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Contents

SUSTAINING CHANGE: THE EMERGING PICTURE OF THE NEOLITHIC TO IRON AGE SUBSISTENCE ECONOMY AT KALBA, SHARJAH EMIRATE, UAE

C.S. Phillips[1] and C.E. Mosseri-Marlio[2]

Abstract

The subsistence economy of Southeastern Arabia is considered within the context of cultural development in the period from the Neolithic to the Iron Age. Despite large scale cultural changes, food procurement systems in the area remained stable, with the marine environment providing a large portion of food resources despite the advent of irrigation agriculture. This study looks at marine and terrestrial resources, and outlines some of the areas of animal exploitation currently under investigation in the assemblages from Kalba, UAE: excess copper in the environment and the susceptibility of sheep flocks to this element; the presence of the non-indigenous rodent *Rattus rattus* and the status of equid domestication in the area within second millennium contexts.

Résumé

L'économique de subsistance du Sud-Est de l'Arabie est examinée dans le cadre du développement culturel entre le Néolithique à l'Âge du Fer. Malgré les changements culturels à grande échelle, le système d'acquisition de nourriture reste stable dans la région. Le milieu marin fournissait une grande part des ressources alimentaires malgré l'apparition de l'agriculture irriguée. Cette étude se penche sur les ressources marines et terrestres et s'intéresse à présenter quelques domaines d'exploitation animale, en cours d'étude dans l'assemblage de Kalba, E.A.U.. : L'excédant de cuivre dans l'environnement et la sensibilité des troupeaux ovins à ce facteur ; la présence de *Rattus rattus*, rongeur exogène et le statut des équidés domestiques dans la région au cours du second millénaire.

Key Words: United Arab Emirates, Narine subsistence, Copper poisoning, Beasts of burden, Natural distribution

Mots Clés: Emirats Arabes Unis, Subsistence marine, Empoisennement par le cuivre, Bêtes de traits, Distribution naturelle

Introduction

In the last forty years there has been a continuing increase in the amount of archaeological research in Southeast Arabia. This includes the study of all periods, from the Neolithic onwards. One of the major research aims has been the integration of this corner of Arabia into the overall picture of maritime trade that took place along with the urban centres of Mesopotamia and the Indus valley in the third and early second millennia BC. Whilst this topic was first approached from a text based, and therefore Mesopotamian point of view (e.g. Oppenheim 1954), more recent field studies have enabled greater consideration of the impact this had on intermediate regions (eg. Cleuziou and Tosi 2000). Surveys and excavations have helped to confirm the identity of Southeast Arabia as that of Magan. Magan is referred to in Mesopotamian texts of the Akkadian and Ur III periods as a place engaged in trade with Meluhha (the Indus Valley and related sites), Dilmun (the Eastern Province of Saudi Arabia, Bahrain and Failaka) and Mesopotamia itself. From Magan, the main contribution to this network of maritime trade was the provision of basic raw materials, notably copper and stone, both of which are abundant in Southeast Arabia. However, it must be emphasised that throughout the Bronze Age, and the following Iron Age, there are no local textual sources from Southeast Arabia, and the Mesopotamian texts which refer specifically to Magan are, as noted above, confined to a period of approximately 300 years, between ca. 2300 and 2000 BC. Consequently, the texts provide little or no indication of how trade was organized and maintained in Magan. However, archaeological evidence, in the form of recognizable imported and exported goods and materials, shows that Southeast Arabia was rarely, if ever, isolated from neighbouring regions, and has been engaged in inter-regional exchange networks from the fifth millennium BC up to the present. However, this does not mean that the intensity and nature

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of these contacts was not subject to frequent change and re-organization. It is inevitable that changes often took place, perhaps coinciding with some of the main regional cultural/chronological periods that have been defined so far[3].

In Southeast Arabia a major change in the scale and organization of external trade is evident at the beginning of the Bronze Age ca. 3000 BC. Prior to this, the regional picture is one of herding, hunting and gathering communities, located both inland (Uerpmann and Uerpmann 2000) and along the coasts (Biagi *et al.* 1984, Phillips nd.). The economy of the coastal sites shows a thorough exploitation of marine resources—fish, molluscs, marine mammals and reptiles, in addition to the herding of sheep, goat and cattle. Long distance contacts with Mesopotamia are indicated by the presence of imported Ubaid pottery. This has been found mainly on the coastal sites of the Arabian Gulf and can generally be dated to the Ubaid 3 and 4 periods, broadly equivalent to the 5th millennium BC (Frifelt 1989). Although Ubaid pottery has not been found on any inland sites in southeast Arabia, it is clear that the early coastal communities did have contact with inland communities (Phillips *op. cit*. Uerpmann and Uerpmann *op. cit*). Alternatively, coastal and inland sites might represent individual communities engaged in seasonal migration. Such migration between coastal and inland regions would give access to a broader range of resources.

