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ARCHAEOLOGIES OF GREEN
BAHRAIN'S NATIONAL PAVILION AT THE EXPO MILAN 2015

ARCHEOLOGIA DEL VERDE
IL PADIGLIONE DEL BAHREIN AL EXPO MILANO 2015



ARCHAEOLOGIES OF GREEN

BAHRAIN'S NATIONAL PAVILION AT THE EXPO MILAN 2015

Environment And Plant Economy At Qal'at Al-Bahrain During The Dilmun And Tylos Periods. First Elements Of Archeobotany

Margareta Tengberg &
Pierre Lombard

The natural resources of the Bahrain archipelago, located off of Saudi Arabia, in the Arabian Gulf Fig. 1 have attracted the attention of travelers and naturalists since the remotest antiquity. The Sumerian myth "Enki and Ninhursag" dating back towards the end of the third millennium BC, but known to us through copies from the Old Babylonian period, probably already evokes Dilmun's famous and privileged situation for the people of Sumer[1]. According to tradition, the god Enki fertilized the land of Dilmun using water brought forth by Utu, thus transforming it into a rich and lush land:

> "... He quenches Dilmun with abundant water, Its saltwater wells become freshwater wells, And in the fields and plains, furrows yield barley ...[2] "

In the Hellenistic period, around 325–324 BC, one of the admirals of Alexander the Great, Androsthenes of Thasos, returning from India, explores the coast of the Arabian Gulf. He mentions the island of Bahrain that took the Greek name of Tylos and describes its vegetation and agricultural practices. This ancient story, today lost, is known to us through the later texts of Theophrastus, Strabo, Pliny and Arrian[3].

Centuries later, several Arab geographers and travelers visited or mentioned Bahrain and described its landscapes and cultures; Ibn Battuta, in particular, focused on "the abundant pens of palm, pomegranate and lemon trees...[4]".

Henceforth, archaeobotanical research now allows us to verify the old stories and improve our knowledge about plants and their use, particularly during the various phases of the Dilmun period. Two studies conducted in Saar (London-Bahrain Archaeological Expedition) and during the Danish excavations at Qal'at al-Bahrain (The Carlsberg Foundation's Gulf Project) have brought together the first elements of these issues. As a result of these studies, we know that the main crops grown on the island were barley (*Hordeum vulgare*), naked wheat (*Triticum durum/aestivum*), and date palms (*Phoenix dactylifera*)[5]. Anthracological analyses[6] confirm the predominance of the latter, and also reveal the use of coastal mangroves[7].

The present study aims to present the preliminary results of archaeobotanical research conducted at Qal'at al-Bahrain in the framework of the French Archaeological Mission in Bahrain. In light of the anthracological study, we shall first suggest a reconstruction of the plant paleoenvironment. What timber species were present near the site, and to what types of ecosystems did they belong? Were logging activities restricted

1 It is now widely agreed to identify the country of Dilmun of Sumerian literature and mythology not only with the Bahrain archipelago, but also with a portion, still poorly defined, of the current Eastern Province of Saudi Arabia, including a number of regional islands (Failaka, Tarut).

2 Attinger, 1984

3 For a discussion of the stories of classical authors see Potts 1990: 125–144. Another reference is the excellent feedback from S. Amigues in his annotated translation of *Plant History Enquiry into Plants* by Theophrastus.

4 Ibn Battuta, ed. trans. C. Defremery and B. R. Sanguinetti. 1990: 127.

5 Nesbitt, 1993; Willcox, 1994.

6 Anthracology (from Greek anthrax, -akos, meaning burning coal) is the study of charcoal collected from archaeological sites.

7 Gale, 1994.

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to local species, or did they include imported species? What contribution did arboriculture make to the local economy?

The carpological[8] analysis would subsequently allow us to concentrate on other aspects of the ancient populations' plant economy. What plants were grown and why? What type of agricultural system was in place? Is it possible to give some crops a value in a trading system at the local or interregional level?

The Site and Its Environment

The tell of Qal'at al-Bahrain once stood at the western tip of a large bay extending to Manama, the current capital of the island, only seven kilometers away. Today, a wide artificial platform fills the bay, thus causing a site that was, if not the ancient capital of the island, at least one of its largest cities and main harbor, to be virtually deprived of any access to the sea. In addition to its significant magnitude (about 17,5 hectares), the tell's essential worth lies in its eight meters of archaeological deposits that indicate an almost uninterrupted occupation from around 2200 BC to the sixteenth century CE. By allowing the diachronic study of the same environment combining sea, palm trees, and desert, this valuable stratigraphy makes Qal'at al-Bahrain a major reference tool for eastern Arabia, at the archaeological and environmental levels. This research eventually aims to analyze the various strategies of human adaptation to this very special environment, while laying emphasis on the evolution of these strategies depending on the nature of the occupation in the successive cultural phases: the "indigenous" city of the Early Dilmun Period (ca. 2200–1750 BCE), the public buildings of the Middle Dilmun Period (ca. 1450–1350 BCE) and the Late Dilmun Period (Pre-Achaemenid and Achaemenid Period, ca. 1000–500 BCE), the Seleuco-Parthian-influenced city (The Tylos Period, ca. 300 BCE/300 CE), the Islamic city of the fourteenth and sixteenth centuries CE.

Thanks to its many artesian wells, the north of the island of Bahrain, where Qal'at al-Bahrain stands, has since ancient times been the most densely populated part of the archipelago. However, the presence of human settlements over thousands of years has caused profound changes in the natural environment; it is the primary cause of entirely manmade landscapes that characterize the north of the island today. Modern cities that continue to expand intrude upon traditional palm groves and several archaeological sites, if they do not destroy them. Save for a relic mangrove located in Ra's Tubli on the east coast, the north of the island is void of ecosystems that we can still qualify as natural. The driest areas in the south, less exposed to human impact, are characterized by desert vegetation consisting mainly of small timber species, including *Heliotropium* spp. *Tavemiera aegyptiaca* and *Zygophyllum qatarense*. Along the coast, sand dunes alternate with vast stretches of saline soils known as sebkhas; the first shelter psammophilic vegetation dominated by *Cyperus Conglomeratus* and *Seidlitzia rosmarinus*, while the latter are characterized by a very sparse vegetation of halophytes, mostly belonging to the Chenopodiaceae plant family.

Materials And Methods

Three types of archeobotanical remains are found in Qal'at al-Bahrain: charcoal, carbonized seeds and fruits, and mud brick impressions. The carbonized material was recovered using a Siraf[9] flotation system, consisting of one flotation tank and two settling tanks, where water is recycled with a gasoline-powered pump. A very-fine mesh sieve (0.3 mm) was used to collect wood and small seeds, especially those of wild grasses and pulses. More than 3300 liters of sediments collected from different archaeological contexts (occupation floors, backfill layers, hearths, tannour (oven), and pits) have been treated during two excavation operations conducted in the spring and fall of 1995. However, almost half of the samples obtained date back to the Islamic period and will not be discussed in this article.[10]

After the flotation, all samples were carefully examined to separate the seeds from the charcoal. The seeds were identified by their morphology examined under a binocular magnifier, and the charcoal

by their anatomy observed in the three xylological planes (the transverse, longitudinal tangential and longitudinal radial planes) under a reflective microscope. The identification process was supported by the use of reference collections and atlases of wood anatomy[11].

