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Plant supplying strategies in an Islamic Omani harbour city: archaeobotanical analysis from a workshop (B39) in Qalhāt (XIVth-XVIth c. AD)

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Abstract

Few archaeobotanical studies have been undertaken on Islamic period sites in eastern Arabia. Excavations conducted by Dr. Axelle Rougeulle (UMR 8167) at Qalhāt in the framework of the *Qalhāt Development Project*, have provided the opportunity to improve our knowledge on plant consumption and supply strategies. Samples from the workshop B39 (14th-16th c. AD) excavated in 2014-15 have provided a substantial amount of seed and fruit remains that are the object of this study. First, the distribution of plant remains within B39 provides us with hints to the use of the different spaces. Thus it is suggested that some domestic activities such as food preparation and the cleaning of crops prior to their consumption took place in room E. Most of the remains correspond to crops of tropical origin such as Asian rice (*Oryza sativa*), finger millet (*Eleusine coracana* ssp. *coracana*), mung bean (*Vigna* cf. *radiata*), mat bean (*Vigna* cf. *aconitifolia*), cowpea (*Vigna unguiculata*) and sesame (*Sesamum indicum*). Their presence at the site raises the question of their origin, either as imported goods or crops cultivated locally. In the case of an importation, the Indian subcontinent seems to be the most probable centre of origin although other regions, notably Yemen, may also be considered.

Further, we discuss the possibility for the introduction of tropical crops into local agrosystems present near the site.

Key-words

Archaeobotany, Sultanate of Oman, Islamic period, tropical crops, importation, acclimatisation

Introduction

The archaeological research concerning the Islamic period in the Arabian Peninsula has so far focused mainly on harbour sites along the Persian Gulf and the Sea of Oman. The identification of multiple imported productions (mostly pottery), has allowed archaeologists to reconstruct the trade routes across the western Indian Ocean and thus to appreciate the primordial place of the Arabian Peninsula within these maritime networks (Le Maguer 2016). The excavations carried out on the site of Qalhāt in the Sultanate of Oman, since 2008 in the framework of the *Qalhāt Project*, and since 2013 in the *Qalhāt Development Project* directed by Dr. Axelle Rougeulle, contribute to this general theme. Indeed, the finds of imported ceramics from different regions bordering the Persian Gulf and the Indian Ocean show the importance of the port city of Qalhāt in commercial exchanges from the 13th to the 16th centuries AD (Rougeulle *et al* 2014, Simsek *et al* 2015). The excavation campaigns at the site have also provided the opportunity to adopt a strategy for the sampling and study of archaeobotanical remains in order to complete our still limited knowledge on the exploitation, use and trade of plant resources during the Islamic period in the Arabian Peninsula (Bouchaud *et al* 2016). A preliminary analysis of macrobotanical remains (seeds, fruits, wood) carried out on the site has permitted us to define the main components of the plant diet and to suggest the existence of local agricultural systems in the form of date palm gardens. In particular, the discovery of sorghum (*Sorghum bicolor*), a cereal originate from tropical and subtropical regions of Africa and India, has raised the question of the importation of plant products to the site *versus* their integration into pre-existing agricultural systems (Dabrowski *et al* 2015a). The results of the archaeobotanical analysis bearing on material from a workshop (B39) excavated during the 2014-15 campaigns under the direction of Dr. Thomas Creissen are presented here and help us to answer some of questions related to the organisation of the building as well as the general plant supplying strategies of its inhabitants. What information does the distribution of macro-botanical remains give about the function of rooms inside the building? Were the identified domestic plant taxa cultivated locally or were they imported? And if imported, from where could they have come?

The archaeological site of Qalhāt

The ancient city of Qalhāt is located on the Omani coast of the Indian Ocean, 50 km north of Ra's al-Hadd, the eastern point of the Arabian Peninsula, and near the modern city of Sûr (Fig. 1). The site is set on an outcrop of conglomerates and limestone rocks, bordered on the west by the Oman Mountains known as the Jebel el-Hajar and on the north by the mouth

of the Wadi Hilm. The closely situated modern village of Qalhāt is established where date palm gardens are now maintained (Desruelles and Beuzen-Waller 2013). The local climate is arid, defined by high temperatures and low amounts of precipitation (around 100 mm/year) unequally distributed in space and time (Sanlaville 2000: 49, Kwarteng *et al* 2009). In the mouth of the Wadi Hilm, the water sinks into the ground before arriving to the sea thus creating a water table close to the surface that is of benefit to local date palm gardens (Wilkinson 1977: 47).