In the 4th millennium BC, contacts with Mesopotamia are no longer evident, but the coastal communities certainly continued to thrive (Prieur and Guerin 1990). A significant change then occurs towards the end of the 4th millennium. This is signalled by evidence for renewed contacts with Mesopotamia and the appearance of sedentary, mixed farming communities (Cleuziou 1980).

The impetus for this change can be explained as a local response to the demand for raw materials, especially copper, required by the emerging city states of Mesopotamia; a demand which persisted well into the second millennium BC. But irrespective of whether or not this was the primary force behind the observed changes, the fulfilment of external demands would only have been possible in conjunction with the perceived changes in the region's domestic economy.

With the appearance of mixed farming, inclusive of irrigation agriculture and animal husbandry, emphasis has, until now, been placed on the newly emerged oasis communities of the interior. At sites such as Hili, Bat, and Wadi Bahla, all located along the western flank of the al-Hajar mountains, the necessary technology for irrigation agriculture had clearly been established (Orchard 1995). Such sites would have had a fundamental role in regional and inter-regional trade. The interdependence of inland and coastal communities, particularly those of the southern Gulf coast, such as Umm an-Nar and Tell Abraq would probably have become more intense from this time on. However, the extent to which the industrialised[4] inland oases would have been able to sustain themselves, as well as contributing to the food economy of those coastal sites where cultivation would have been less viable, needs detailed consideration. In respect to this question, the analysis of botanical and faunal food remains from sites in this region is of great importance for understanding the most fundamental issues regarding subsistence and the response to increased demand.

However, in addition to the evolved inland oases, it is important not to overlook one of the region's important food resource areas. This is the "coastal oasis", where agricultural production, animal husbandry and the exploitation of marine resources can be combined. Recent excavations at Kalba, located on the northern Batinah/Shimaliyah coast are beginning to illustrate the economy of one such area over a broad time period. The excavation of a coastal midden dating from the Neolithic period and a further site with occupations ranging from the Early Bronze Age to the Iron Age, is revealing a faunal complex which comprises a wide range of domesticated and wild animals: goat, sheep, cattle, small equids, camels, gazelle, dugong, dolphins, sea turtles, fish and molluscs. Because the excavation

[3] The Neolithic to Iron Age archaeological periods defined for Southeast Arabia are currently referred to by a combination of phases named after key archeaological sites/cultures (eg. Umm an-Nar) and technological stages (eg. Iron Age). In this article we have adopted a Neolithic – Bronze Age – Iron Age nomenclature. This can be related to the previous cultural/chronological scheme as follows: Neolithic, 5th to 4th Millennium BC, Early Bronze Age ca. 3000 to 2000 BC. (cf the "Hafit Horizon" ca. 3000 to 2500 BC and Umm an-Nar Culture ca. 2500 to 2000 BC), Middle Bronze Age ca. 2000 to 1600 BC. (cf. the" Early" or "Classic Wadi Suq period"), Late Bronze Age ca. 1600 to 1300 BC. (cf the "Late Wadi Suq period"), Iron Age ca. 1300 to 300 BC.

[4] Communities engaged in the manufacture of pottery, stone vessels and shell artefacts. Labour intensive tasks would also include copper mining and all of the activities associated with copper processing. Overland and maritime transport requirements would also exact demands on the population.

of these sites is still in progress, it is too early to speak of specific developments in the faunal assemblages. However, it is possible to give an impression of the diversity of the animal economy, as well as examples of specific topics that are being addressed.

Kalba

Kalba is located on the northern coast of the Gulf of Oman (Fig. 1). More specifically, it lies at the southern end of the Shimaliyah coast near the point where it meets the northern Batinah coast. The border between the two is marked at Khutum Mulaha where the al-Hajar mountains come close to the coast and complete the arc of mountains and foothills which begins at Ras al Hamra, north of Muscat, and form the inland edge of the Batinah coastal plain. North of Khutum Mulaha the Shimaliyah coast extends as far as Dibba and is characterised by a number of bays separated by mountain ridges. The first of these bays is one of the largest and provides the setting for Kalba and Fujairah. Because of the close proximity of the mountains to the coast, the Shimaliyah, and in particular Kalba, is characterised by a number of complementary environments (Fig. 2).