The study of mud brick impressions was made possible thanks to a vegetal degreaser (often made of chaff and/or cereal straws) found in the bricks of Qal'at al-Bahrain, as is the case in numerous sites of the Near and Middle East. The bricks were split by hand prior to being examined under a binocular magnifier.

Trees And Wood

Given the small amount of collected charcoal, some levels have yielded only a few samples. If part of the coal was found in hearths (UF 1122, 1125 and 1163), most of it was from occupation layers and likely reflects repeated emptying of the combustion structures. The analysis of a total of 475 fragments allowed the identification of twelve timber taxa Table 1.

From an ecological standpoint, these can be grouped into three categories that indicate both the plant environment of the past and the logging methods.

- Native wildlife species,
- Cultivated species,
- Exotic / imported species.

Native Species and The Plant Environment

A number of wild species, probably native of Bahrain, have been identified. Among them are the prosopis (*Prosopis cineraria*) and the Nile acacia (*Acacia* cf. *nilotica*), two tree species of the pulses family (Leguminosae)[12]. They draw water from the depths and grow on sandy or alluvial soils where they form an open tree vegetation of a pseudo-savannah type. Today, these two species do not grow spontaneously in Bahrain. In the past, they were most likely favored by the outstanding discharge of groundwater in the northern part of the island. Moreover, the gradual lowering of the groundwater discharge[13] and logging activities have possibly contributed to the disappearance of these two species. The only type of uncultivated acacia existing today in Bahrain is the *Acacia tortilis*, a more xerophytic species, found near Saar[14] but also observed in other localities, specifically in the central depression. In Middle Eastern regions where *Prosopis cineraria* and *Acacia nilotica* are still growing, their wood is used in carpentry and their foliage and pod in cattle feeding. The Nile acacia also provides gum and tannin used for skin preparation.

The wood of Tamaris (*Tamarix* sp.) is associated with the Late Dilmun period[15]. This wood genus comprises several species in the Middle East, most of which are hydrohalophile and common in coastal areas and on the borders of sebkhas. It is currently represented in Bahrain by two species: *Tamarix arabica* and *T. pycnocarpa*[16].

The *Avicennia marina*, observed in a few fragments of the Late Dilmun period is a characteristic species of mangroves. These coastal forests grow in the intertidal zone along the non-rocky shores of tropical and subtropical regions[17]. It is presumably such a rich plant formation that Theophrastus described it by stating: "They say that when the tide goes out on the east coast of the island of Tylos, a large number of trees appear that the island seems to be walled"[18]. Only

8 Carpology (from Greek *karpos*, meaning seed) is the study of fruits and seeds collected from archaeological sites.
9 Williams. 1973.
10 The study of this material will be later published in the first volume of the publication of the new French excavations in Qal'at al-Bahrain (1989-2001) dedicated to the Islamic levels (13th-16th centuries).
11 Fahn et al. 1986 Jagiella und Kürschner, 1987; Schweingruber.1990.
12 In the transverse plane, the *Prosopis cineraria* is a diffuse-porous wood with alternating bands of fibers and paratracheal parenchyma that is often aliform. The homogeneous rays are uni-, bi-, and triserial. The Nile Acacia (Acacia nilotica) in the transverse plane is characterized by a diffuse-porous wood and a vasicentric paratracheal parenchyma. The rays are homogeneous, uniserial and multiserial, up to five-cells wide.
13 Larsen, 1983: 133–141.
14 Cornes and Cornes, 1989: 140.
15 The wood of Tamaris (*Tamarix*) is recognizable by its very large heterogeneous rays which width in the tangential longitudinal plane can reach up to thirty cells, depending on the species. Rays and vessel elements have distinctive tiers in the radial longitudinal plane.
16 Cornes and Cornes. 1989: 115.
17 In the transverse plane, the *Avicennia marina* has a wood structure with included concentric phloem. Together with the phloem are found sclerotic parenchymal bands and sclerenchyma cells. The uni- and multiseriel rays are heterogeneous.

one extremely small mangrove remains today in Ra's Tubli in Bahrain, on the east coast of the island, within five kilometers of Qal'at al-Bahrain. However, other better-preserved mangroves are found elsewhere in the Arabian Gulf: in Kuwait[19], Qatar[20], Saudi Arabia[21], the United Arab Emirates[22] and Iran[23]. All these mangroves currently contain only one tree species, the *Avicennia marina*, from the Avicenniaceae family. Nevertheless, anthracological analyses of Gulf sites have shown that another mangrove was part of this type of ecosystem in the past. On the site of Saar, wood belonging to the Rhizophoraceae[24] family was identified and associated with the Early Dilmun period[25]. This wood was considered as imported – probably from the Indian sub-continent – but more recent studies conducted in Tell Abraq and ed-Dur suggest that the Rhizophoraceae were native to the Arabian Gulf region[26]. They must have grown along with the *Avicennia marina*, in the mangroves of the Gulf until at least the Classical era. However, from a morphological point of view, Theophrastus' description of mangrove trees in Bahrain seems to refer more to an *Avicennia marina* than a Rhizophoracea: "...all these trees are the size of a fig tree, an extraordinarily fragrant flower, an inedible fruit, similar in appearance to that of a lupine.[27]" While several wood species of the Rhizophoraceae family are appreciated for construction because of their density and resistance to rot, the *Avicennia marina* wood is considered as mediocre, and most often used as fuel.

Two shrub taxa were identified in Qal'at al-Bahrain: one belonging to the genus *Lycium* and the other to the Chenopodiaceae[28] family. The only species of *Lycium* now present in Bahrain is *Lycium shawii*, a thorny shrub that grows on soils of sand and gravel. It is likely that charcoal in Qal'at al-Bahrain is associated with this species, yet the anthracological analysis, in this case, does not allow proving this association. Numerous small timber species belonging to the Chenopodiaceae family are found in Bahrain. Similar to the Tamarix wood species, most of them are adapted to the saline environments of coastal regions or inland depressions[29].

Cultivated Species and Horticultural Practices

The anthracological analysis of Qal'at al-Bahrain has allowed the identification of three cultivated fruit trees: the date palm (*Phoenix dactylifera*), the pomegranate (*Punica granatum*) and the jujube (*Ziziphus spina-christi*)[30]. The presence of *Phoenix dactylifera* fragments in almost all samples of the site emphasizes the importance of this species to the local economy. The date palm was and still is the main component of palm groves or *bustans* that are traditional agricultural systems that allow the cultivation of a large number of plants in a small area while saving water. The value of the date palm was certainly not restricted to its fruits. Its various parts provide other useful products including cordage fibers, leaves for basketry, and stipes for woodwork. The traditional constructions of Bahrain known as *barastis* are entirely made of different parts of the date palm. Given the large economic interest in this species, it is unlikely that trees still providing fruits have been cut down for fuel. Hence, the date palms which have released the many fragments of charcoal identified in the archaeological layers had undoubtedly already gone beyond the productive phase.

