L = 1.94mm, B = 2.0mm, T = 2.18mm.

The seeds had a typical tetrahedral shape with a small radicle at one summit, bent over a somewhat flattened face. The hilum was not preserved.

One specimen from GH VII (square L6b, AH 26) has been AMS-dated and clearly represented an intrusion from the later occupation levels.

Cf *Lens* MILLER (45.41.)

Preservation state: carbonised seeds (whole and fragments)

Site: ÖK

Measurements: (n = 6) L = 3.2mm (2.4 – 4.0), B = 3.3mm (2.6 – 4.0), T = 2.1mm (1.8 – 2.4).

The seeds were composed of two round, laterally rather flat cotyledons. The position of the radicle on the otherwise regularly curved circumference was indicated by a slight notch. Fragments of the smooth testa were sometimes preserved. We left the identification to *confer* (*cf*), because of the hilums, which shape and position are specific, could not be observed.

Two seeds from GH III (square J10c, AH 14) were AMS dated and clearly younger in date. Specimens belonging to this species were therefore excluded from the analysis.

***Lathyrus* L. (45.42.)**

Preservation state: carbonised seed

Site: KB

Measurements: L = 3.0mm, B = 2.5mm, T = 2.5mm

The seed was axe shaped, almost rectangular in profile. One of the triangular faces bore the radicle. The large size of the seed let us assume a contamination from younger levels.

Vicieae large-seeded

Preservation state: carbonised seed fragments and cotyledons

Site: ÖK

Measurements: average diameter approximately 3mm (range between 2.8 and 4.5mm)

This taxon groups seed fragments composed of two symmetric cotyledons composed of dense tissue. The shapes of the seeds varied: some were rounded or tetrahedral, some were more flat. The testa, when preserved, was smooth, but most of the specimens were eroded. Radicle and hilum were missing. The fragments have been identified as large seeds of the *Vicieae* tribe, but their preservation was inadequate to more precise identification.

These remains were excluded from the analysis, since the dating of other *Vicieae* remains showed their intrusive origin (see AMS dating of cf. *Lens* and *Vicia ervilia*).

***Triticum monococcum* L. (145.14.2.)**

Preservation state: carbonised seed

Site: ÖK

Measurements: L = 4.8 mm, B = 2.34 mm, T = 2.58 mm

The caryopse was oval elongated, with pointed base and apex. The ventral and dorsal sides were convex. The cross section was triangular rounded.

According to the large size and plump shape the seed had the appearance of a domestic einkorn grain. AMS dating evidenced that it is an intrusion dated to the Neolithic period.

***Triticum dicoccon* Schrank (145.14.5.)**

Preservation state: carbonised seeds (whole and fragments)

Site: KB

Measurements: L = 2.3mm, B = 2.5mm, T = 2.3mm

In profile, the seed had a flat ventral side, a rounded back and a pointed apex. The bottom part of the grain was broken but the length reached at least 6mm.

***Hordeum vulgare* L. (145.19.8.)**

Preservation state: carbonised seeds

Site: KB

Measurements: L = 5.3mm, B = 3.5mm, T = 3.1mm

The profile was regularly spindle shaped. The ventral face bore a superficial furrow, had regularly curved flanks and was the largest in its middle. Bottom and apex were blunt, although often damaged. The testa was strongly eroded. Only 1 grain could be measured.

Cerealia

Preservation state: carbonised seed

Site: ÖK

Measurements: L = 5.1mm, B = 2.6mm, T = 2.0mm

The seed was ovate elongated, pointed at the base with a thin embryo cavity, damaged at the apex. The ventral and dorsal sides were straight, the flanks slightly curved. The surface was very damaged.

This seed represents probably an intrusion from overlaying levels.

8.4. Modern *Amygdalus* endocarps

The description of the endocarps of the different Amygdalus species described here are a synthesis between data gained from the literature (Browicz, 1969; Browicz, 1972a; Browicz, 1972b; Browicz & Zohary, 1996; Grasselly, 1976; Grasselly & Crossa-Raynaud, 1980; Townsend & Guest, 1966-1985) and from own observations on modern specimens from different collections (Botanical Institute Basel, Nesbitt and Samuel collection, Felipe and Grasselly collection Zaragoza). The nomenclature was adopted from (Browicz & Zohary, 1996).

The essential morphological features are the shape and size of the endocarp, the arrangement of the ventral and dorsal sutures and the surface pattern. The ventral suture is most often well built, forming lips defined by the course of the vascular bundles and having a more or less angular shape. Laterally, the vascular bundles diverge into secondary bundles, which imprints form more or less strong reticulate, pitted, rugulate, grooved or areolate sculptures over the endocarp. The texture of the endocarp shell differs from dens to fibrous, with vascular bundles included in the shell or not. An important feature results also from the position and size of the attachment scar of the peduncle (hilum).

Subgenus *Amygdalus*

Section *Amygdalus*

Communis species group

Amygdalus communis (including *A. korschinskyi*)

This species include all the almond varieties cultivated today and many feral and „weedy" forms. Its occurrence as a wild plant has been questioned. Some authors recognise its existence as a truly wild species occupying primary habitats, but disagree on its geographical distribution, which is either the Levantine countries (Browicz & Zohary, 1996) or middle Asia (Browicz, 1989; Grasselly, 1976). Other authors consider *A. communis* not as a genuine wild form, but rather as a hybrid or a descendant of other wild almond species (Kester & Gradziel, 1996). This shows that the wild ancestor of the cultivated almond has not yet been properly identified, and therefore its geographical origin remains hypothetical. Browicz and Zohary (1996) recognise 3 subspecies: i) subsp. *communis*, the cultivated fruit tree, ii) subsp. *spontanea*, spontaneously growing large mesic wild forms and weedy forms, not distinguishable with the morphology and iii) subsp. *microphylla* (syn. *A. korschinskyi*), a smaller and more xeric subspecies, growing in the Levant.

Amygdalus communis is very variable in regard to size, form and ornamentation of the endocarp, thickness of the shell and also taste of the seeds (Browicz, 1969). The endocarp is ovoid to ellipsoidal, up to 50x30mm (Browicz & Zohary, 1996). The stone is keeled and finely pitted, more or less grooved, frequently somewhat compressed. *Anygdalus korschinskyi* has irregularly pitted or only pitted in the lower part stones, sometimes with pits running into short grooves, and indistinctly keeled (Browicz, 1972a).

Amygdalus trichamygdalus

The drupe is broadly ovoid to narrowly ovate and compressed, up to 30x20mm, and the stone is pitted (Browicz, 1972a).

Amygdalus fenzliana

The endocarp is ovoid and laterally compressed, large. The hilum surface is flattened, rather small and elongated, irregular, and the base is pointed. The keel is sharp and protruding, bordered by one main longitudinal furrow on each side and a few others less well-built and not continuous grooves. The flanks are smooth and slightly pitted in the upper part, reticulate in the dorsal half, particularly at the base. The fruits are bitter (Grasselly & Crossa-Raynaud, 1980).

Amygdalus webbii

The endocarps are ovate and globular, sometimes pointed at the base, 15 to 20mm long. The keel is slightly built, bordered with longitudinal grooves visible only in the basal part. The ornamentation consists in small pits, sometimes elongated into short grooves. The hilum surface is flat and large, bordered by a serie of pits. The shell is dense but perforated by longitudinal vascular bundles. The nut tastes extremely bitter (Ak, Acar & Sakar, 2000).

Amygdalus haussknechtii

The drupes are about 25x18mm. The endocarp is elliptico-ovate, laterally compressed, with an obtuse or mucronate apex, sparsely foveolate, carinate and more or less sulcate (Browicz, 1969).

Amygdalus browiczii (including *A. zabulica*)

We have not found any description of the endocarp of *A, browiczii*, but as mentioned by Grasselly (1980), it should be identical to *A. zabulica.* The thick mesocarp and deep suture gives the fruit the aspect of an apricot. The endocarp is ellipsoid elongated, 18x12mm, with the hilum extremity slightly flattened and the other rounded. The stone is laterally rather compressed. The keel is not protruding but sharp and the two grooves on each side are distinct on the whole length. The flanks are pitted, with some pits elongated in short grooves. The seed is little bitter.

Amygdalus kuramica

This tree differs from the cultivated species by its small, flat endocarp, up to 17x12mm, with very typical sculpture (Grasselly & Crossa-Raynaud, 1980). The endocarp is ovoid, laterally flattened and slightly pointed at the basal end. The shell is thick (15mm). The hilum scar is small. The keel is sharp but not protruding, bordered by one strong main groove on each side extending over the whole length of the stone. The flanks bear some deep longitudinal grooves, which make a ramification in the lower part of the endocarp. The seed is bitter (Grasselly & Crossa-Raynaud, 1980).

Amygdalus bucharica

The endocarp is ovoid, up to 20x11mm, flat at the hilum extremity, elongated and pointed at the other end, laterally compressed. The shell is thin (10mm). The hilum plate is large. The keel is not protruding but sharp, and its two lateral grooves are weak. The flanks bear a superficial ornamentation consisting in longitudinal grooves, which can form a reticulate pattern in the basal part of the endocarp. It is a very variable species in several features like the sculpturing of the stone surface and the shape of the apex (Grasselly & Crossa-Raynaud, 1980). The endocarp is mostly straight, but can also be a bit curved (Browicz, 1969).