At Kalba, at least four different environmental zones can be defined in the area between the present day shoreline and the mountains. These include the mangroves of Khor Kalba, the large area of *sabkha* (coastal salt flats) inland from Khor Kalba, gravel plains and wadi beds, and the broad alluvial fan of the Wadi Ham. Together, these zones have the potential of providing a wide range of resources. The coast and mangrove areas are plentiful in marine species, and whilst today it is of no economic importance, the large area of *sabkha* is evidence of a far more extensive lagoon environment in earlier times. The gravel plains and wadi beds support a dense growth of trees and vegetation suitable for herding, and with the mangroves, are a source of timber and fuel. The alluvial fan of the Wadi Ham is an area of fundamental value. Unlike many of the wadis which have comparatively short catchments, the Wadi Ham originates from a high point near Masafi in the mountains north-west of Kalba. In its

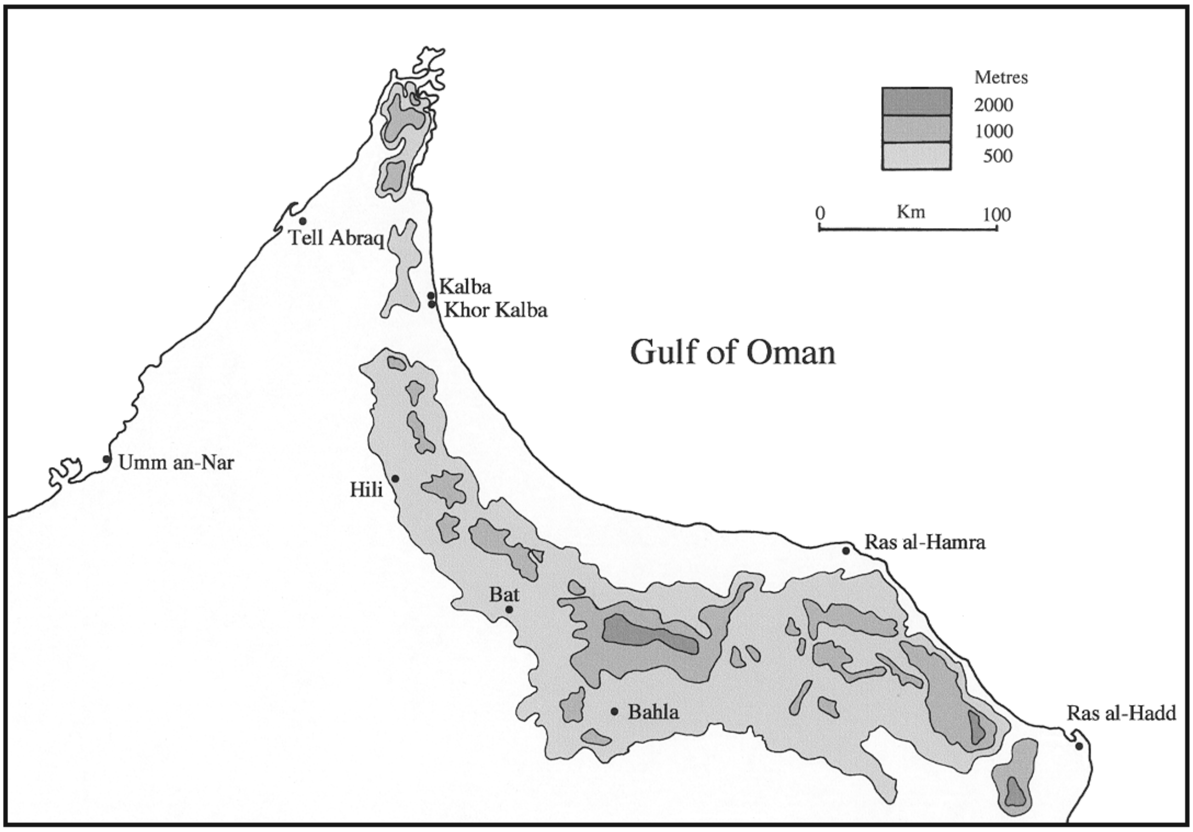

Fig. 1. The location of Kalba and other sites mentioned in the text.