The pomegranate has been identified by its seeds in several Near Eastern sites since the Bronze Age[31]. In the Gulf region, the charcoal in Qal'at al Bahrain is the oldest proof (the Late Dilmun period) of this species. The pomegranate, cultivated for its fruit, may have been introduced to the region from Mesopotamia or Iran.

The jujube tree, which fruit is also valued, is perfectly native to the Arabian Peninsula where it grows either spontaneously in pseudo-savannahs, or cultivated in palm groves or around residential areas. In the Middle East, the solid and durable *Ziziphus spina-christi* wood is often used to make furniture and tools.

Exotic Species and Wood Imports

The majority of timber taxa identified in Qal'at al-Bahrain Panel. 1 seem to have been locally exploited. However, two of them are an exception because, for environmental reasons, they could not have grown on the island in the

past. They are the ash wood (*Fraxinus* sp.) and pine wood (*Pinus halepensis / brutia*), both associated with the Late Dilmun period[32]. The wood of these two species must have been imported from cooler and more humid regions of the Middle East, possibly from northern Mesopotamia, Anatolia, or the foothills of the Zagros. In the Arabian Gulf region, ash wood was also identified on the Mleiha site, in levels dating back to the third and fourth centuries CE[33]. From an anatomical perspective, it was impossible to specifically determine the ash type found at Qal'at al-Bahrain, but it is most probably the *Fraxinus syriaca*: a Near Eastern species observed also in the Hellenistic/Parthian levels at Larsa, in Lower Mesopotamia[34]. Today, this light yet strong ash wood is often used in construction.

Pine wood was identified in two samples of the Late Dilmun period. These samples are the most ancient proof of this wood in the Gulf region[35]. Later, in the Classical period, *Pinus* was also proven in the sites of Failaka and ed-Dur[36]. The *Pinus halepensis* and *P. brutia*, which the anthracological analysis could not separate, are two common species in the eastern part of the Mediterranean region. The *Pinus brutia* was also observed in the Zagros Mountains in Iraqi Kurdistan[37]. Pine wood is not considered as a very good timber. It had reportedly reached the Gulf region in the form of boxes used to transport various objects[38]. The origins of the Euphrates poplar (*Populus euphratica*) associated with the Middle Dilmun period remains difficult to determine[39]. Although this riparian species is poorly adapted to the ecological conditions of Bahrain, it could have grown, for example, along the irrigation canals of irrigated palm groves. The importation of this tree from Mesopotamia, where *Populus euphratica* is frequent along the Tigris, the Euphrates, and their tributaries, is equally a plausible argument.

Cultivated Plants and Weeds

Most of our carpological data [Panel 2] originate from a context that is rich in plant remains, an extensive ashy layer (UF 1265) with a thickness of nearly one meter, which served as backfill material during the Late Dilmun period [Table 2]. Conversely, little information is available on the Tylos period (Seleuco-

18 Theophrastus, *Enquiry into Plants*, II, IV, 7, ed. trans. Amigues, 1989: 86.
19 Halwagy, 1986.
20 Batanouny, 1981; Abdel-Razik, 1991.
21 Migahid and Al-Sheikh, 1977.
22 Western, 1989.
23 Zohary, 1963.
24 The Rhizophoraceae family includes four genus of mangroves: *Rhizophora, Ceriops, Brugiera*, and *Kandelia*. They grow along the coasts of tropical regions. Heywood, 1996: 157–158.
25 Gale, 1994.
26 Beside the *Avicennia marina*, a species of Rhizophoraceae was the main taxon exploited at Tell Abraq, in the United Arab Emirates from the period of Umm an-Nar until the Iron Age (Tengberg, 1998: 169–179). Wood from the Rhizophoraceae family was also observed in ed-Dur (Tengberg, 1998: 212).
27 In a recent Flora of Bahrain, the *Avicennia marina* flowers and fruits are described as follows "... flowers waxy, exuding a heavy perfume ... Fruit has single-seeded fleshy capsule" (Cornes and Cornes, 1989: 197). This description is largely consistent with that of Theophrastus on the morphology of mangroves in Tylos. Theophrastus, *Enquiry into Plants*, II. IV. 7, ed. trans. Amigues, 1989: 86.
28 In the transverse plane, the *Lycium* sp. is a diffuse-porous wood, by groups of 2-6 or more in a flame figure. The rays are uniserial, or less often, biserial. Some vessels contain spiral thickenings. The Chenopodiaceae identified in Qal'at al Bahrain has shown, in the transverse plane, a foraminous included phloem. The rays are heterogeneous and tiered.
29 Cornes and Cornes, 1989: 70–87.
30 The anatomy of the date palm (*Phoenix dactylifera*), belonging to the family of monocots shows primary cribro-vascular bundles surrounded by lignified parenchyma. The bundles contain fibers, parenchyma cells, and metaxylem vessels (often 2 or 3 per bundle). The perforations of the vessel elements are scalariform and reticulate, and the vessel pits are opposed, elongated, with scalariform patterns. The pomegranate wood (*Punica granatum*) is diffuse-porous, isolated or by groups of 2–3(9). The rays are uniserial, or less often, biserial and heterogeneous. The jujube in transverse plane (*Ziziphus spina-christi*) is a diffuse-porous wood, isolated or by groups of 2–4. The rays are heterogeneous and typically uniserial.
31 Zohary and Hopf, 1994: 162.
32 Ash wood (*Fraxinus* sp.) is characterized by a ring-porous wood with pores that are isolated or by groups of 2–3 (4). The parenchyma is vasicentric paratracheal in the earlywood, confluent and banded in the latewood. The rays are uni- and multiserial and homogeneous. The pine wood (*Pinus halepensis/brutia*), belonging to the subphylum gymnosperms, presents a homoxylous wood with distinct growth rings. The transition from earlywood to latewood is often abrupt, and sometimes progressive. Secretory thin-walled channels are located in both the earlywood and latewood. Three to four pinoid pits are found in the cells of the intersection fields.
33 Tengberg, 1998: 204–209.
34 Neef, 1989: 152–154.
35 It is worth mentioning that a Pinus seed was also spotted in the pollen spectrum of a wall plaster sample in Qal'at al-Bahrain, dating back to the same period (palynological analyses conducted by J. Medus, Faculty of Science, St Jerome University, Marseille).
36 Willcox, 1990; Tengberg, 1998
37 Zohary, 1973: 343.
38 Haerinck E., comm. pers.
39 In the transverse plane, the Euphrates poplar (*Populus euphratica*) shows a semi-porous or diffuse-porous wood, isolated or by groups of 2–4 (5). The homogeneous rays are uniserial and (rarely) biserial. The perforations are simple and the intervessel pits are alternate and large.

Parthian), for which only two samples were examined.