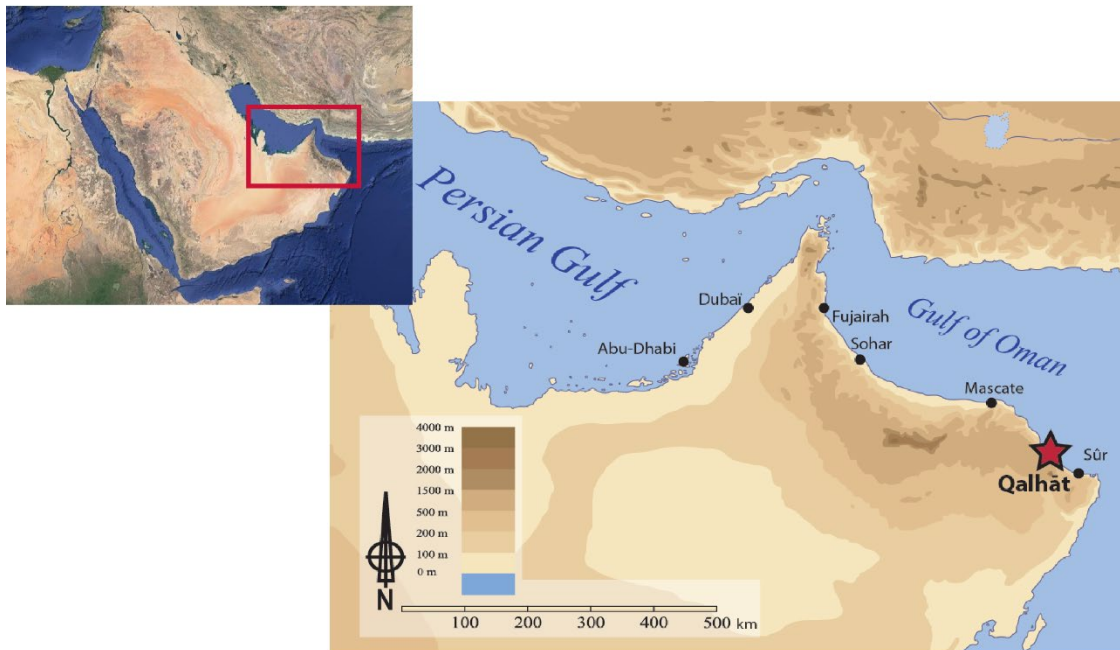


Figure 1. Localization of the site of Qalhāt (red star) with modern cities (black dots) (© Google Earth; Map background: H. David, Ifpo).

Today's vegetation cover around the site (Fig. 2) is characterised by open xeromorphic shrub-lands, predominantly composed of spiny *Acacia tortilis* trees, associated with jujube trees *Ziziphus nummularia/spina-christi* and shrub species such as *Tephrosia purpurea*, *Heliotropium brevilimbe*, *Pulicaria glutinosa*, *Lycium shawii*, *Ochradenus arabicus*, *Convolvulus virgatus*, *Senna holosericea* and *Physorynchus chamaerapistrum*. Salt-tolerant species common on saline soils in coastal areas are also attested such as *Suaeda fruticosa*, *Limonium stocksii*, *Heliotropium bacciferum*, or in the mouth of the Wadi Hilm, *Tamarix aucheriana*. To the south, the lagoon of Sour shelters a monospecific mangrove with *Avicennia marina* (Ghazanfar 1999, König and Fried 2015). Because of its proximity to the Jebel el-Hajar, taxa growing in the foothills and the mountains are also available at a short distance from the site.



Figure 2. The environment of Qalhāt. A: View of the vegetation cover on site composed mainly of *Acacia tortilis*; B: Date palm gardens growing north of the site.

The first mention of the city in literary sources occurs around the end of the 11th century. From its beginning, Qalhāt was closely linked to the kingdom of Hormuz. It has been a major harbour and an important trade place of the Indian Ocean from the 13th century until the beginning of the 16th century. In 1508, the Portuguese claim to have completely sacked and destroyed the city and Qalhāt was completely abandoned during the second half of the 16th century. Nowadays, the archaeological site is a very large area of ruins surrounded by different sets of fortification walls. The ancient inhabited part of the city is mostly located northward, where more than 300 buildings have been identified yet, with only the so-called mausoleum of Bibi Maryam, small mausoleums and two cisterns still standing. After a preliminary survey (1998) and few soundings (2003) (Vosmer 2004), a new archaeological project began in 2008 at the request of the Ministry of Heritage and Culture of Oman. This project is still running and is led by Dr Axelle Rougeulle (CNRS, UMR 8167).

During the many excavations, a great amount of finds – mostly ceramics – delivered important clues to understand the former trade routes Qalhāt was belonging to. Apart from local and few Yemeni productions, most of the pottery sherds belong to Eastern Arabia, Iranian and most of all Indian ceramics. These importations also include Far East productions, like Chinese and Vietnamese porcelain, Thai Celadon or Burmese ware. No African importations have been found. According to an extensive survey, a general map of the medieval city can now be drawn (Fig. 3). Apart from the streets, squares, cemetery and fortification walls, different kinds of buildings have been identified: houses, storehouses, mosques, funerary structures, small shops, cisterns and at least two constructions devoted to craft industry. Both are in the same area, maybe a craftsmen quarter, located north from an inner wadi. One of these buildings is a ceramic workshop which was in activity from the very end of the 13th century until the end of the 14th century and then became a dump for neighbouring ceramic factory used until the 16th c. (B 41). The building concerned by this study, B39, might have been used as a jewellery/small objects workshop during its latest phase. It has been abandoned during the first half of the 16th century, possibly sacked by the Portuguese in 1508.



Figure 3. Map of Qalhāt with the localization of the building 39 in the red circle.

From 2014 to 2015, B39 has been almost completely excavated, all the layers of collapse being removed. Its general shape appears to be quadrangular, about 10x13 m (130 m²), with the main entrance to the east and a smaller one to the south. This building includes different areas (A, B, D, E and F) that are in turn subdivided into multiple rooms (Fig. 4). The excavations have clearly demonstrated that two main phases should be distinguished for the building (a few remains could belong to a former occupation which is very scarcely documented). The first construction dates back to the very end of the 13th century or the beginning of the 14th century. Its general layout is quite similar to the present one: a large area divided into two rooms in the west (A); a central courtyard (?) with a basin eastward (B) and, further east, another room a little bit narrower (E). One cistern (F) was located to the south of this room and another one hosting a basin to the north (D). The function of the entire building and of the different rooms remains unclear, apart for the cistern. The presence of numerous basins might be related to the ceramic workshop B41. None of the archaeobotanical samples studied belongs to this early phase.

B39 was later transformed during two successive phases: phase 1 (2nd half of the 14th c. AD – 15th c. AD) and phase 2 (15th c. AD – 1st half of the 16th c. AD). All the basins like the cistern were filled. In room B, the basin was probably abandoned during the second half of the 14th century (UF 5069), but all the changes inside the building are probably not strictly contemporaneous. To the west, in area A, a former partition wall was dismantled and a new one erected further south. A1 is a small room located in the south-west corner of the building. According to the finds, it was probably used for craft activities during the very last phase. The sample studied from A1 (UF5029) belongs to an intermediary phase which is not clearly dated (14th century?). In room A2, UF 5080 – probably a backfill – might belong to the same phase. Before the abandon of B39 (end of phase 2), this room was clearly devoted to craft activities, as shown by many elements found in the layers 5035/5042: hammer stones, moulds, mother-of-pearl, semi-precious stones, weight, shells containing pigment, etc. A small room was set in the southern part of area B (B1). Inside, UF 5022 is a backfill dating from the 15th century, whereas UF 5014, an ashy layer rich in charcoal, belongs to the late occupation phase (phase 2). The function of this room is not known. Just below the layer of collapse, the remaining part of room B (B2) is filled with a backfill covering the former basin and topped by a hard beaten hearth floor (UF 5043/5045). Inside these layers are many pottery shards mostly dating to the 14th century. One might assume that this floor was first set up during the early phase of room B (phase 1) but was still in use until the collapse of the 16th century (phase 2). As no shards belonging to phase 2 have been found in this room, the floor of this courtyard was most probably frequently cleaned up.