Amygdalus tangutica (including *A. dehiscens*)

A globulous, 20mm long fruit (Browicz & Zohary, 1996; Grasselly & Crossa-Raynaud, 1980) and roughened endocarp (Kester & Gradziel, 1996) are the only descriptions found for this almond.

Orientalis species group

Amygdalus orientalis

The endocarp is ovoid elongated, up to 19x10mm, flattened at the top, pointed at the base, and laterally compressed. The hilum plate is oval and elongated, rather small. The keel is obtuse, very sharp, protruding, and is bordered with one deep and broad groove on each side over the whole length of the endocarp. Sometimes a secondary, longitudinal weaker groove is present in the upper half of the lips. The surface pattern is composed of longitudinal grooves starting around the hilum plate and getting weaker on the flanks. In some cases, the grooves can form ramifications on the sides and form a dense reticulate pattern. *A. orientalis* is very variable in size and shape of the fruits (Dönmez & Yildirimli, 1998).

Amygdalus graeca

This species is closely related to *A. orientalis*. The stone is 18x12mm and bears 1 or 2 grooves along both sides of the obtuse keel, otherwise is smooth or partly and indistinctly reticulate-grooved (Browicz, 1972a).

Amygdalus eleagnifolia

The endocarp is up to 20mm long, obtuse to mucronate, more or less foveolate, with the pits, in particular near the base, merging into small furrows, and indistinctly sulcate (Browicz, 1969).

Amygdalus kotschyi

The endocarp is 10-15mm long, has an obtuse base, no keel, is smooth or pitted, with pits merging into small furrows, or has short shallow grooves (Browicz, 1969; Browicz, 1972a).

Amygdalus carduchorum

The endocarp is ovate-globose up to 15mm long, almost smooth to indistinctly pitted and bears soft short furrows, sometimes slightly keeled (Browicz, 1972a).

Amygdalus mongolica

The fruit is 20mm long and 10mm broad (Browicz & Zohary, 1996).

Section *Chamaeamygdalus*

Amygdalus nana

Apart that the fruit is ovate and relatively small (10-20mm long) (Browicz & Zohary, 1996), no mention was made about the endocarp.

Amygdalus georgica

This species has small and broadly ovate fruits (17-20mm long) with shallow grooves.

Amygdalus ledebouriana

The fruit of this species closely resembles to that of *A. nana*, but is larger.

Amygdalus petunnikovii

This species has relatively large fruits (15-28mm long) and the endocarp is constricted or beak-like at the hilum extremity.

Section *Spartoides*

Amygdalus arabica

The drupes are globose to ovate, slightly compressed, up to 14-20x8-12mm. The endocarp is smooth or has indistinct grooves near the hilum base and the keel is hardly developed (Browicz, 1972a; Townsend & Guest, 1966-1985).

Amygdalus scoparia

The endocarp is rather small, up to 15-10mm, ovoid pointed, with the hilum extremity slightly blunt, the other pointed. The keel is not protruding but sharp, bordered with two more or less well built but superficial grooves. The dorsal furrow is rather deep. The flanks are almost smooth and the hilum scar is small.

Subgenus Dodecandrae

Amygdalus lycioides

The fruit is ovate to broadly ovate, laterally compressed and small (15x12mm). The endocarp is longitudinally grooved or reticulated and narrowly keeled (Browicz, 1972a).

Amygdalus spinosissima (including *A. turcomanica*)

The endocarp is ovoid pointed, flattened, up to 14x10mm, but ovate to ovate-lanceolate and more or less flattened to subglobose or globose-ovate fruits were also observed (Grasselly & Crossa-Raynaud, 1980). The hilum surface is small and flat, sometimes bordered with a small hump in its dorsal part. The keel is not protruding but sharp, the grooves on each side are more or less well build. The dorsal furrow is distinct. The flanks are almost smooth, sometimes with weak longitudinal grooves.

Amygdalus eburnea

The fruit is small (10-15mm long), ovate to ovate-globular (Browicz & Zohary, 1996). The endocarp is sometimes wider than long and slightly sculptured (Grasselly & Crossa-Raynaud, 1980). The hilum extremity is slightly sulcated, rarely reticulate-sulcate, the other extremity is sub obtuse and the endocarp is carinated (Browicz, 1969).

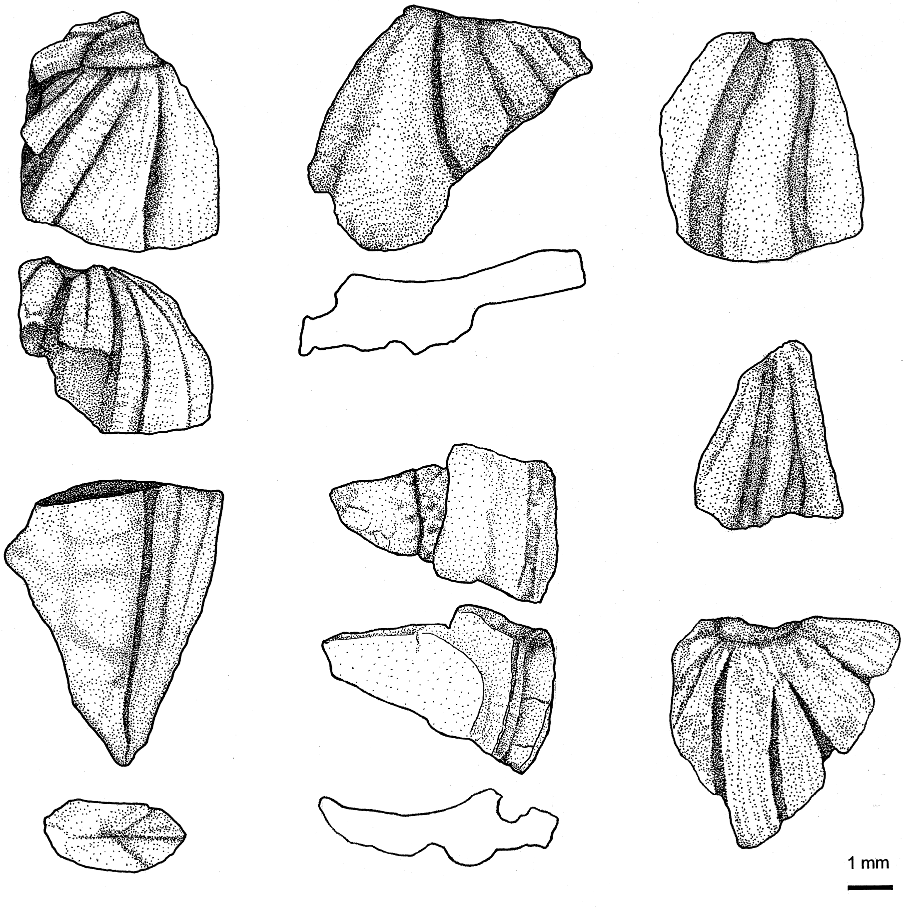
Amygdalus brahuica (including *A. afghana*)

The endocarp is ovate, up to 15x12mm, slightly asymetric, more or less flat, with a blunt or obliquely truncated hilum extremity and an obtuse or mucronulate point. The hilum scar is small, surrounded with multiple thin and deep grooves. The keel is not protruding, but acute and bordered with longitudinal furrows on both sides. The shell surface is reticulate-sulcate, sometimes pitted.

Amygdalus erioclada

No description of the endocarp was found.

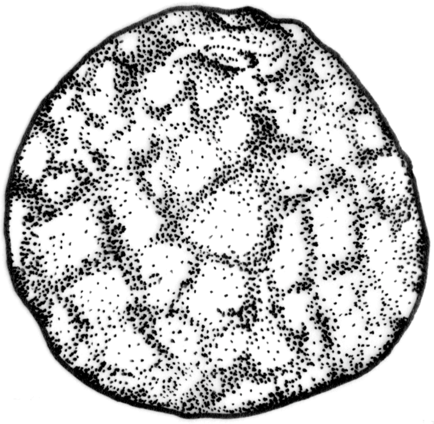
1



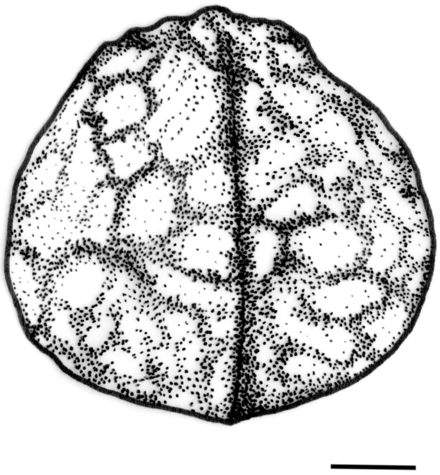
2

1. *Amygdalus graeca/orientalis,* charred endocarp fragments. 2. *Amygdalus graeca/orientalis,* charred endocarp fragments.