Cereals

Two cereal taxa are identified in Qal'at al-Bahrain: the barley (*Hordeum vulgare*) and the bare wheat (*Triticum durum/aestivum*). The hulled barley, known by the trace of lemma and palea along the caryopsis is associated with all periods, with the exception of the Hellenistic period. The presence of asymmetric caryopses indicates that at least part of the barley grown in Bahrain was the six-rowed barley (*Hordeum vulgare* subsp. *Hexastichum*).

Bare wheat is present in a sample of the Achaemenid period. It is however impossible to rely solely on the morphology of caryopses to distinguish between hard wheat (*Triticum durum*) and bread wheat (*Triticum aestivum*), but the few rachis segments attached to the grains rather indicate a hexaploid *aestivum*-type wheat. The chaff impressions of hulled barley and naked wheat (rachis segments, glumes, lemmas and paleas) on mudbricks of the Middle Dilmun period confirm the results of the seeds' examination. The same cereal taxa are also found on other sites of the Gulf region from the beginning of the third millennium BCE[40].

Cultivated Pulses

Neither of the "classic" pulses including lentils (*Lens culinaris*) and peas (*Pisum sativum*), consumed since the Neolithic times in many sites of the Near and Middle East, were observed in the samples of Qal'at al-Bahrain. Another cultivated pulse, lucern (*Medicago cf. sativa*) is however proven, and was probably used for forage purposes. Even today, lucern is frequently grown in the Gulf region and constitutes – along with clover (*Trifolium alexandrinum*) – the main forage.

Oilseeds Plants

A very well preserved sesame seed (*Sesamum indicum*) was found in levels dating back to the Middle Dilmun period. It is the earliest proof of this species in the Gulf Region. *Sesamum indicum* is also proven to exist in Yemen through pottery impressions dating back to the first millennium BCE[41]. During the Greek and Roman periods, sesame seems to have been grown extensively in the Near and Middle East, since it was mentioned by classical authors[42].

Aromatic Plants

Coriander (*Coriandrum sativum*) was present in Qal'at al-Bahrain in the Middle and Late Dilmun periods. This species, most likely grown as a condiment, is known in the Makran (southwest Pakistan) since the second half of the third millennium[43], as well as in several Near East sites. It was also known to the Egyptians of the second millennium BCE[44].

Fiber Plants

Several cotton seeds (*Gossypium* sp.) were found in a sample (UF 1265) dating back to the Achaemenid period (Late Dilmun period). They are the first archaeobotanical proof of this textile plant in the Arabian Peninsula. However, cotton cultivation in Bahrain had been already known to us through written literature. Theophrastus was the first to mention it, always citing Androsthenes, in his *Historia Plantarum*: "The Island seems to abundantly produce arborescent cotton with leaves that look like small vine leaves and bear, instead of a fruit, the receptacle of the cotton flower, as big as a fake apricot, and well closed. In due time, this receptacle opens wide, allowing for the cotton to be removed and woven into cheap or luxury muslins.[45]" More than a millennium later, the Arab traveler Ibn Battuta noted once again the presence of cotton crops on the island[46].

The date of introduction of cotton to Bahrain remains unknown, but cotton presumably originated from the Indian subcontinent, where it had been known and used since the Neolithic period[47]. The Indian cotton is mentioned in Indian texts since the first millennium BCE[48] as well as in the works of several classical authors[49]. It was however impossible to determine, based on the morphology of the seeds found in Qal'at al-Bahrain, whether this cotton type was the *Gossypium arboreum* or the *Gossypium herbaceum*, the two cotton species cultivated in the ancient world. And

since cotton trees are often described as "wool trees" in Greek and Roman literature, some researchers conclude that the cotton type found on the island is rather the *Gossypium arboretum*, or "arborescent cotton", and not the of *Gossypium herbaceum*, or the "herbaceous cotton"[50]. However, the morphological variation within each species is significant to the extent that their differentiating criteria might overlap, thus causing the botanical identification to be random[51]. Nevertheless, geographical and historical reasons indicate that the cotton crop once grown in Bahrain is likely to be the "Asian" *Gossypium arboreum*, rather than the "African", *G. herbaceum*.

Edible Fruits

Just like the stipe fragments, carbonized date palm seeds (*Phoenix dactylifera*) are very common in the archeobotanical samples of Qal'at al-Bahrain. They constitute, by far, the most common carpological remains, as is the case in most Eastern Arabia sites[52]. It is true that the dates' seeds, thanks to their woody tegument coat[53], often have a better preservation than other organic remains, but their omnipresence certainly demonstrates the importance of the date palm fruit in the diet of humans as well as in that of domestic animals[54].

Archaeobotany does not stand alone in bearing witness to the importance of dates in the Early Dilmun period. The study of dental pathologies of ancient populations equally reveals a particularly high rate of dental caries, due to a diet high in sugar[55]. Dates were quite possibly the main food plant, as was the case around fifty years ago among the villagers of the island[56]. Dates may have been consumed in various ways; directly as a fruit, or as an ingredient in a variety of preparations. Archaeological excavations have also revealed several "date incubators" used to manufacture the syrup or "honey" of dates (*dibs, asal aswad, or asal el-tamr*)[57]. These "date incubators" (locally known as *madbasa*) consist of a small room, usually facing south, and which floor or functional benches comprise a series of channels leading to a buried container. To extract the syrup or "honey", the bags of dates are stacked on top of each other until they fill the room. During the fermentation of fruits, accelerated by the sun and heat, the juice is released from the dates and recovered in the collection container. Several *madbasa* associated with various periods are found in Qal'at al-Bahrain, the oldest of which dates back to the middle of the second millennium BCE (Middle Dilmun period)[58]. This type of device was ethnographically documented in Bahrain and Oman, although nowadays the *dibs* is rather industrially manufactured[59].

The date palm has been grown in Lower Mesopotamia at least since the fifth millennium BCE, as proven by the carbonized seeds found in Tell el-Oueili[60]. Since the Uruk period, dates and date palm crops have been mentioned in historical or economical texts[61]. Several of these texts often mention a particular type of dates known as the "Dilmun dates"[62]. It appears that these dates enjoyed a great reputation throughout the Mesopotamian history. A late text of the Neo-Babylonian period even notes the existence of two varieties of Dilmun palm trees: "*tilmun*"