Apart for a single grind or hammer stone located near the entrance of room B1, no information is available as to the function of B2. In room E, a new wall was built and the room extended eastward. Its last floor was almost completely topped by a very ashy layer belonging to the 16th century (UF 5085). In the south-east corner of this room, St 26 is an oven/*tannour* made

of a semi unearthed jar. Along the southern wall, UF 5091 and 5088 both belong to the same hearth topped by the collapse layer. Just below this collapse or partly belonging to it, UF 5034 is a very localized ashy layer. The whole levels belonging to room E are dated to phase 2, except those from early backfill. Room E was most probably dedicated to cooking activities.

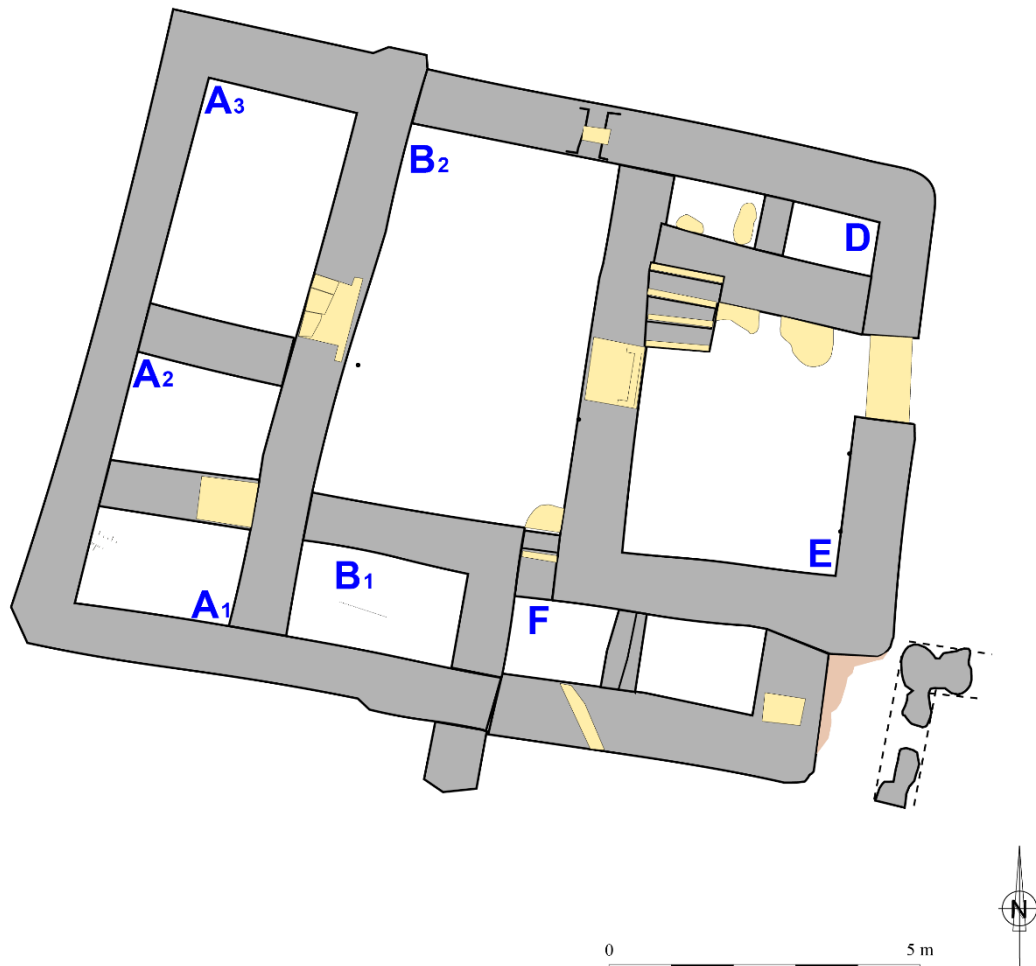


Figure 4. Plan of building B39.

During the phase 2, the southern wall of B39 has been enlarged, and a new room set above the filled cistern (F). Inside this room, floors and layers alternate (5082, 5086 and 5087), all dating to the 16th century. They contain much ash, charcoal and a lot of fishbones, which seem to demonstrate that this room had a domestic use. Later, the southern wall of room F might have been destroyed and this area could have been an open space. Leaning on both the northern wall and the southern dismantled (?) wall, UF 5048 belongs to the very last occupation (phase 2) (it was topped by the collapse). It also contains ashes, charcoal and many fishbones. The north-east corner of the building was occupied by a raised platform (D) connecting to room E by a stair. Just below this platform, the former basin was probably first converted into some kind of cellar that was progressively abandoned and filled. Among these fillings, UF 5053 might belong to the 14th or 15th century (phase 1) and UF 5055 to the 15th/16th centuries (phase 2). UF 5044 is the lower part of a collapse located around the eastern

entrance of area B, between the interior and the exterior of the building (phase 2). According to the collapse layers, room E was almost completely covered by a roof made of wooden timbers and probably palm matting. The original shape of room D is unclear, but the platform was completely surrounded by high walls and probably also covered. Area A, room B1 and room F were also topped by a roof, whereas room B2 was probably in the open air. In sum, during the latest phase (phase 2), most of the domestic rooms were located in the east whereas those dedicated to craft activities were situated in the western part. Between them, area B was mostly an open courtyard, except a small room (B1) located in the south-west corner.