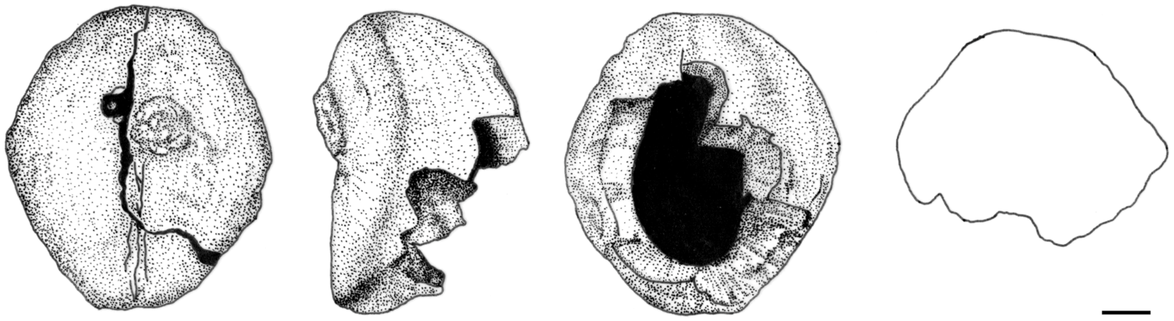
Plate 2

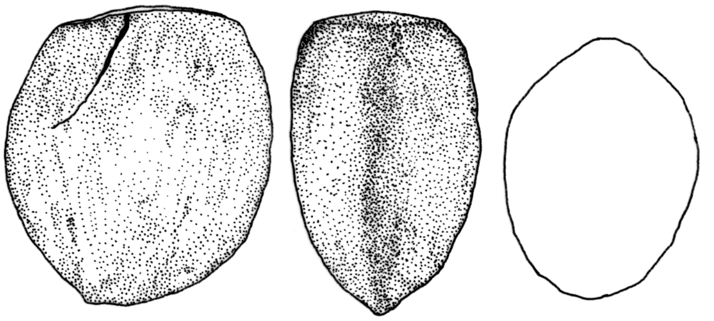


3

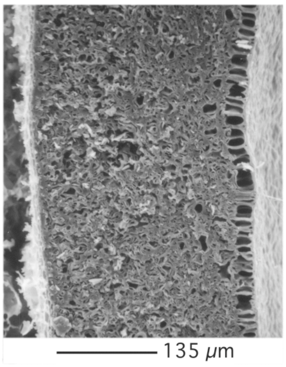


4



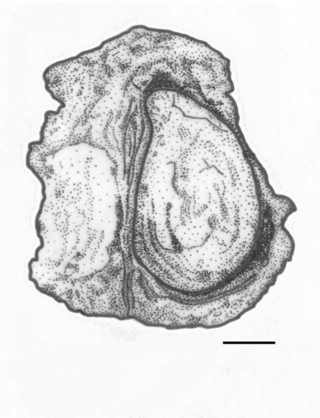


5

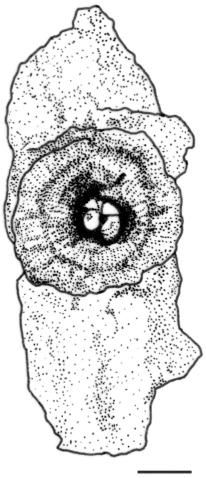


6

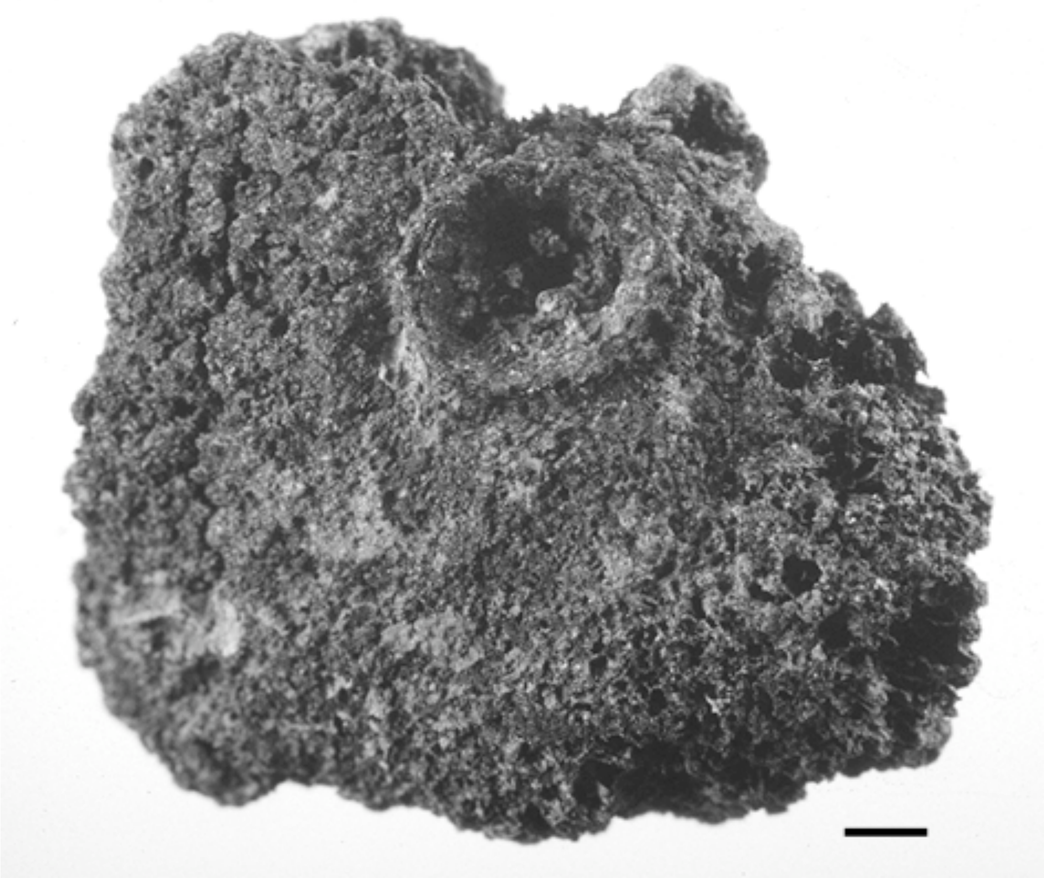
3. *Celtis,* mineralised endocarp. 4. *Crataegus,* charred pyrene. 5. *Pistacia,* charred endocarp.
6. Transverse section of experimentally charred modern endocarp of *Pistacia atlantica* Desf. Showing the intern layer of palissadic cells.



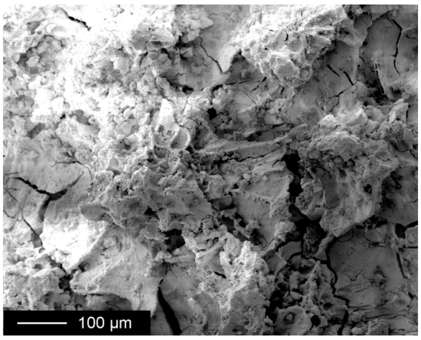
6



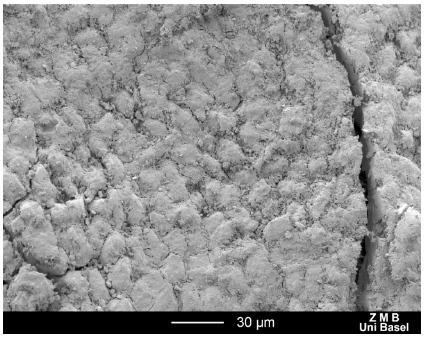
7



8

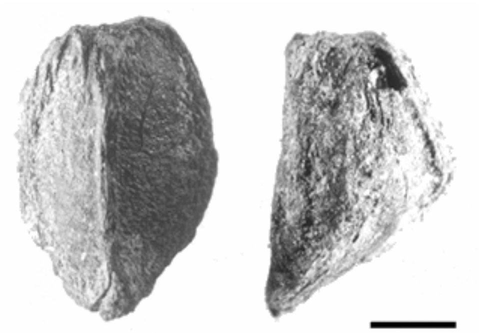


9



10

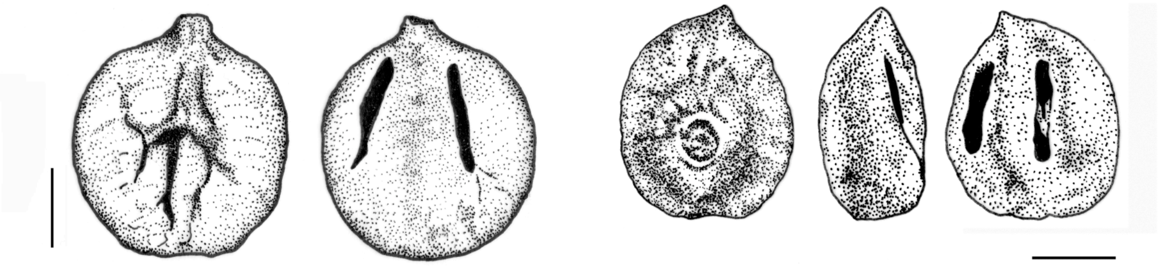
6. *Pyrus,* charred fruit fragment with seeds. 7. *Pyrus,* charred fruit fragment with the remains of the calyx. 8. *Pyrus,* charred fruit fragment with the remains of the calyx. 9. *Pyrus,* detail of charred fruit flesh showing clusters of stone cells surrounded with elongated parenchyma cells. 10. *Pyrus*, charred fruit flesh showing the structure of the testa.