40 The same cereal taxa found at Qal'at al-Bahrain: hexaploid naked aestivum-type wheat and six-row barley are associated with Failaka (Willcox, 1990), Saar (Nesbitt, 1993), Hili (Cleuziou and Costantini, 1980), Umm an-Nar (Willcox, 1995), Mleiha (Pena-Chocarro and Barron-Lopez, 1999), Bat (Tengberg, 1998), and Tell Abraq (Tengberg, 1998; Willcox and Tengberg, 1995).
41 Soderstrom, 1969.
42 Gallant, 1985.
43 Tengberg, 1999 : 10.
44 Zohary and Hopf, 1994: 88.
45 Theophrastus, *Enquiry into Plants*, II, IV, 7, ed. trans. Amigues, 1989: 86.
46 Ibn Battûta, ed. trans. C. Defremery and B.R. Sanguinetti, 1990 127.
47 Moulherat et al., In press.
48 Gopal, 1961.
49 Herodotus, Arrian and Pliny have described all "wool trees" that grow in India. Theophrastus, Research on Plants, II, IV, 7, ed. trans. Amigues, 1989: 259.
50 *Ibid.*; L.W. King in Potts 1990: 134.
51 Brubaker et al., 1999 : 6.
52 Tengberg, 1998.
53 The tegument or seed coat is a shell that protects the ovule at first, and then the seed of spermatophytes. In the case of the date palm fruit which is morphologically a berry, the seed is commonly called "kernel"; an incorrect appellation from a strictly botanical point of view.
54 Dates and/or seeds of dates (mashed or boiled) are used as fodder in Bahrain and in other regions of the Middle East, such as Makran in Pakistan where this practice was observed since the onset of the 20th century. Nesbitt, 1993: 33-34: Hughes-Buller, 1906
55 Littleton and Frølich. 1989; Højgaard. 1986: 66.
56 Hansen. 1968 93.
57 Rougeulle. 1982; Højlund. 1990.
58 Højlund, 1990.
59 Rougeulle, 1982: 70–71.
60 Huot. 1988.
61 Landsberger, 1967; Cocquerillat, 1968: The Assyrian Dictionary of the Oriental Institute of Chicago (II), 1968 338.
62 Nesbitt, 1993: 32.

and "*asnû*", the latter apparently producing a sweeter fruit of a more refined taste[63]. Nothing, however, proves that these products having an "appellation of origin" actually came from the island of Bahrain, or even from the mainland of the country of Dilmun; in fact, the label "Dilmun dates" could hardly be more indicative than that of "Brussels sprouts" or "Agen prunes[64]"... Nevertheless, the term "Dilmun" could still be interpreted as a real quality label[65].

In addition to the jujube wood (*Ziziphus spina-christi*) described above, a number of carbonized kernels belonging to this species have been identified in Qal'at al-Bahrain. The jujube fruits of yellow-colored drupes when ripe are edible and highly appreciated in the arid regions of the Middle East. Ziziphus kernels and seeds are found in several archaeological sites of the Gulf region, reflecting the popularity of this fruit even in the past[66].

A grape seed (*Vitis vinifera* subsp. *vinifera*), dating back to the Achaemenid period (Late Dilmun period) is the oldest archaeobotanical proof of this species in the Arabian Gulf. In his account, Theophrastus mentions the vine cultivation without specifying whether grapes were destined for consumption or wine production[67]. Through literature, we know that the wine was produced and consumed in Arabia, at least since the Classical period[68]. The metal "wine-sets" dating back to the Achaemenid period[69] or more recent times[70] found in a number Gulf sites including Qal'at al-Bahrain, suggest that this drink could have already been consumed in Bahrain in the first millennium BCE; such equipments may however been used in the preparation of other types of fermented drinks such as barley wines or craft beers.

Wild Pulses

Some wild pulses seeds were observed. It was however impossible to associate them with a specific genus or species.

Wild Grasses

Several wild grasses were identified in the ashy backfill layer dating back to the Achaemenid period (UF 1265). They are *Avena*, *Lolium*, and *Phalaris*. Each of these three types includes weed species commonly found in the cereal fields of the Near and Middle East. It is most likely that the caryopses observed in Qal'at al-Bahrain had been introduced to the site in the form of crop contamination.

Discussion

The results of the archaeobotanical research conducted at Qal'at al-Bahrain reveal the image of a surrounding environment highly influenced by man since the second millennium BCE. The archaeobotanical assemblages, whether of charcoal, or seeds, are dominated by cultivated species, including the date palm. The site was presumably surrounded by palm groves within which many other economic plants were cultivated, as is the case today. These palm groves or *bustans* are thought to have been organized according to a tiered system where the foliage of date palms provided shade for other planted fruit trees and low plants such as cereals, fodder plants, and vegetable plants. The cultivation of low plants was probably done in small plots, separated from each other by levees to better control the irrigation.

The regular presence of water is a prerequisite for the functioning of this man-created ecosystem. However, the average rainfall in Bahrain, rarely exceeding 100 mm per year, is inadequate and very irregular to ensure dry-land crops every year. Extensive cereal growing can sometimes be made on a small scale after the rainfall, yet such an opportunistic planting is highly unreliable for feeding a population in the long term. Moreover, most plants grown in the past in Bahrain, including the date palm and cotton, need more substantial water intake. As a result, the Dilmun *bustans* of the past, similar to those of the present day, must have benefited from an irrigation system that had undoubtedly been drawing its strength from the many artesian springs of the northern and western parts of the main island, stemming from the Eocene and Cretaceous aquifers lying deep beneath the Arabian Peninsula.

The Bahrain archipelago, along with the neighboring area of

Al-Hasa, thus constitutes a real "natural exception" within the Gulf region[71]. In ancient times, the natural pressure of water springs, albeit strong, allowed fresh water to directly reach the surface without any mechanical intervention[72]; the vast reservoirs linked to these artesian springs allowed a water intake that is both abundant and permanent, routed to the gardens by gravity, through an open channel network, locally known as "*qanat*", a particular system specific to the island of Bahrain but directly inspired by the famous Iranian technique[73]. As in Pharaonic Egypt, the *shaduf* (a water drawing system based on the balance wheel principle) formerly used in the traditional *bustans* of Bahrain, was also used in ancient times as a more simple way to stock water from the water table, or to ensure the irrigation of higher areas not reached by, or very far from, artesian springs.

Irrigation from artesian springs is mentioned in Classic literature. Theophrastus, for example, notes that "if water pours from the sky, it would be of no use for crops, since there are numerous springs on the island that can irrigate all cultivations, and are more beneficial to cereals and trees. This is why, after a rainfall, we allow this water to cover the fields, as if trying to wash off the first...[74]" The process of "rinsing" the fields after the rains may seem surprising, but is still practiced today in Bahrain. It aims to clean the soil from the salts that splash the plants during heavy rains[75].

Unlike Lower Mesopotamia that yielded numerous administrative texts, we know virtually nothing about the organization of labor, land distribution, and marketing conditions of the Dilmun palm groves' products. Our only source, still limited, emphasizes the Middle Dilmun period, especially the period of occupation of Bahrain by the Kassites of Babylonia towards the fifteenth / fourteenth century BCE. The small archive in cuneiform script gradually updated at Qal'at al-Bahrain since 1995, in the ruins of what appears to be the palace of the Kassite governor of the island[76], provides some relevant, yet still patchy and inconsistent information. The few documents so far studied or published are often accounting documents, where simple daily administrative operations were recorded, consisting of "deliveries" and "receipts" of goods[77]. There is no doubt that part of these goods, including perishables, was produced locally. In addition to the delivery of crop shares (cereals?) to the palace, these records note the delivery of condiments, sesame and black cumin (*Nigella sativa*) dating back quite precisely to the fourth year of the reign of Agum (around 1450 BC)[78].

If it is likely that most fruits and vegetables grown in the Dilmun period were consumed locally, we might as well acknowledge that certain agricultural products entered a local or interregional trading system. The economic Mesopotamian texts indicate that the Dilmunites used to import wood, wool, and textiles from other regions of the Middle East, and it is more than likely that they exported certain local products in return. Cotton, specifically, could have been one of those "cash crops", at least since the Achaemenid period. The same could be partially true for the famous "Dilmun dates" with due consideration of the abovementioned reservations.