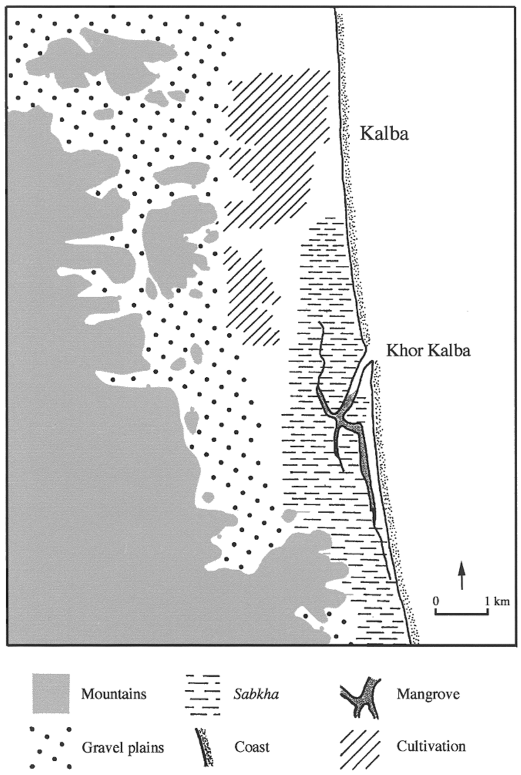

Fig. 2. The distribution of environments at Kalba.

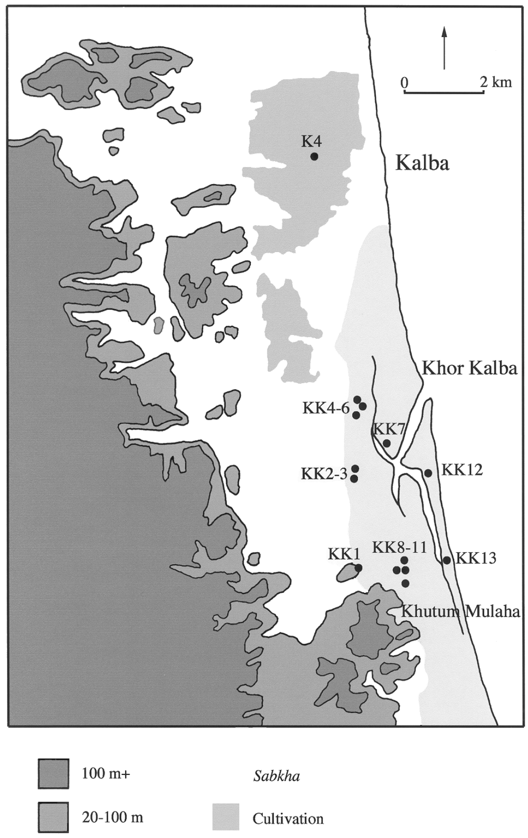

Fig. 3. The distribution of archaeological sites in the area of Kalba and Khor Kalba.

upper reaches the wadi has cut a deep gorge through the mountains. However, when it reaches the coastal plain its energy is reduced as the flow of the wadi spreads out. This causes a combination of erosion and deposition which has resulted in a crescent of finer sediments deposited nearer the coast. This is the area used for cultivation. The latter is also favoured by the availability of water. This is a result of sub-surface fresh water flow coming up against the saline water deposits of the coastal area. Being less dense, the fresh water rides above the saline water deposits. Consequently, wells can be dug within a few metres of the shore line. Finally, along with the rounded boulders of some wadi deposits, the mountains are an additional source of building materials. Perhaps more important, however, are the copper and soft-stone deposits found in the nearby mountains of the Wadi al-Hayl. Both of these materials have been important in the economy of Southeast Arabia since the third millennium BC.

Archaeological sites at Kalba

A large number of sites have now been recorded in the Kalba area (Fig. 3). This includes numerous burial monuments found mainly on the gravel plains and some isolated hills. Several types of burials are present and excavations have shown that they range in date from the early to middle Bronze Age ca. 3000 to 1600 BC (Phillips *et al.* nd.). No burials of Late Bronze Age or Iron Age date have yet been located. There is however a very large cemetery of post Iron Age date, probably dating from the 1st to 3rd centuries AD.