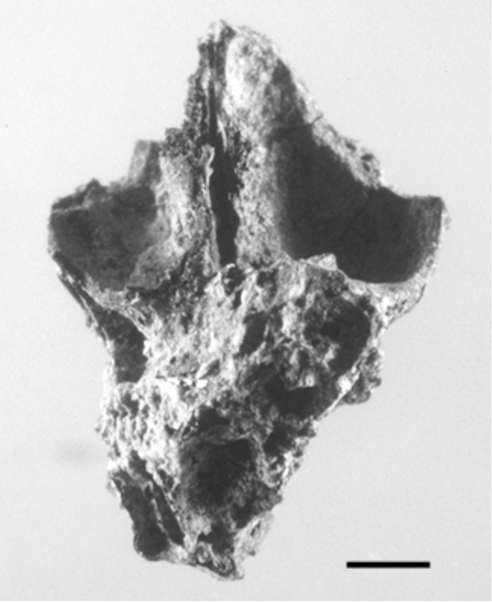
10

11a

b

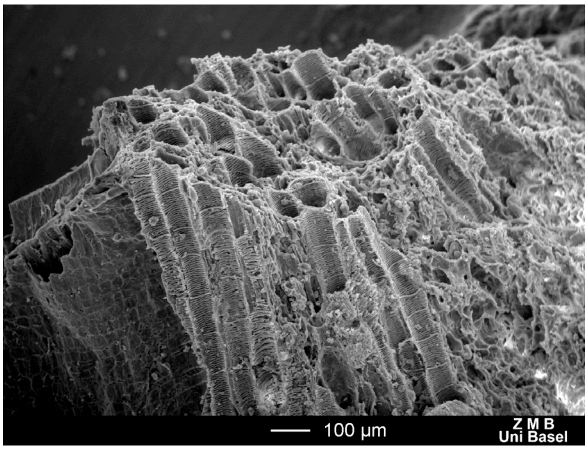


12

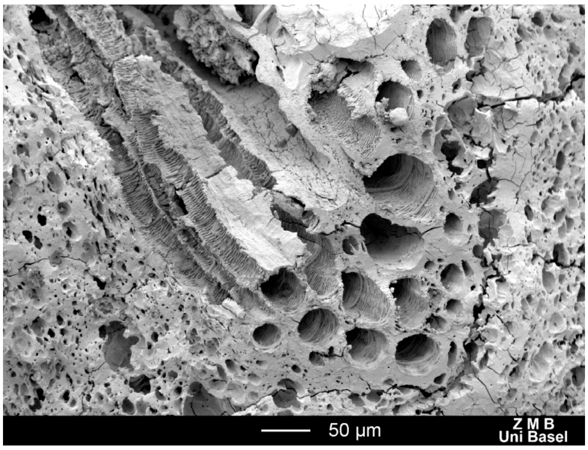


13

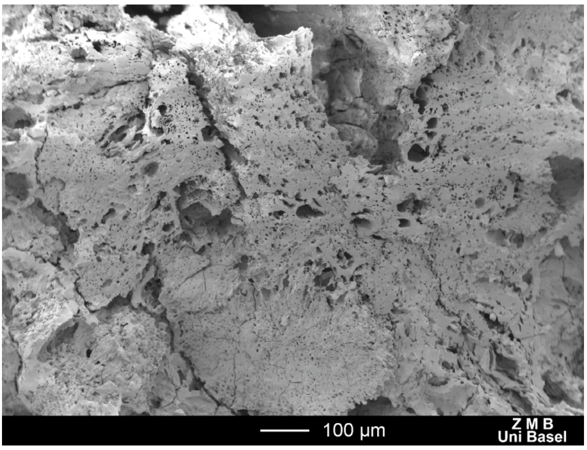
10. *Rosa*, charred fruitlet. 11.a. *Rosa*, inner cavity of charred pseudocarp. 11.b. *Rosa,* outer side of charred pseudocarp with testa remains. 12. *Vitis*, charred seeds. 13. *Vitis*, charred fruit fragment with seeds.



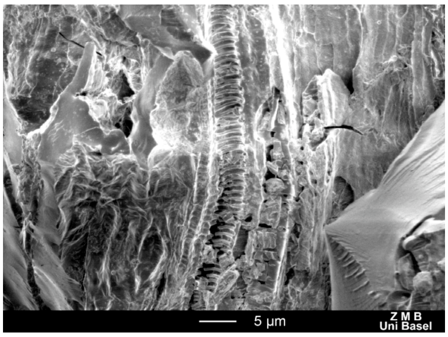
14



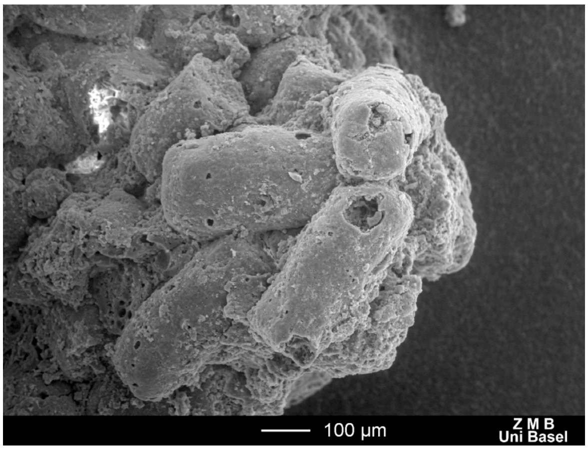
15



16a

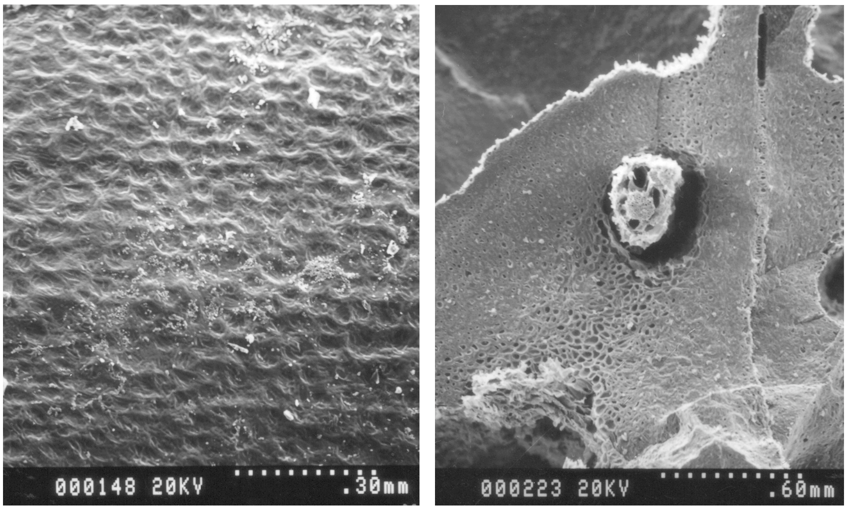


b

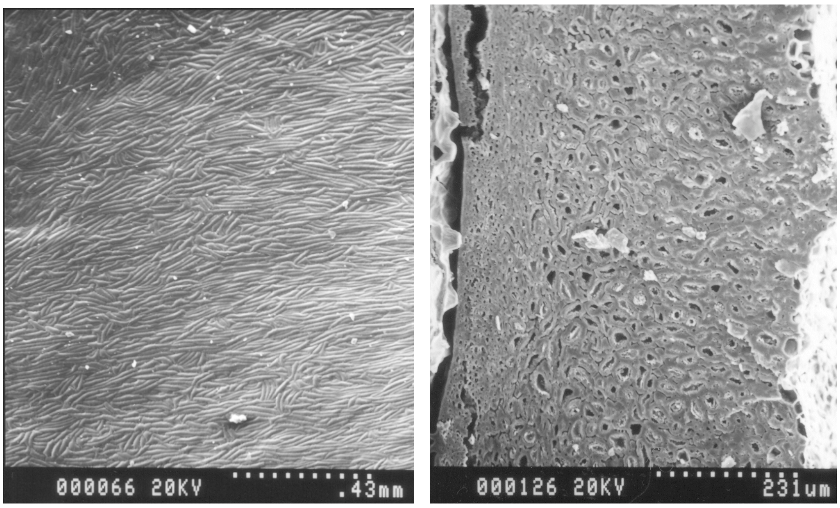


17

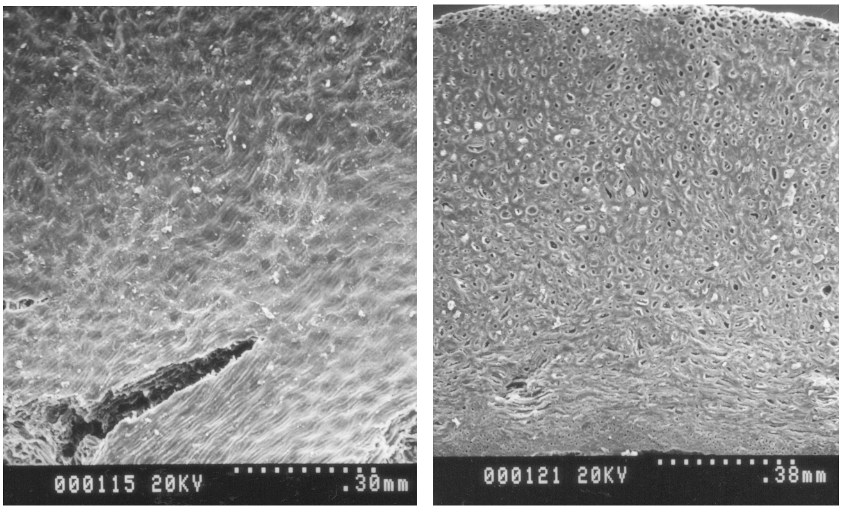
14. Amorphous object *indeterminata*, charred. 15. Amorphous object *indeterminata*, charred. 16.a. Amorphous object *indeterminata*, charred. 16.b. Detail of 16.a. showing vascular structures. 17. Detail of charred cf Faeces, composed of an aggregate of oval elements.