Material and methods

Archaeobotanical samples from various contexts (occupational levels, earthen floors, backfills, collapses, hearths) identified during the excavation of the different parts of B39 (A, B, D, E, F) have been processed. Similar quantities of sediments were collected from the different areas except from area D, represented by 2 samples only. None of the samples belongs to the occupation of the first building and most are dated to the latest phase of occupation of the second building, that is phase 2 dated to the 15th c. – first half of the 16th c. AD. Macro-botanical remains have been extracted from a total of 19 samples¹. The volume of individual samples ranged between less than 1 litre and 30 litres with a total of 204.5 litres of sediment processed at site (October-November 2015).

The majority of the collected plant remains (96%) were preserved by carbonization. Other types of conservation (e.g. by mineralization and desiccation) were rarely encountered. Charring, as the result of the exposure of plant elements to fire, is a common phenomenon linked either to daily activities, such as cooking and the burning of domestic refuse, or accidental fire. As the site is situated in an arid environment we could also expect that some plants, for example construction wood, may occasionally be preserved by desiccation but then it is not always easy, by a mere visual examination, to determine whether they are actually archaeological or modern. To extract archaeobotanical remains from the sediment samples we used a flotation machine in which water was recycled with the help of domestic pump (Fig. 5). Sediment samples from the excavation were poured into the flotation tank. The light fraction consisting of plant remains floating on the surface of the water was recovered in a fine-meshed sieve (0.3 mm) placed under the spout of the main flotation tank. The heavy fraction (bones, shells, ceramic, glass, coins, pearls, etc.) was collected from a larger sieve (mesh size: 1 mm) fixed inside the flotation tank. After extraction plant remains were dried before being exported to the archaeobotanical laboratory in the National Museum of Natural History in Paris, France, for further analysis.

¹A total of 23 samples have been processed but three of them did not contain any botanical remains so they have not been considered in this study. Another one (UF 5044-5) has only coprolithes but it has been taken into consideration for complete account.



Figure 5. The flotation machine used at Qalhāt constructed from empty oil drums. The main flotation tank to the right (blue) and two decantation tanks to the left (green).

The seed and fruit remains were extracted from the flotation residues and studied with the help of a binocular stereomicroscope (Nikon SMZ645). The botanical identification of seeds and fruits is based on morphological and anatomical criteria which imply the comparison of the archaeological material with modern reference collections as well as with illustrations in seed atlases (Cappers *et al.* 2006, Jacomet 2006, Cappers *et al.* 2009, Cappers *et al.* 2012). Results are presented in number of remains and minimum number of individuals (MNI). The MNI of cereals and pulses has been calculated by counting whole seeds/fruits as one and adding the number of fragments divided by two. For the other economic taxa such as the fruit remains, the MNI has been evaluated by reconstructing whole individuals from fragments available. Percentages calculated are based on the MNI of the determined and undetermined remains. The fragmentation rate has been calculated dividing the total number of fragments by the total of determined remains; the density per liter dividing the total number of (determined and undetermined) remains by the volume.

Results

A total of 164 archaeobotanical remains corresponding to a MNI of 138 have been retrieved from building B39 at Qalhāt (Table 1). Most of the samples analysed date to the latest occupation (phase 2) of B39 and subsequently archaeobotanical remains are much more numerous from this phase corresponding to 96% of the total number of identified items. They consist of whole and fragmented seeds and fruits as well as some vegetative elements such as chaff and perianths. In addition to these, 2039 uncharred seeds belonging to the *Amaranthaceae* family on the one hand and to the genus *Aizoon* (*Aizoaceae*) on the other hand occurred in several samples but their general aspect and high numbers suggest that they rather correspond to modern contaminations and they have thus not been included in this study. On the contrary the rare mineralized seed/fruit remains (N=2) are included as this type

of preservation occurs naturally in some taxonomical groups, such as the Boraginaceae from which we identified one nutlet. Finally, charred animal droppings were also recorded but are not included in the counts below.