Evidence of settlement, dating from the Neolithic to the Iron Age is located in two distinct areas. This includes several shell middens found in the *sabkha* area surrounding Khor Kalba and a large settlement found in the cultivated area of Kalba.

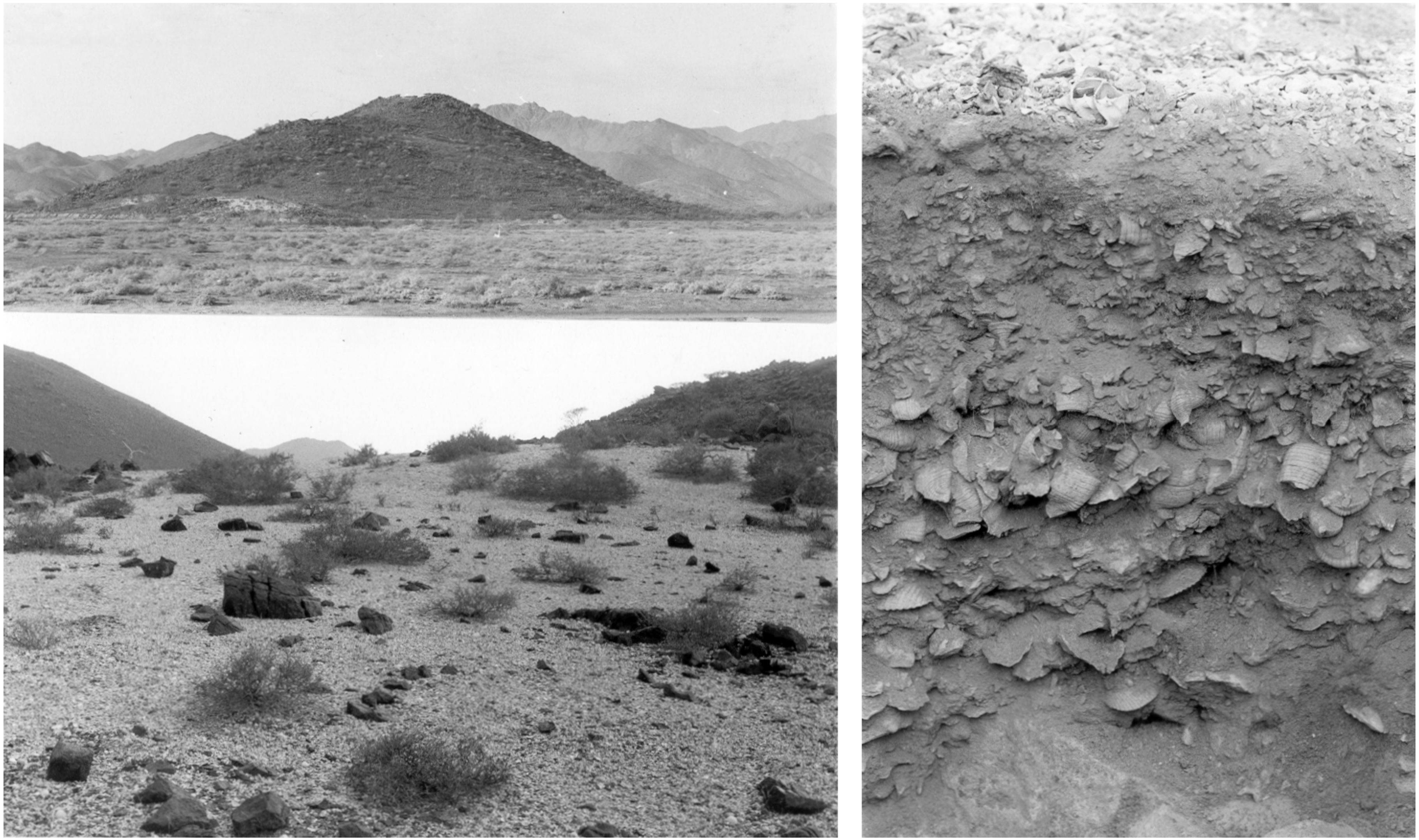

Fig. 4. View of Khor Kalba 1 (KK1). Top left, general view of site location; bottom left, extent of shell deposits; right, thickness and density of shell deposits, approximate depth 50 cm.