1

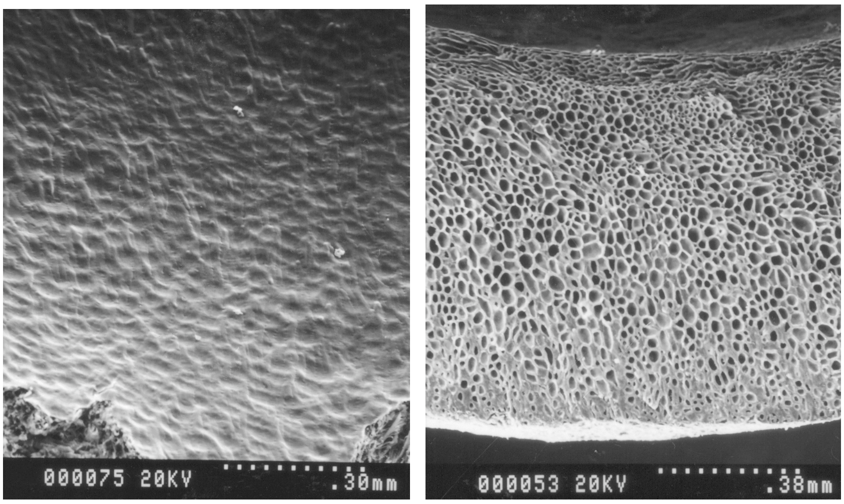


2

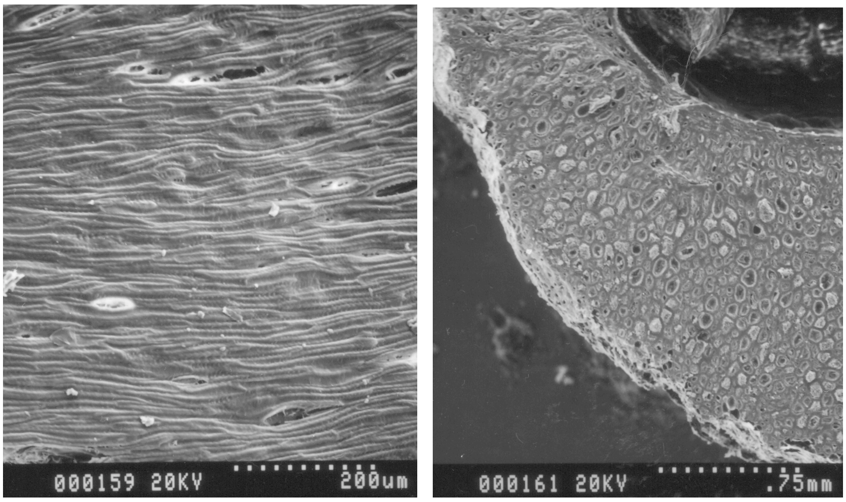


3

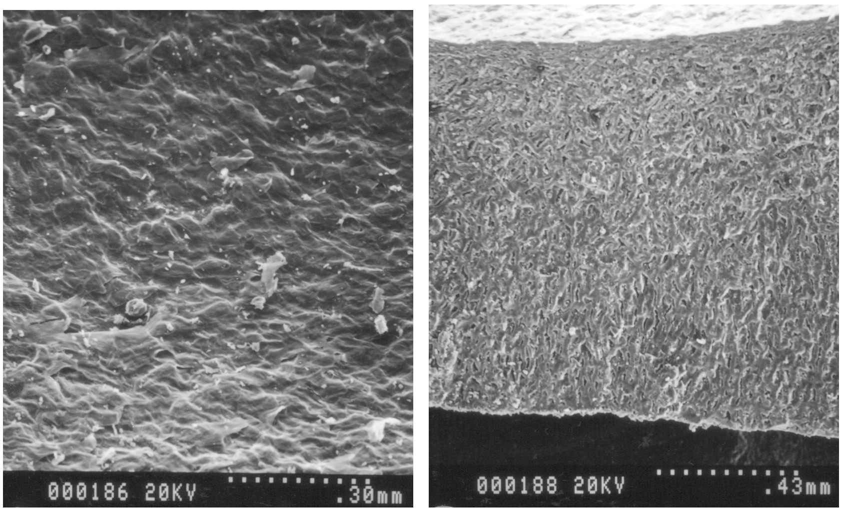
1. Experimentally charred *Amygdalus communis* endocarp from UCL collection (GCH 2948): inside and cross section 2. Experimentally charred *Prunus domestica* subsp. *domestica* from UCL collection (GCH 4135): inside and cross section 3. Experimentally charred *Prunus divaricata* subsp. *ursina* endocarp from UCL collection (SP 156).