Phase	Phase 1				Phase 2								Phase 1 /Phase 2		Total			
Dating	2 nd half of the XIV th -XV th c.AD				XV th - 1 st half of the XVI th c. AD													
Sector	B		D		B		A		D		E		F		B			
UFs	5069 (B2)		5053		5014, 5022 (B1), 5054 (B2)		5035, 5042 (A2)		5055		5034, 5044, 5085, 5088, 5091		5048, 5086, 5087		5043, 5045 (B2)		18	
Number of samples	1		1		3		3		1		6		3		2		20	
Total of volume sieved (litre)	7,5		6		29		51		4		62		33		12		204,5	
	NR	MNI	NR	MNI	NR	MNI	NR	MNI	NR	MNI	NR	MNI	NR	MNI	NR	MNI	NR	MNI
Cereals																		
<i>Eleusine coracana</i> ssp. <i>coracana</i> , caryopsis	-	-	-	-	4	4	1	1	-	-	1	1	1	1	-	-	7	7
<i>Eleusine coracana</i> ssp. <i>coracana</i> , min. caryopsis	-	-	-	-	-	-	-	-	-	-	-	-	2	2	-	-	2	2
<i>Oryza sativa</i> , caryopsis	-	-	-	-	2	2	-	-	1	1	-	-	1	1	-	-	4	4
<i>Oryza sativa</i> , fg. caryopsis	-	-	-	-	2	1	-	-	-	-	2	2	-	-	1	1	5	4
cf. <i>Oryza sativa</i> , caryopsis	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	1	1
cf. <i>Oryza sativa</i> , fg. caryopsis	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	1	1
<i>Oryza sativa</i> , desiccated fg. of lemma and palea	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	1	1
Panicoidae, caryopsis	-	-	-	-	-	-	-	-	-	-	3	3	-	-	1	1	4	4
Panicoidae, desiccated fg. of lemma	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	1	1
<i>Triticum aestivum</i> / <i>durum</i> , caryopsis	-	-	-	-	-	-	1	1	-	-	-	-	2	2	-	-	3	3
Pulses																		
<i>Lens culinaris</i> ssp. <i>culinaris</i> , cotyledon	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	1	1
cf. <i>Lens culinaris</i> ssp. <i>culinaris</i> , fg. cotyledon	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	1	1
<i>Vigna</i> cf. <i>aconitifolia</i> , cotyledon	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	1	1
<i>Vigna radiata</i> / <i>mungo</i> , cotyledon	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	1	1
<i>Vigna</i> cf. <i>radiata</i> , cotyledon	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	1	1
<i>Vigna unguiculata</i> , immature seed	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	1	1
Fruit plants																		
<i>Phoenix dactylifera</i> , date stone	-	-	-	-	1	1	-	-	-	-	1	1	-	-	-	-	2	2
<i>Phoenix dactylifera</i> , fg. date stone	1	1	-	-	3	1	-	-	-	-	3	2	-	-	-	-	7	4
<i>Phoenix dactylifera</i> , fg. date stone with endocarp	-	-	-	-	8	-	-	-	-	-	5	-	-	-	-	-	13	-
<i>Phoenix dactylifera</i> , fg. date stone with pericarp	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	1	-
<i>Phoenix dactylifera</i> , fg. date stone endocarp	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1	-
<i>Phoenix dactylifera</i> , perianth with pedicel	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	2	-
<i>Ziziphus</i> sp., fg. endocarp	-	-	-	-	3	1	-	-	-	-	5	2	-	-	-	-	8	3
Oil-producing crop																		
<i>Sesamum indicum</i> , seed	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	1	1
Herb																		
<i>Coriandrum sativum</i> , seed	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	1	1
Wild/Weedy plants																		
<i>Amaranthus</i> / <i>Chenopodium</i> , seed	-	-	-	-	6	6	-	-	-	-	55	55	-	-	-	-	61	61
<i>Asphodelus</i> cf. <i>tenuifolius</i> , seed	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	1	1
Boraginaceae, mineralized nutlet	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	1	1
Caryophyllaceae, seed	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	1	1
<i>Echinochloa colona</i> , caryopsis	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	1	1
<i>Malva</i> sp., seed	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	1	1
cf. <i>Medicago</i> , seed	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	1	1
<i>Portulaca</i> cf. <i>oleracea</i> , seed	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	1	1
<i>Salsola</i> sp., seed	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	1	1
Indeterminate																		
Indeterminate, seed/fruit remains	1	1	1	1	4	4	2	2	-	-	4	4	5	5	1	1	18	18
Indeterminate, fg. endocarp	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	1	1
Indeterminate, berry	-	-	-	-	2	2	-	-	-	-	-	-	-	-	-	-	2	2
Indeterminate, fg. pericarp	-	-	-	-	1	1	-	-	-	-	1	1	-	-	-	-	2	2
Indeterminate, pedicel	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	1	1
Amorphous organic remains	-	-	-	-	x	x	-	-	-	-	x	x	-	-	-	-	x	x
Coproliths																		
Coproliths, rodent dropping	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	1	1
Coproliths, insect feeder dropping	-	-	-	-	3	3	-	-	-	-	2	2	1	1	-	-	6	6
Modern seeds																		
<i>Aizoon</i> cf. <i>canariense</i>	-	-	-	-	22	22	30	30	2	2	40	40	21	21	370	370	485	485
Amaranthaceae	1	1	20	20	44	44	470	470	47	47	160	160	15	15	797	797	1554	1554
Total of determined remains																		
Total of indetermined remains	1	1	1	1	7	7	3	3	0	0	6	6	5	5	1	1	24	24
Total of remains	2	2	1	1	45	29	7	7	1	1	91	81	14	14	3	3	164	138
Total of modern seeds	1	1	20	20	66	66	500	500	49	49	200	200	36	36	1167	1167	2039	2039
Fragmentation rate	1,00	-	0,00	-	0,58	-	0,25	-	0,00	-	0,20	-	0,11	-	0,50	-	0,31	-
Density of remains per litre	0.3	-	0.2	-	1.6	-	0.1	-	0.3	-	1.5	-	0.4	-	0.3	-	0.8	-

Table 1. Results of the seed/fruit analysis from building B39 of Qalhāt. They have been grouped together by phase and by room. (NR = number of remains; MNI = Minimum Number of Individuals).