Outside the entirely anthropized and cultivated sphere that the palm groves represented, the anthracological analysis

63 Andre-Salvini, 1999a: 48. Cat. 6.
64 Nesbitt, 1993 : 32.
65 Andre-Salvini, 1999a : 48. Cat. 6: Connan. Lombard et al.,1998 : 176–177.
66 In Eastern Arabia, carbonised jujube kernels (*Ziziphus* sp.) have been proved in the following sites: Hili (Cleuziou and Costantini, 1980), Bat (Tengberg, 1998: 188), Mleiha (Pena-Chocarro and Barron-Lopez, 1999), and Ra's al-Hamra (Biagi and Nisbet, 1992).
67 Theophrastus, *Enquiry into Plants*, IL IV. 7, ed. trans. Amigues, 1989: 87.
68 Maraqten, 1993.
69 Lombard, 1986: 227 (Qal'at al-Bahreïn); Lombard, 1987 (Failaka).
70 Potts, 1989: 16(Ed-Dur); Haerinck, 1992: 197–199 (Ed-Dur).
71 Larsen, 1983: 133-141; Dalongeville, 1999.
72 It is estimated that in the period of Dilmun, the water level in the sediments reached a height of 6 m above sea level (Dalongeville, 1999: 30, 32). This high hydrostatic pressure which generated real "geysers", continues to decline today with the gradual depletion of fossil aquifers, even resulting in the drying up of several of the Island's main springs (*ayn*).
73 The purpose of this network of underground tunnels was to carry the water collected in reservoirs built near the springs, rather than to drain the foothill groundwater basin, virtually non-existent in Bahrain. These qanats that continued to be numerous and active in the pre-oil era, have now almost disappeared from the island. The time of their introduction to Bahrain remains unknown.
74 Theophrastus, *Enquiry into Plants*, II. IV. 7, ed. trans. Amigues, 1989: 87.
75 Potts, 1990 : 137.
76 Andre-Salvini and Lombard, 1998 ; Andre-Salvini, 1999b.
77 Andre-Salvini, 1999b: 128.
78 Ibid.: 127, Cat. 168. 169.

has given us a hint, albeit partial, of the natural ecosystems in Bahrain. The identified timber species and the plant formations that they reflect (wooded steppe, mangroves, hydro and halophytic formations) are characteristic of the phytogeographical Saharo-Arabian zone, including Bahrain. However, these ecosystems have been severely disrupted or gradually destroyed (as is the case for the wooded steppe of *Prosopis cineraria* and *Acacia nilotica*) by human activity over the millennia.

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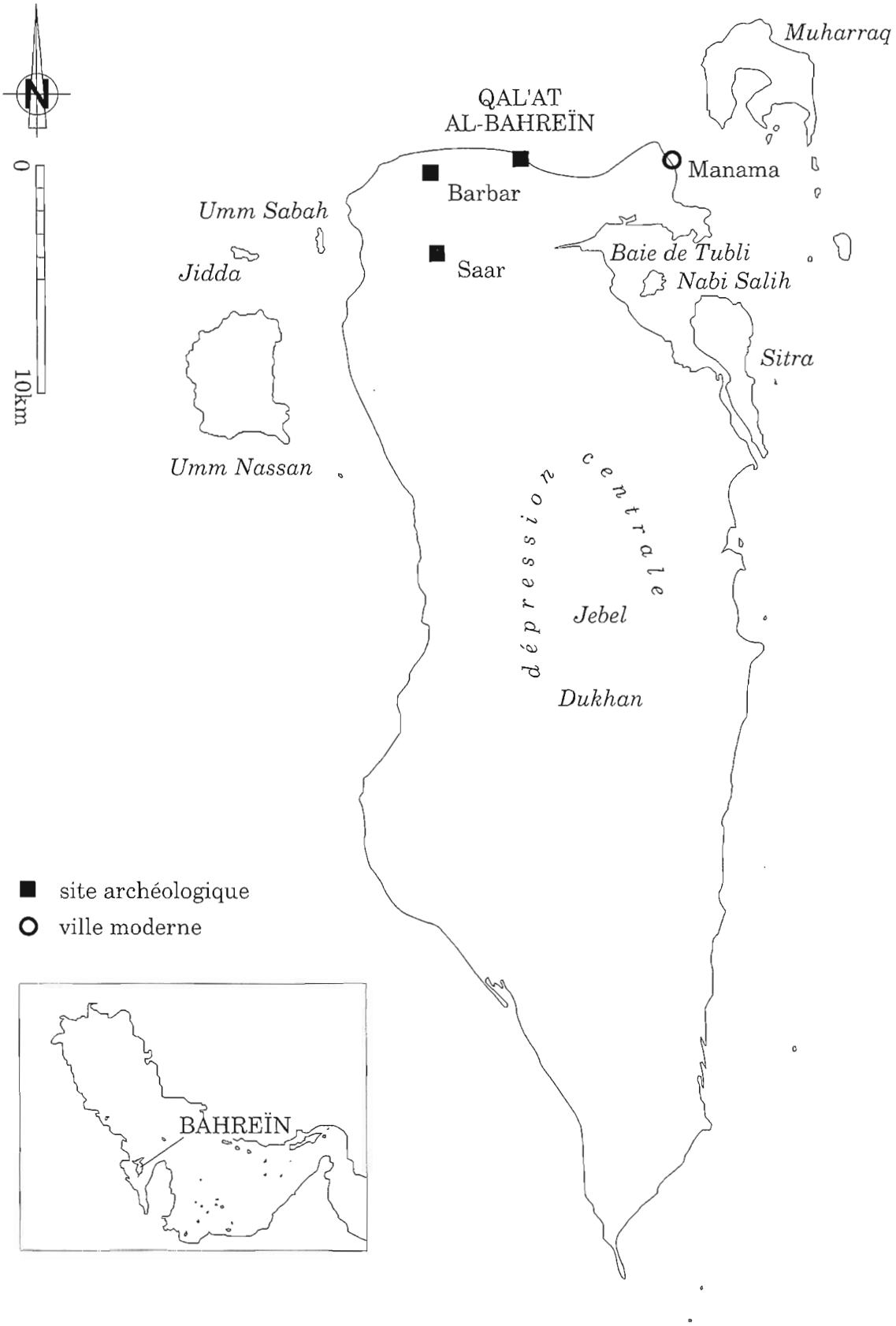


Fig / Figer 1
الصورة١

Map of the Bahrain archipelago with the location of Qal'at al-Bahrain
Mappa dell'arcipelago del Bahrain con il sito di Qal'at al-Bahrain
خريطة أرخبيل البحرين مع موقع قلعة البحرين

نشرت في الأصل باللغة الإنجليزية:
Ecological Urbanism, Lars Müller Publishers, Baden, Germany, 2010