1



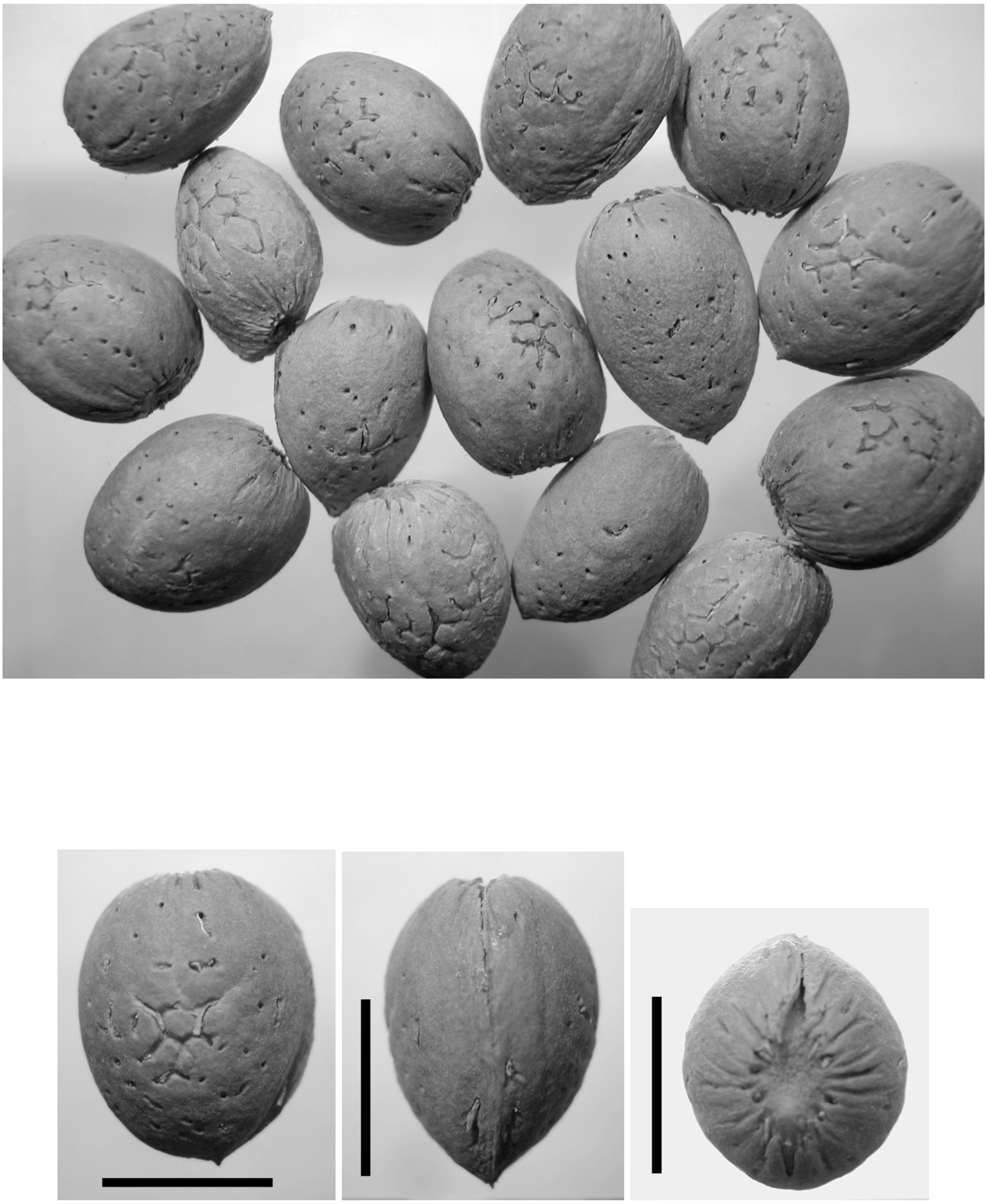
2



3

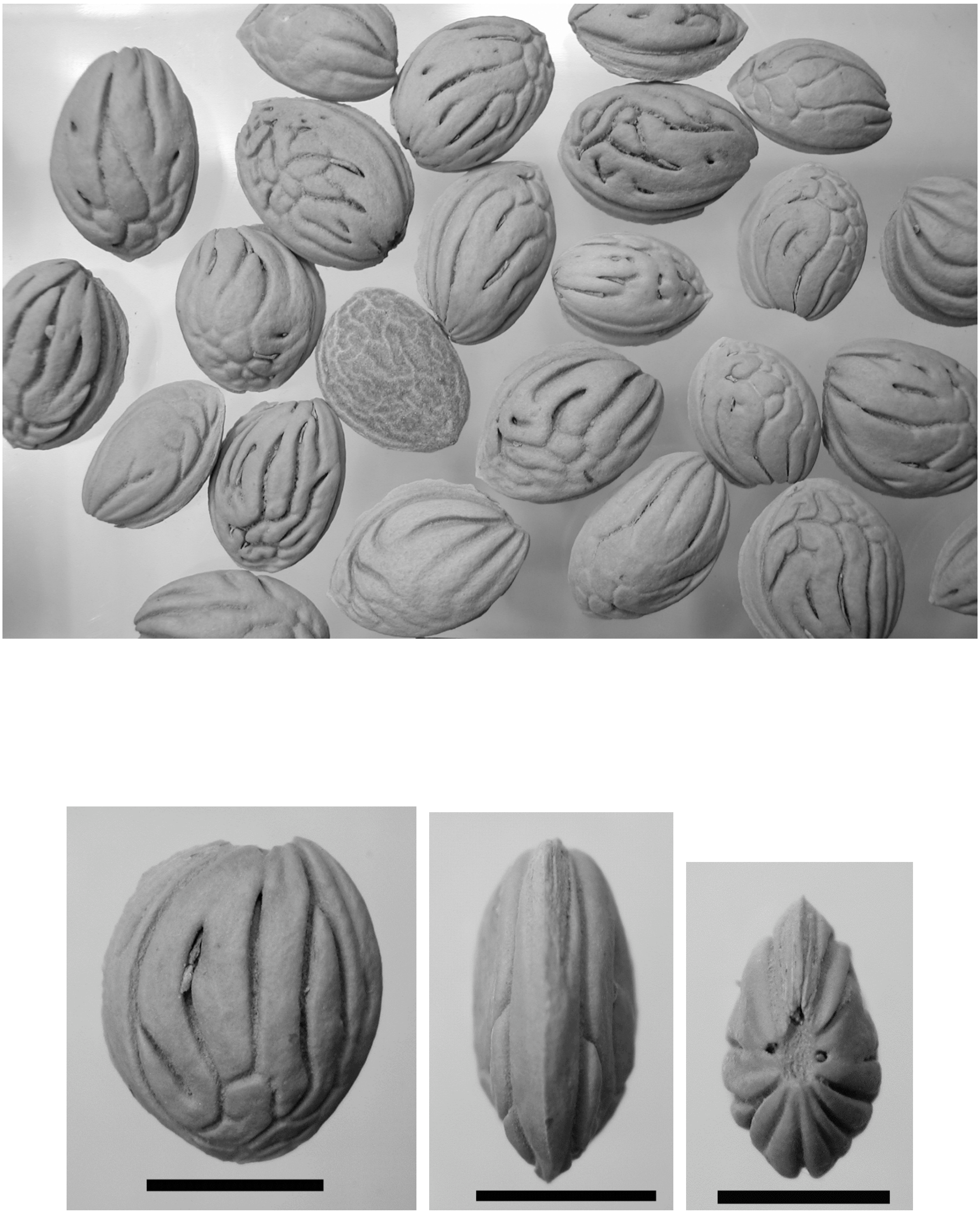
1. Experimentally charred *Cerasus avium* endocarp from University College London (UCL) collection (GCH 3694) : inside and cross section 2. Experimentally charred *Crataegus monogyna* pyrene from UCL collection : inside and cross section 3. Experimentally charred *Pinus pinea* seed from UCL collection: inside and cross section.

Amygdalus fenzliana endocarps. Scale = 1cm. Proveniance Iran (Felipe and Grasselly collection, Zaragoza)

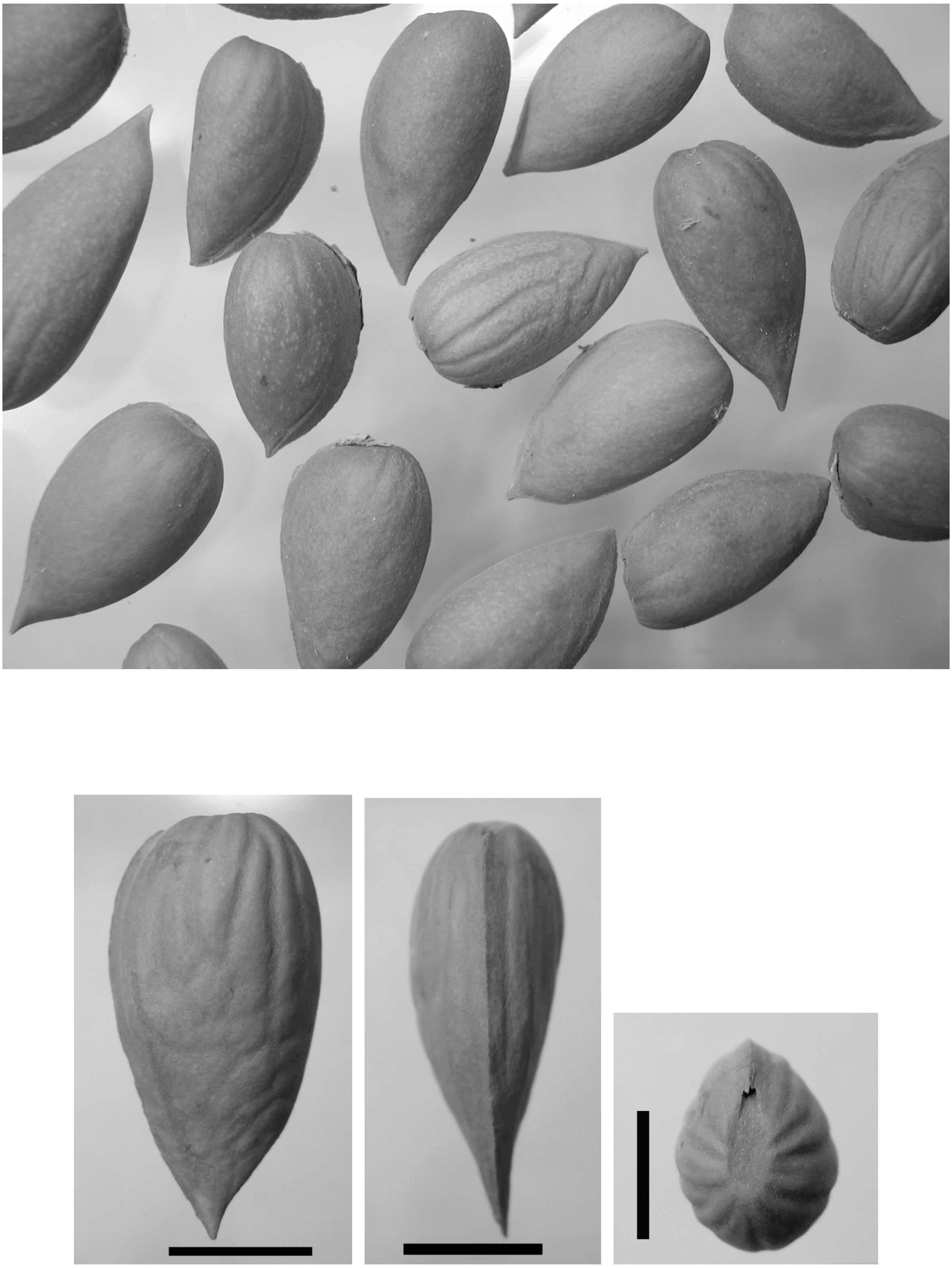


Amygdalus webbii (Greece) endocarps. Scale =1cm. Proveniance Greece (Felipe and Grasselly collection, Zaragoza)