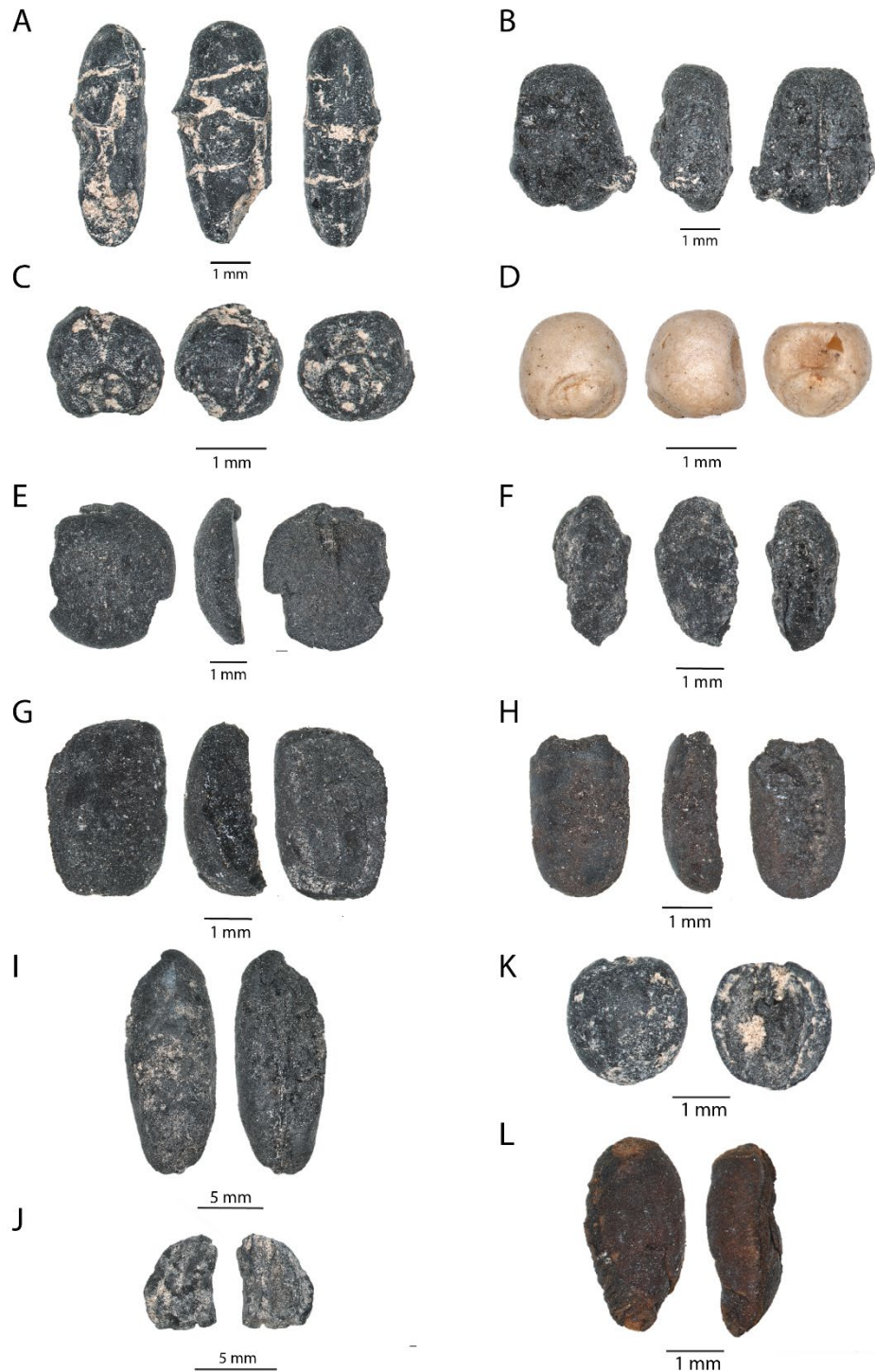


Figure 6. Seed and fruit remains from building B39 at Qalhāt.

A= Caryopsis of Asian rice (*Oryza sativa*) in dorsal, lateral and ventral view;
 B= Caryopsis of free threshing wheat (*Triticum aestivum/durum*) in dorsal, lateral and ventral view; C and D= Caryopsis of finger millet (*Eleusine coracana* ssp. *coracana*) carbonized (C) and mineralized (D), in dorsal, lateral and ventral view; E= Cotyledon of lentil (*Lens culinaris* ssp. *culinaris*) in dorsal, lateral and ventral view; F= Immature seed of cowpea (*Vigna unguiculata*) in dorsal, lateral and ventral view; G= Cotyledon of mung bean (*Vigna* cf. *radiata*) in dorsal, lateral and ventral view; H= Cotyledon of mat bean (*Vigna* cf. *aconitifolia*) in dorsal, lateral and ventral view; I= Date stone (*Phoenix dactylifera*) in dorsal and ventral view; J= Endocarp remain of jujube (*Ziziphus* sp.) in dorsal and ventral view; K= Akene of coriander (*Coriandrum sativum*) in dorsal and ventral view; L= seed of sesame (*Sesamum indicum*) in front and lateral view.

The whole archaeobotanical assemblage includes 13 cultivated and 9 wild taxa (Fig. 6). Among the former, cereals correspond to the most well represented category (20% of the MNI) with the predominance of Asian rice (*Oryza sativa*) (7%) and finger millet (*Eleusine coracana* ssp. *coracana*) (7%), originate respectively from tropical regions in Asia and East Africa. The Asian rice grain is more or less elongate in shape and laterally compressed, with a short embryo and characterized by longitudinal ridges (Fuller and Castillo 2014). Finger millet grains are identified on the basis of their globose and angular shape in lateral view as well as by the puseolate surface of their pericarp (Fuller 2017). Some other probably domestic millet types were also recorded (3%) but identified only to the level of the subfamily (Panicoideae). Besides the cereals of tropical origin, free-threshing wheat (*Triticum aestivum/durum*) (2%) was also present in the Qalhāt samples. Chaff remains, only preserved desiccated, are in general attested in very low quantities at the site (1%).

Very few remains of pulses (4%) were found and belong to lentil (*Lens culinaris*) (1%) and to several species of the genus *Vigna* (3%) with representatives from tropical Asia and Africa. We identified mung bean (*Vigna* cf. *radiata*), mat bean (*Vigna* cf. *aconitifolia*) and cowpea (*Vigna unguiculata*). It is rather difficult to distinguish the species *V. radiata* and *V. mungo* from one another but the plumule length exceeding half of the length of the cotyledon and the elongate cells visible on the testa would rather indicate mung bean (*V. radiata*) than black gram (*V. mungo*). Mat bean may be differentiated by its narrower and longer shape compared to the other species of the genus. The only find of cowpea corresponds to one immature seed that can nevertheless be recognised by its sub-rectangular shape and the size of its hilum.

Remains from fruit plants account for 7% of the total assemblage. They consist of seed remains from date palm (*Phoenix dactylifera*) (4%) and fruit stones from the jujube tree (*Ziziphus* sp.) (2%). The latter may come from either cultivated or wild specimens. One herb – coriander (*Coriandrum sativum*) – and one oil plant – sesame (*Sesamum indicum*) – have provided one item each (1%). Sesame is represented by one badly preserved seed but the so characteristic cells reticular pattern is still visible and allow identification. Wild herbs and shrubs are more numerous than crops in our assemblage (50%). This is due mainly to the high amount of seeds belonging to genus *Amaranthus/Chenopodium* (44%) mostly attested in room E (UFs 5088-5091). Finally some plant remains (17%) could not be identified due to their fragmentary and/or generally badly preserved state.