Phase	Ancient Dilmoun						Middle Dilmoun (kassite)				Recent Dilmoun (pre Achaemenid and Achaemenid)										Tylos (séleuco_parthe)			
Dating	c. 2200–1750 BC. notre ére						c. 1450–1350 BC. notre ére				c. 1000–500 BC. notre ére										c. 300 BC. notre ére–300 AD			
UF	1119	1120	1122	1125	FA	FR(%)	1122	1125	FA	FR(%)	188	634	569	1154	1163	1178	1265	1265	FA	FR(%)	193	1561	FA	FR(%)
Acacia cf. nilotica																		7	7	2,6				
Avicennia marina													2					1	3	1,1				
Chenopodiaceae							5		5	10,0														
Fraxinus sp.																			2	0,7				
Lycium sp.																			4	1,5				
Phoenix dactylifera	25	25	50	25			125	100,0	37	74,0	50	19	1	20		7	62	4	163	60,4	25	2	27	90,0
Pinus halepensis/brutia														5		8			13	4,8				
Populus euphratica							6		6	12,0														
Prosopis cineraria															42	3		1	46	17,0		3	3	10,0
Punica granatum												6	2					2	10	3,7				
Tamarix sp													5				1	10	16	5,9				
Ziziphus spina-christi							2		2	4,0							1		1	0,4				
indeterminate																	5		5	1,0				
Number of investigated coals	25	25	50	25	125	100,0	25	25	50	100,0	50	25	10	25	50	10	75	25	270	100,0	25	5	30	100,0
Total	100,0																							

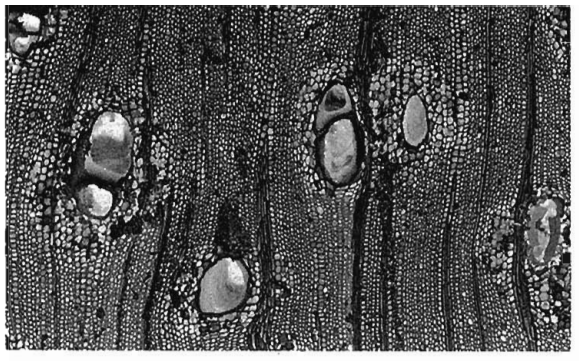
Table / Tavola 1
الجدول ١

Results of the anthracological analysis: absolute and relative frequencies of identified timber taxa.
Risultati dell'analisi antracologica: frequenze, assolute e relative, di taxa di legno che sono stati identificati.
نتائج التحليل الأثري: التكرار المطلق والنسبي في الأصناف الخشبية المحددة

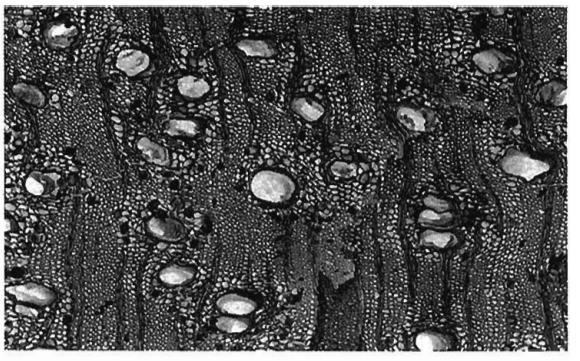
Phase	Ancient Dilmoun		Middle Dilmoun (kassite)		Recent Dilmoun (pre Achaemenid and Achaemenid)		Tylos (séleuco_parthe)	
Dating	c. 2200–1750 BC. notre ére		c. 1450–1350 BC. notre ére		c. 1000–500 BC. notre ére		c. 300 BC. notre ére–300 AD	
Float volume (liters)	354		41,4		39,4		27	
Number of samples studied	5		4		11		2	
	Ntotal	un.(N éch)	Ntotal	un.(N éch)	Ntotal	un.(N éch)	Ntotal	un.(N éch)
Triticum durum/ aestivum					15	1		
Triticum cf. aestivum, segment de rachis					3	1		
Hordeum vulgare vétu, caryopse symétrique					21	1		
H. vulgare vétu, caryopse asymétrique	3	1			35	3		
H. vulgare	6	2	1	1	11	4		
H. vulgare, segment de rachis	4	3			2	1		
Céréales			1	1	1	1	1	1
Avena					1	1		
Lolium					3	1		
Phalaris					1	1		
Gramineae	1	1			4	1		
Medicago cf. sativa					13	1		
Leguminosae					1	1	1	1
Coriandrum sativum			48	1	1	1		
Gossypium					7	1		
Sesamum indicum			1	1				
Phoenix dactylifera	19	4	2	2	281	9	8	2
P. dactyliferam périanthe					2	1		
Vitis vinifera subsp. vinifera					1	1		
Ziziphus spina-christi					4	1		
Monocotyledonae, frags. de tiges					34	2	1	1
indeterminate	1	1			4	4		

Table / Tavola 2
الجدول ٢

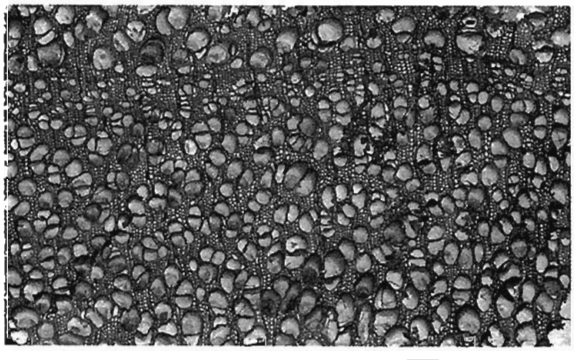
Results of the carpological analysis: Absolute number and ubiquity of identified taxa.
Risultati delle analisi carpologiche: numero totale e ubiquità del taxa identificato.
نتائج تحليل الفحم: العدد المطلق للأصناف المكتشفة ووجودها الكلّي.



a



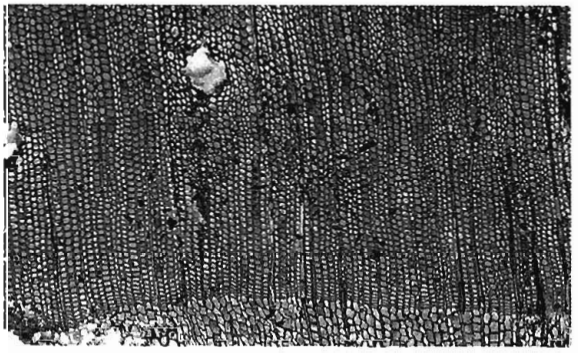
b



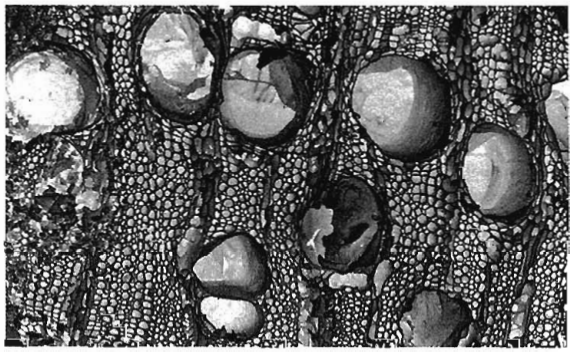
c



d



e



f

Panel / Pannello 1
الشريحة ١

Timber taxa identified in Qal'at al-Bahrain, cross-sections examined under a scanning electron microscope (SEM). / Taxa di legno identificati in Qal'at al-Bahrain, sezioni esaminate sotto un microscopio a scannerizzazione elettronica (SEM).