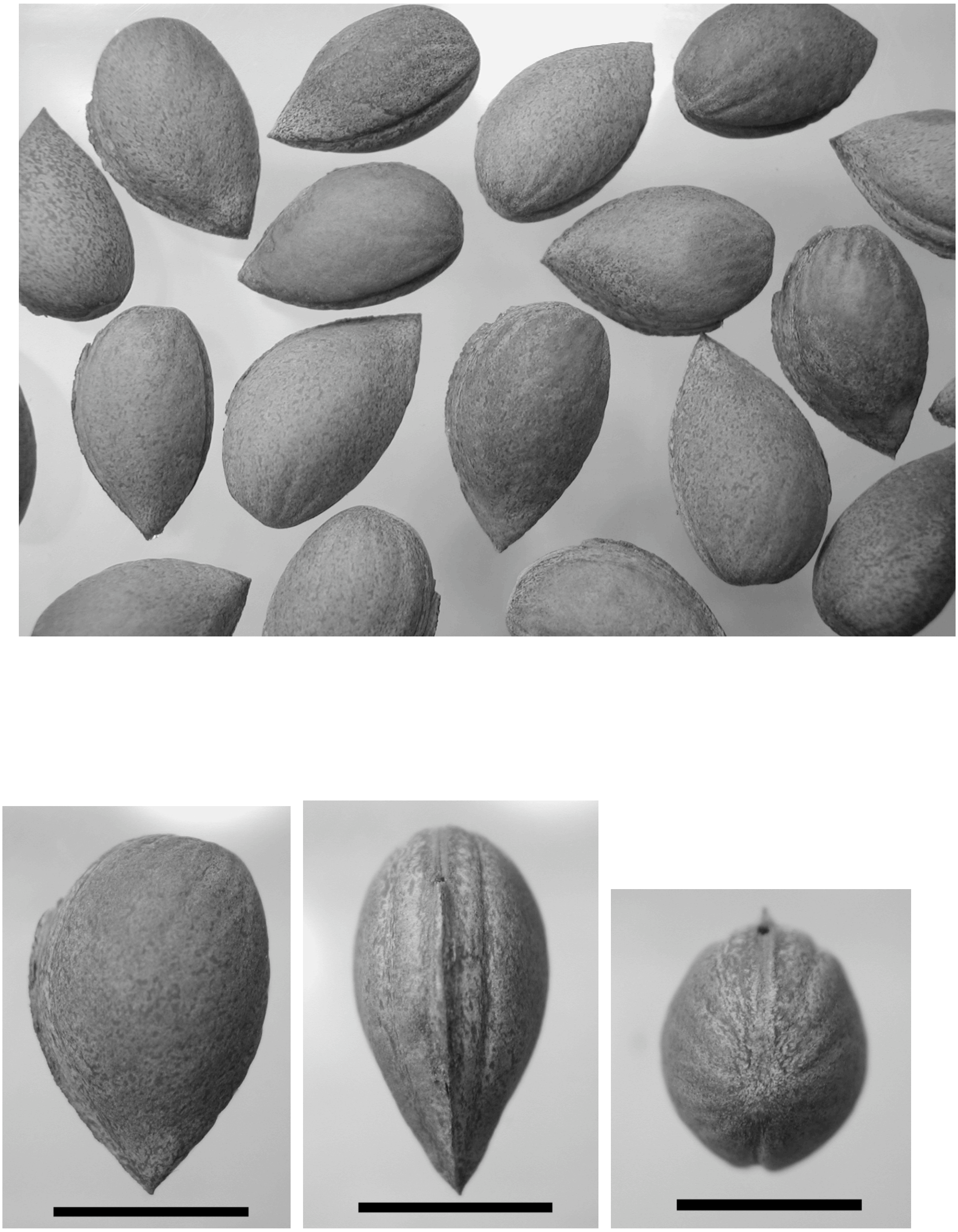
Amygdalus zabulica endocarps. Scale = 1cm. Proveniance Kabul, Afghanistan (Felipe and Grasselly collection, Zaragoza).



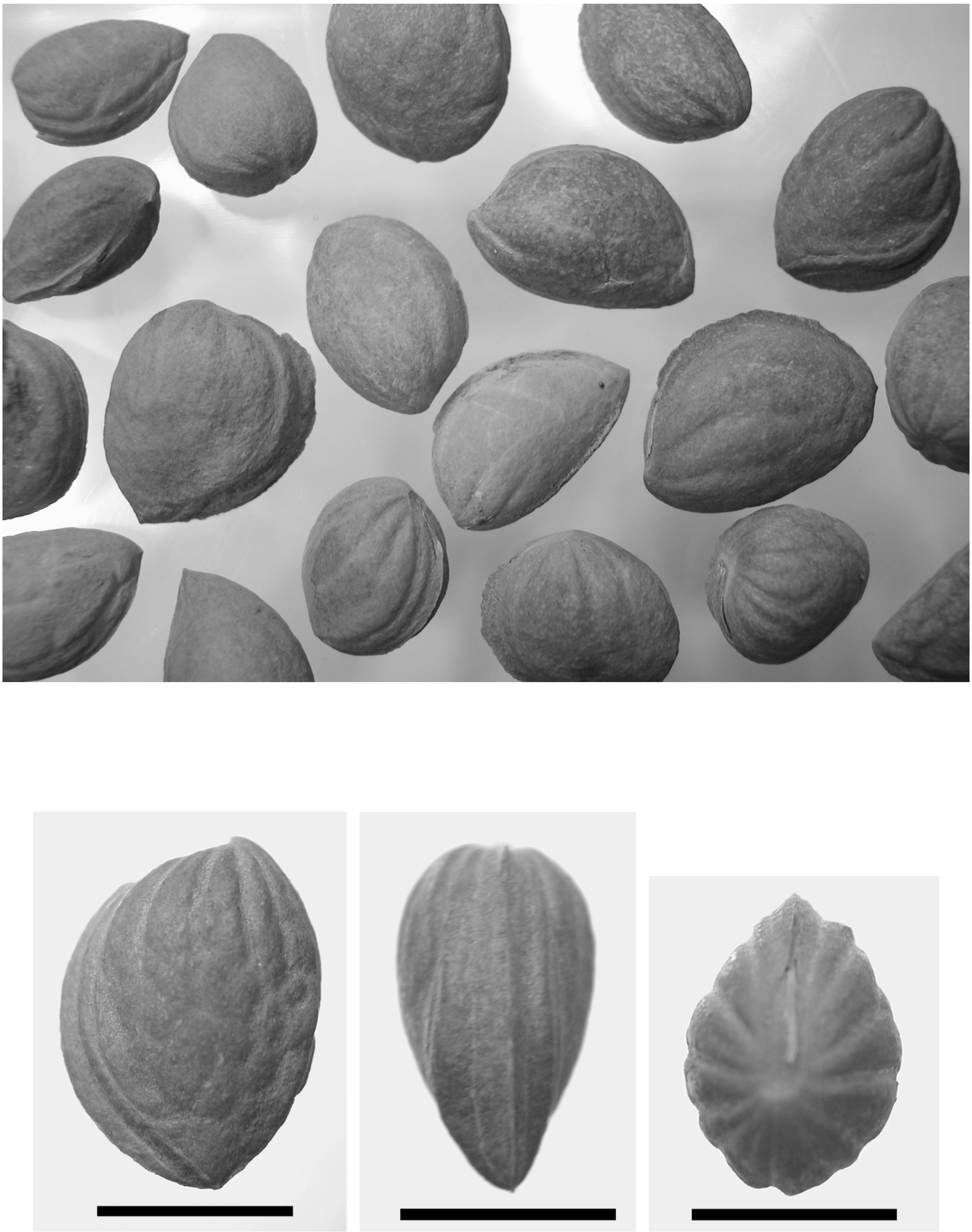
Amygdalus brahuica endocarps. Proveniance Tcharatou Ghazmir, Afghanistan (Felipe and Grasselly collection, Zaragoza).