Discussion

Spatial analysis and interpretation of the archaeobotanical assemblages

The archaeobotanical assemblages are liable to inform us on the function of the rooms in building 39 as well as on local crop-processing activities. Indeed, their spatial distribution pattern shows that plant remains were concentrated in some parts of the building. Thus, room E contained more than half (55%) of the total amount of macrobotanical remains and the two

rooms in area B account for 29% of seeds and fruit remains while the other rooms contain less than 10% of the remains. These both rooms have also the most important density of remains per litre each (1,55 for area B and 1,5 for room E). Most of the botanical remains were preserved in a charred state and thus probably resulted from activities of a domestic nature, associated with fire structures such as the hearth found in room E. The charred seeds from crop plants, such as cereals and pulses, are likely to correspond to accidental burning during cooking activities that require the use of fire for example roasting and baking (Hillman 1981, 1984, van der Veen 2007). According to traditional Indian recipes, we know for instance that rice can be boiled and cooked together with pulses, the latter in the form of whole seeds or split for *dhal* (Vergara and de Datta 1996). Finger millet can be transformed into flour, and it is generally used for making porridge or bread (Jansen and Ong 1996). Their relative abundance in room E compared to other parts of the building seems to corroborate the hypothesis that this room was principally dedicated to domestic activities during the last phase of occupation. The presence of the only hearth of the building in this room also gives an indication of its use and moreover accounts for the higher concentrations of carbonised remains that were found here. Others areas such as areas B and F might be also involved in domestic activities since seeds and fruit remains have been found associated with levels containing much ashes, charcoals and bones and, in addition, area B has quite the same density of remains than room E.

Some of the wild taxa may correspond to arable weeds cleaned out from the crops before consumption. The successive steps of post-harvest processing produce different types of by-products of which some can be used as fuel or simply discarded into the fire as it has already been noticed on other archaeological sites in the Near East (van der Veen 1999). This may be the case for the two seeds of barnyard grass (*Echinochloa colona*) a common weed in present-day rice fields (Moody 1989: 131, Galinato 1999, Rao *et al* 2007, 2017) and also identified as such in archaeological contexts in India (Fuller 2011a). In that case, its presence in the building may testify to the cleaning of rice crops inside the building 39, perhaps prior to cooking. For other taxa it is more delicate to determine if they correspond to weeds or to other categories of plants, for example wild plants brought naturally (wind) or through the use of animal dung. This is of particular interest about the high amount of carbonized *Amaranthus/Chenopodium* seeds found in the only hearth of room E which may correspond to one of these categories. The high concentrations of wild/weedy plants in the room E might once more suggest that post-harvest processing took place here.

Date seeds and jujube fruit stones may have been thrown into the fire after consumption or used as fuel, a practice already observed on other sites in arid environments for example at Madâ'in Sâlih in Saudi Arabia (Bouchaud 2013). The fragmentary state of some of the date stones from Madâ'in Sâlih has been explained as the possible result of the use of the dung from camels having consumed date fruits or date stones as fuel. As the date remains from Qalhāt are also frequently found in a fragmented state their use as a food for livestock

here too cannot be excluded. This is a practice still attested today in the vicinity of oases (Tisserand 1990). The use of dung as fuel has been documented by ethnoarchaeological studies in many arid and semi-arid regions (Miller 1984, Charles 1996, Reddy 1998).

If we assume that the desiccated rice chaff remains found in low numbers in the building are really as old as the carbonised rice grains, they may highlight the use of by-products resulting from the cleaning of cereal crops. Traditionally rice chaff is used as fuel, for example in India, but also for cattle feeding (Abe 2007: 62-63, van der Veen 2007). The presence in the same room of a stone mortar (Fig. 7) suggests that dehusking of hulled cereals may have taken place inside the building perhaps directly in relation to food preparation and consumption (Abe 2007: 93).



Figure 7. Stone mortar from room E (UF 5092).

Importation or acclimatisation of allochthonous plants?

The seed assemblage from Qalhāt is characterised by the presence of many taxa native to tropical regions bordering the Indian Ocean, in particular the Indian subcontinent, and some of them are attested here for the first time in the Arabian Peninsula. This raises the question about their origin: do these plant remains correspond to goods (notably foodstuffs) imported by long-distance trade or were they introduced and acclimatised to be cultivated locally? The first alternative seems likely given the function of Qalhāt as a major harbour city involved in the long-distance trade networks of the western Indian Ocean but local cultivation has also to be considered as an option.

First, remains of date palm, cereals and pulses are regularly found in Arabian sites. The archaeobotanists generally interpret them as local agricultural products cultivated in irrigated date palm gardens. This was also the conclusion of our first study of the plant assemblages at Qalhāt (Dabrowski *et al* 2015a). Date palm, jujube trees, wheat and lentils could have grown in these agrosystems, traditionally organised in several vertical “layers” where date palms

provide shade for lower crops. Date palm gardens are thought to have appeared in the Oman peninsula during the Early Bronze Age (3rd mill. BC) and are attested there until today (Cleuziou 1982, Mouton *et al* 2012, Tengberg 2012). Palm gardens could have existed close to the city as they still do (on a small scale) in the Wadi Hilm today where irrigation is possible through wells that give access to the close water table. Moreover, the famous 14th century traveller Ibn Battûta (1982, vol. 2: 93) indicated in his writings that the village of Thîby, identified as present-day Tiwi situated 15 km north of Qalhât, possessed numerous orchards whose fruits were brought to Qalhât. He mentioned also the importation of dates from Oman, that is from the northern part of the modern Sultanate, to this region. Other large palm groves are also attested nowadays upstream in the mountains and might already have been present there during the Islamic period. In this case, the site of Qalhât could have been involved in a regional trade network including importation of plant products from other localities along the coast or in the interior. It seems possible, and even likely, that part of the supply in plant foods at Qalhât corresponded to local and regional agricultural produce, probably from multi-crop date palm gardens.