أصناف خشبية تم تحديدها في قلعة البحرين، قطع عرضية وضعت تحت المجهر الإلكتروني الماسح. الأكاسيا

a Acacia cf. nilotica [Nile acacia], UF1341 [x 70].
النيلية UF١٣٤١ [٧٠/]

b Prosopis cineraria [Prosopis], UF1163, [x 70].
البروزوبيس UF١١٦٣ [٧٠/]

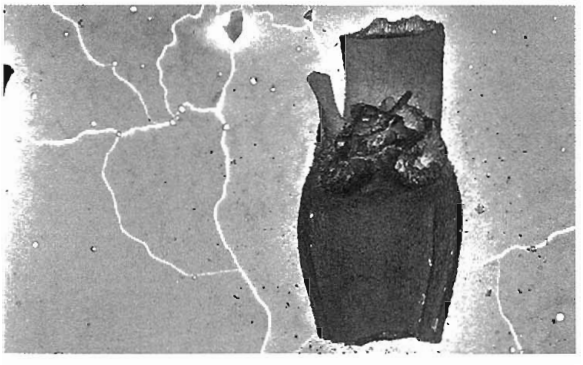
c Populus euphratica [Euphrates poplar]. UF1112 [x 70].
الحور الفراتي UF١١١٢ [٧٠/]

d Phoenix dactylifera [date palm / palma da dattero], UF1122 [x 70].
نخيل التمر UF١١٢٢ [٧٠/]

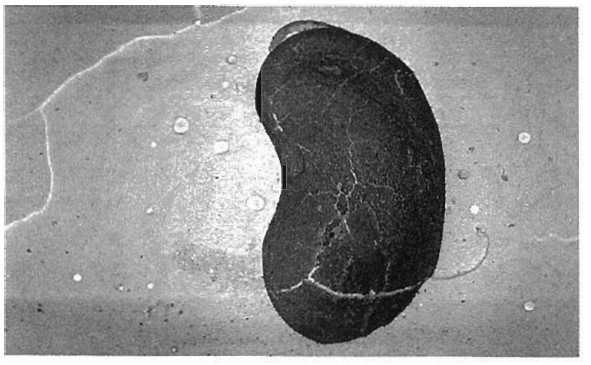
e Pinus halepensis/ brutia [pine], UF 1163, [x 70].
الصنوبر UF١١٦٣ [٧٠/]

f Fraxinus sp. [ash], UF1265, [x 70].
الدردار UF١٢٦٥ [٧٠/]

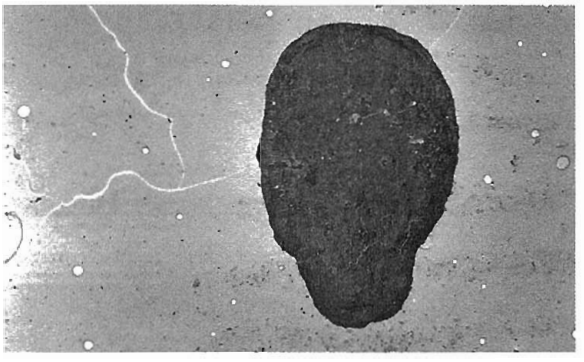
نشرت في الأصل باللغة الإنجليزية:
Ecological Urbanism, Lars Müller Publishers, Baden, Germany, 2010



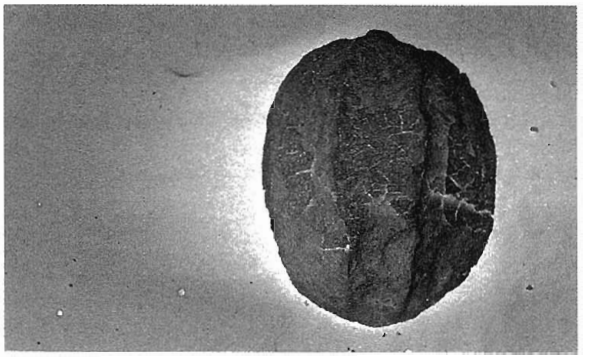
a



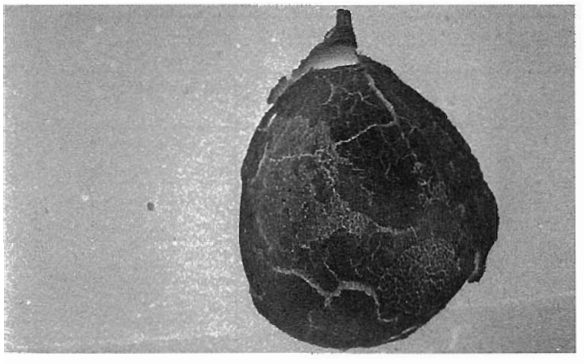
b



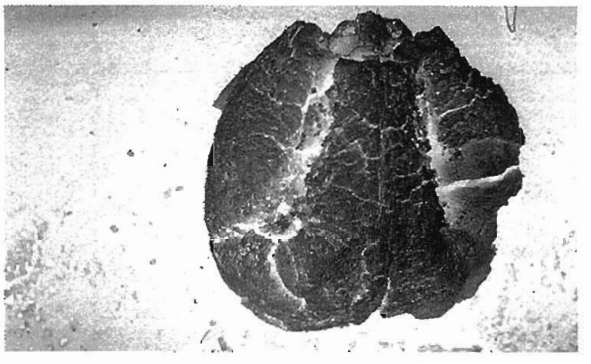
c



d



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Panel / Pannello 2
الشريحة٢

Carpological remains identified in Qal'at al-Bahrain, examined under a Scanning Electron Microscope (SEM). /
Resti carpologici identificati in Qal'at al-Bahrain, esaminati sotto un microscopio a scannerizzazione elettronica SEM).
بقايا فحميّة مكتشفة في قلعة البحرين، وضعت تحت المجهر الإلكتروني الماسح.

a Triticum cf. aestivum, rachis segment (aestivum-type wheat)/ segmento di rachide (frumento di tipo aestivum), UF 1265 (x 20).
شدف من الرايهيس (قمح من النوع اللين) (UF١٢٦٥)

b Medicago cf. sativa (cf. lucern), UF 1265 (x 27).
البرسيم (UF١٢٦٥)

c Sesamum indicum (sesame), UF 1156, (x 27).
السمسم (UF١١٥٦)

d Coriandrum sativum (coriander/coriandolo) UF 1156. (x 27).
الكزبرة (UF١١٥٦)

e Gossypium sp. (Cotton/Cotone), UF 1265 (x 14).
القطن (UF١٢٦٥)

f Vitis vinifera subsp. vinifera (vine/vite), UF 1265 (x 23).
الكرمة (UF١٢٦٥)