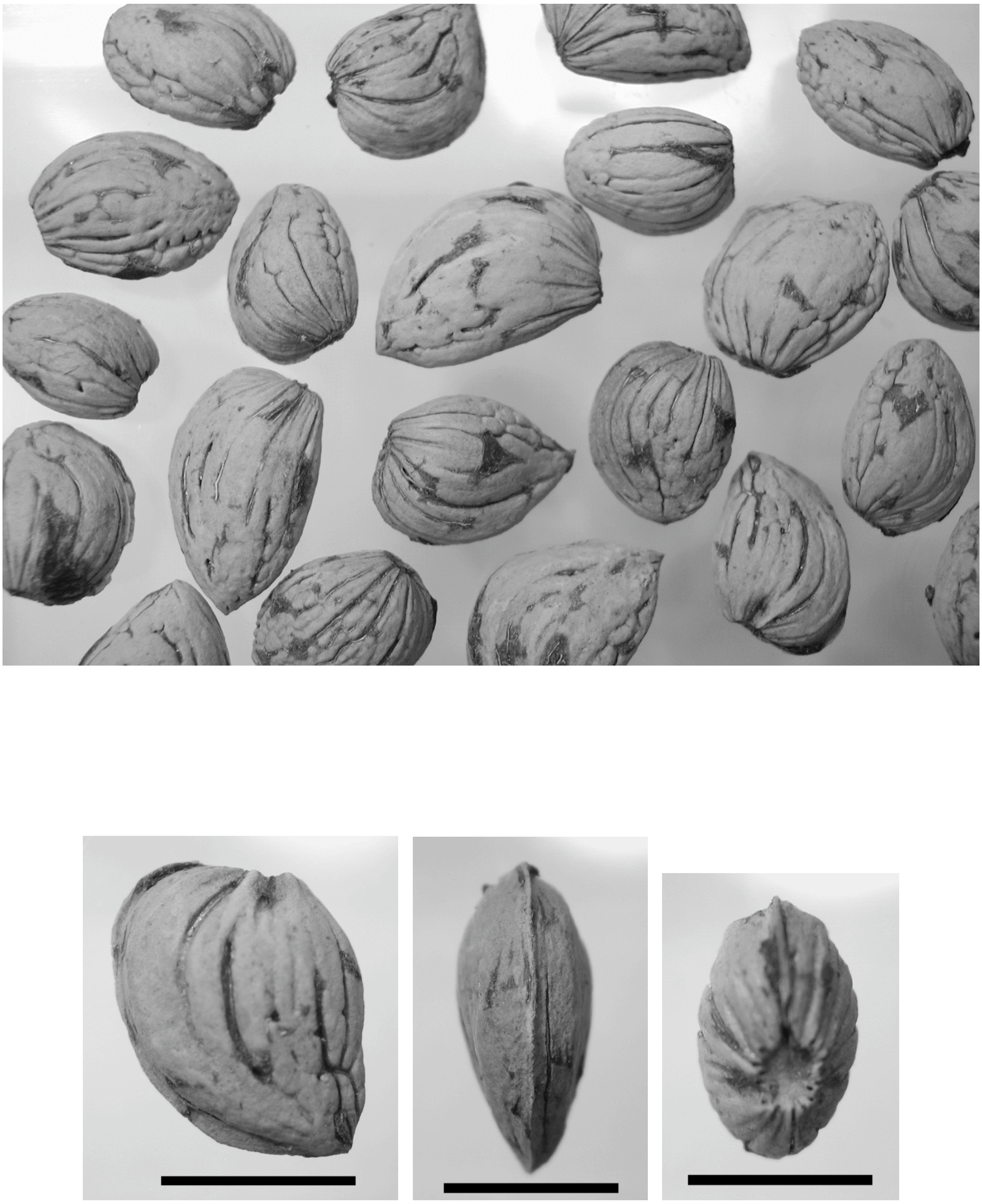
Amygdalus bucharica endocarps. Scale = 1cm. Proveniance Afghanistan (Felipe and Grasselly collection, Zaragoza).



Amygdalus scoparia endocarps. Scale = 1cm. Proveniance Iran (Felipe and Grasselly collection, Zaragoza).



Amygdalus spinosissima endocarps. Scale = 1cm. Proveniance Shah Maksud, Afghanistan (Felipe and Grasselly collection, Zaragoza).



Amygdalus brahuica endocarps. Scale = 1cm. Proveniance Salang, North Afghanistan (Felipe and Grasselly collection, Zaragoza).

	length (mm)	**breadth** (mm)	**height** (mm)
Amygdalus fenzliana* (Iran) n=2			
Maximum	21.80	14.60	8.50
Average	21.75	14.90	8.35
Minimum	21.70	15.20	8.20
Amygdalus webbii* (Toledo) n=7			
Maximum	19.40	15.00	12.60
Average	18.57	14.01	11.43
Minimum	17.40	12.55	10.50
Amygdalus webbii* (Greece) n=15			
Maximum	15.80	12.20	10.50
Average	14.64	11.25	9.29
Minimum	13.75	9.90	7.90
Amygdalus zabulica* (Kabul Afghanistan) n=18			
Maximum	19.85	14.00	8.65
Average	17.78	12.60	8.03
Minimum	16.70	11.90	7.50
Amygdalus kuramica* (Salang North Afghanistan) n=8			
Maximum	20.15	15.00	9.15
Average	18.35	13.61	8.66
Minimum	17.30	13.00	8.30
Amygdalus kuramica* (Tcharatou Ghazmir Afghanistan) n=10			
Maximum	20.90	14.30	8.95
Average	17.35	12.23	7.93
Minimum	16.00	11.35	6.60
Amygdalus kuramica* (Shah Maksud) n=10			
Maximum	20.60	13.10	8.70
Average	16.32	11.01	7.57
Minimum	13.00	9.00	6.30
Amygdalus bucharica* (Khulm Afghanistan) n=26			
Maximum	27.10	13.55	9.70
Average	22.80	11.82	7.92
Minimum	18.60	10.10	6.70
Amygdalus bucharica* (Balkh Afghanistan) n=10			
Maximum	25.20	13.15	8.90
Average	20.14	10.54	7.74
Minimum	16.80	9.00	6.60
Amygdalus bucharica° (Bot. Garden n=3			
Maximum	21.75	12.40	8.00
Average	19.53	11.27	7.33
Minimum	17.75	10.00	6.30
Amygdalus orientalis" (A. Erkal, Konya area) n=5			
Maximum	26.00	14.90	10.20
Average	21.76	11.74	8.76
Minimum	17.30	8.60	6.60

* = size od endocarps from Felipe and Grasselly collection, Zaragoza
° = size of endocarps from the Botanical Institue collection, Basel

Amygdalus orientalis° (HJB 1990) n=	**length** (mm)	**breadth** (mm)	**height** (mm)
Maximum	18.00	9.30	7.90
Average	17.50	9.05	7.35
Minimum	17.00	8.80	6.80

Amygdalus orientalis° (RMN 1735/HJB 1990) n=13			
Maximum	25.40	12.80	8.10
Average	17.17	9.57	6.96
Minimum	14.40	7.80	6.05

Amygdalus scoparia* n=10			
Maximum	17.80	11.50	9.10
Average	16.65	10.64	8.73
Minimum	15.90	9.70	8.30

Amygdalus scoparia° (Iran market, Bot. Garden Teheran) n=9			
Maximum	16.00	11.05	8.85
Average	13.05	9.57	7.85
Minimum	10.65	8.20	7.00

Amygdalus spinosissima* (Zaragoza) n=4			
Maximum	15.50	9.95	7.70
Average	14.00	9.29	7.23
Minimum	13.00	8.30	6.70

Amygdalus spinosissima* (Shah Maksud Afghanistan) n=10			
Maximum	17.70	12.45	8.50
Average	14.50	10.93	7.89
Minimum	11.15	9.40	7.10

Amygdalus brahuica* (Salang North Afghanistan) n=10			
Maximum	17.90	13.20	8.80
Average	15.74	12.21	7.70
Minimum	13.50	11.10	6.85

Prunus divaricata° (vegetation sylvatico, Bot garden Erevan) n=2			
Maximum	14.00	9.50	7.20
Average	13.75	9.25	7.18
Minimum	13.50	9.00	7.15

Prunus divaricata° (native Sofia) n=9			
Maximum	14.90	10.35	7.15
Average	13.73	9.24	6.68
Minimum	12.70	8.10	6.20

Prunus divaricata° (Spildagi 1400m, Bot garden Izmir)			
Maximum	13.50	11.45	9.15
Average	12.62	10.95	8.83
Minimum	11.60	10.05	8.25

* = size od endocarps from Felipe and Grasselly collection, Zaragoza
° = size of endocarps from the Botanical Institue collection, Basel

Curriculum Vitae

Born 23rd March 1971 in Aarau AG, as daughter of Marie-Claire Martinoli born Katz and Emmanuel Martinoli.

1978 – 82	Primary school in Delémont JU
1982 – 87	Secondary school in Delémont JU
1987 – 90	College in Porrentruy JU in scientific section
1990 – 97	University Neuchâtel NE: certificate in Zoology, certificate in Botany, complementary in general Chemistry, Palaeontology, Ecology, Plant Ecology and Vertebrate Faunistic.
1994 – 96	Thesis in Zoology “„Observations éco-éthologiques, étude du régime alimentaire et terrains de chasse d’une colonie de *Myotis myotis* (Borkhausen, 1797) à Courtételle (Jura)“
1996 – 97	Thesis in Botany „Etude archéobotanique de macrorestes végétaux d’époques nabatéenne et romaine tardive, ez Zantur, Pétra, Jordanie“
1997 – 1998	Work experience in Archaeobotany at the Swiss Federal Institute of Technology Zurich
1998	Work experience in Archaeobotany at the University Basel
1998 – 1999	Work experience in Archaeobotany at the University College London
1999 – 2001	Scientific collaborator in Archaeobotany at the University Basel
2001	Scientific collaborator for the “Çatalhöyük Archaeology Project”, University of Cambridge, UK
2003	Scientific collaborator for the project “Study of a Archive of Crop and Seed Stores at Neolithic Çatalhöyük, Turkey, The Australian National University, AU
2001 – 2004	PhD student by Prof. S. Jacomet with the project “Plant Food Economy and Environment during the Epipalaeolithic: an Investigation of the Macrobotanical Remains from Öküzini and Karain B, Southwest Anatolia”

Lecturers involved in the education: M. Aragno, K. Bernauer, M. Blant, M. Brossard, A. Buttler, R. Deschenaux, P.-A. Diehl, P.-A. Fürst, J.-D. Gallandat, J.-M. Gobat, E. Gross, G. Hillman, S. Jacomet, C. Jacquat, D. Job, P. Küpfer, W. Matthey, C. Mermod, J.-C. Pedroli, J. Remane, J.-P. Schaer, P.-A. Siegenthaler, G. Süss-Fink, J.-M. Weber.