However, the presence of taxa of foreign origin still raises the question of the importation of food plants used in the diet of the inhabitants. For some of the allochthonous taxa, it seems difficult to imagine that they were acclimatised to the local agrosystems as their ecological requirements may represent a limiting factor. This is for example the case for rice whose cultivation necessitates large quantities of water (Vergara and de Datta 1996). Still, there are several mentions of the cultivation of rice in the Arabian Peninsula from historical sources and the crop is still produced today in the al-Hasa oasis in eastern Saudi Arabia where a drought-tolerant variety of rice called Hassawi rice is cultivated (Al-Bahrany 2002, Zhang *et al* 2012). Ibādî manuscripts and other textual references show that rice cultivation was established in Oman during the Islamic period (Ulbaydli 1993). In addition, Ma Huan (1970: 169), a Chinese sailor who visited the kingdom of Hormuz in 1413, mentions that rice was cultivated alongside wheat without defining exactly where in the kingdom. Varisco (1991) also considers that this crop could have been grown in small quantities in Yemen in the end of the 14th c. AD where it was probably intended for local consumption. In Egypt, the archaeobotanical study conducted at the Medieval harbour of Quseir al-Qadim as well as textual evidence strongly suggest that rice was grown in the Nile valley at that time (van der Veen 2011: 77-83). Ibn al-Mujawir also writes that rice was transported to Aden not only from India but also from Egypt (Smith 1995, Smith 2008: 159). Besides, one single archaeobotanical record of rice has been found so far from another medieval port site in the Arabian peninsula, a trade warehouse dated from the late 10th to the early 12th c. AD on the site of Sharma in Yemen, where it is interpreted as an importation (Dabrowski *et al* 2015b).

There are thus multiple possible origins for the rice remains found at Qalhât: local cultivation in irrigated palm gardens, importation from other parts of southern Arabia or even from Egypt. The most likely origin though for these remains is India and several arguments

rather point to this direction. Asian rice was cultivated in the northern part of the Indian sub-continent since at least 2500 BC before becoming widespread in the whole Indian peninsula during the 1st millennium BC (Fuller 2011b, Fuller *et al* 2010). The contacts with India were close as evidenced by other types of imports such as Indian ceramic wares (Rougeulle 2010, 2017, Rougeulle *et al* 2014). Moreover, historic chroniclers such as Marco Polo highlight the particular commercial relationships maintained by the city of Qalhāt with the subcontinent. He mentions the import of Indian goods and “plenty of cereals” in exchange with Arab horses (Vallet 2010: 555, Rougeulle 2017). Ibn Battûta (1982, vol. 2: 93) even specifies that the rice consumed in the harbour city came from the Indian subcontinent.

Most of the other exotic taxa identified at Qalhāt are attested for the first time in the Arabian Peninsula. They also point to an Indian origin: finger millet, cowpea, mung bean, mat bean and sesame. In India and Africa, finger millet is used traditionally for making alcoholic and non-alcoholic beverages as well as for food preparations in the form of porridge or unleavened bread (Jansen and Ong 1996, de Wet 2006). Seeds of cowpea are mainly used as human food, eaten whole or included in different preparations, but the seeds and pods also constitute an appreciated fodder especially in India (Madamba *et al* 2006). Sesame is likely to have been domesticated in the Indian subcontinent and is cultivated there since at least the 3rd millennium BC (Bedigian and Harlan 1986, Bedigian *et al* 1986), but it seems to have been introduced since protohistoric times in Eastern Arabia (Tengberg and Lombard 2001, Zech-Matterne *et al* 2015). Mung bean was widely cultivated in South India during Neolithic times (Fuller and Harvey 2006). Mat bean seems to have been grown as a secondary crop in India since the 1st millennium BC before becoming much more common during the following millennium (Fuller and Harvey 2006). In addition, Ibn al-Mujawir mentions sesame as a trade item that was sent from India to Aden during the 13th c. AD (Smith 1995). Even though the African continent is the place of origin for both finger millet and cowpea (Hilu and de Wet 1976, Hilu and Johnson 1992, Fuller and Harvey 2006), these crops reached India during the 2nd millennium BC where they became widely cultivated (Boivin and Fuller 2009, Boivin *et al* 2014). In the absence of African ceramic wares at Qalhāt an Indian origin for these species too seems thus more likely.

The Indian origin of the subtropical plants mentioned above seems thus quite convincing but other possibilities should not be ignored as in the case of rice. A royal crop register from the Rasulid period indicates not only sesame but also cowpea and mungbean as Yemeni productions at the end of the 14th c. AD (Varisco 1991). The presence of Yemenite so called “Mustard” ceramic wares at Qalhāt show interactions between the two regions. Crops such as millets and *Vigna* beans are less water demanding than rice (Ehlers and Hall 1997, Tsehaye *et al* 2006, Nene 2006, Chandrashekar 2010) and could potentially have been grown in local date palm gardens as is also suggested by historical sources. In particular, Ibādī manuscripts indicate that mung bean and sesame were grown locally in Oman during Islamic times (Ulbaydli 1993). In the case of sesame, local growing would be more conceivable since

it is attested in Eastern Arabia since the 3rd millennium BC. Moreover, pollen analysis has brought to light possible cultivation of sesame on the site of Salut during the Iron Age (Bellini *et al* 2011). So even if Qalhāt is a harbour connected with distant areas by long-distance trade, the hypothesis of integration of tropical crops into local and/or regional date palm gardens must not be underestimated.

Conclusion

To sum up, the archaeobotanical analysis conducted on samples from the building 39 at Qalhāt provide new information on the plant diet and supplying strategies of the population living there in the 14th-16th century AD. Along with the common plant list characteristic of Arabian agricultural systems from the 3rd millennium BC onwards (date palm, wheat, lentil, etc.), several crops of tropical origin, most of them previously non attested in eastern Arabia, such as Asian rice, finger millet, Indian pulses and sesame have been determined as components of the plant diet. The distribution of seed and fruit remains may highlight the function of room E as dedicated to domestic activities probably linked to food preparation. Crop-processing activities such as the dehusking of hulled cereals or the reuse of date and jujube stones as fuel may have contributed to the constitution of the archaeobotanical assemblage.

The relatively large diversity of exotic taxa generally absent from other sites in the Arabian Peninsula, underlines the role played by the importation of plant products probably mainly from the Indian subcontinent even though other interactions, for example with Yemen, cannot be excluded. In any case, there is no reason to believe that the origins of plant products would not have been multiple: local, regional and far-distance and we have discussed the possibility that some crops of tropical origin were actually cultivated in local date palm gardens.

Further archaeobotanical investigations will be necessary to understand more in detail the plant supplying strategies of the inhabitants of Qalhāt and in general in Eastern Arabia during the Islamic period.

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