The Shell Middens of Khor Kalba

The oldest shell midden is located near the foot of a hill near Khutum Mulaha, on the western edge of the *sabkha* (Fig 4). This site has been recorded as KK1 (i.e. Khor Kalba site 1). A number of finished bifacial stone tools collected at the site are indicative of a date in the fifth millennium BC. Soundings have been made at the site and have shown that the midden deposits are up to 50 cm deep with two layers of densely packed shells. Sampling of these deposits has shown that the majority of shells comprise *Terebralia palustris* and *Saccostraea cucullata*, with smaller amounts of *Anadara ehrenbergi*. This is illustrated by the combined shell counts from two 50 by 50 cm squares which are as follows:

	Upper level	Lower level
Terebralia	473	174
Saccostraea	378	131
Anadara[5]	125	63

Terebralia is typical of mangrove habitats. It is a large potamid gastropod and usually found under the shade of mangrove trees where the substrate is not too muddy and is associated with a number of different mangrove species[6], including *Avicennia marina*, *Rhizophora mucronata* and *Bruguiera gymnorhiza*. It is frequently found on coastal sites of Arabia, sometimes in areas where mangrove is no longer present (thus, being a good indicator of past environments) and clearly represents an important food resource (Glover 1998).

Saccostraea (oyster) is another resident of mangrove habitats, where, in the absence of any hard substrate such as rocks, it is able to attach itself to the trunks and pneumataphores of the mangrove trees. Many of the *Saccostraea* from KK1 exhibit linear imprints of the latter. Like *Terebralia*, *Saccostraea* would have been an important food resource (Glover *op. cit*.). In contrast, *Anadara* is a large bivalve found in sandy, low tidal to subtidal habitats, where it attaches itself to any firm object. *Anadara* is also an important food item.

As well as being quite deep and compacted, the midden deposits of KK1 are also extensive, and therefore indicate large scale exploitation of the mangrove environment. However, it is surprising that no evidence for long term occupation has been found at this site. Similarly, there is little evidence of other faunal remains. Despite meticulous sampling of the deposits, only two fish bones have been found. Similarly, only a few fragmentary mammal bones have been recovered. The only identifiable elements are three sheep/goat teeth. One of these was found at the bottom of the earliest shell deposits. Therefore, it appears that this midden could represent a specialised area, perhaps where the molluscs were extracted and either consumed there and then, or carried elsewhere. The actual settlement might have been located nearer the summit of the hill where some concentrations of shells are present, or at an intermediary location where shell deposits and two possible hut circles were noted. However, excavations in this area have so far been inconclusive. Another feature of the hillside is the abundance of rock art. The patina of the rock engravings, along with stylistic attributes, suggests that these date from at least two different periods. The oldest of the styles appears to be concentrated in the area overlooking the shell midden and usually comprises scenes of humans, dogs and what could be goats (Fig. 5). Equids are also amongst the animals represented. Although not conclusive, it is tempting to think that these might represent early herding scenes and hunted animals contemporary with the midden deposits.

The site of KK1 is located on the western edge of the Sabkha at its furthest inland point. It is probable that when the site was occupied it was at the edge of a more extensive lagoonal and mangrove area. Through time this area has been filled by terrestrial deposits derived from the wadis running into it, and causing the mangrove forest to recede towards the coast. Supporting evidence for this interpretation is provided by a number of younger shell middens located east of KK1, on the area of sabkha itself.

[5] It should be noted that the number given for *Anadara* represents single, unmatched valves. The actual number of individuals would therefore be lower.

[6] Today only *Avicennia marina* grows at Kalba. Charcoal samples from K4 could indicate that other species were also present in the past. However, these samples have not yet been studied.

One of these sites (KK8) has been sampled and produced evidence of two thick layers of shells separated by fine sediments and ashy deposits. The dominant shell species found in these deposits were the same as at KK1. However, there is a marked difference in the proportion of species in the two levels. The shell counts obtained from two one metres squares are as follows:

	Upper level	Lower level
Terebralia	150	380
Saccostraea	176	560
Anadara[7]	550	0

Further work needs to be done at this site in order to see how representative these counts are and what the perceived increase in Anadara collection could signify. It is also appropriate to note that on the surface of this site are clusters of *Telescopium telescopium*. Like *Terebralia*, *Telescopium* is also a mangrove gastropod. However, there is little evidence for its presence in this region. Where *Telescopium* is found, such as in Southeast Asia, it is frequently an important food resource. Unlike *Terebralia*, *Telescopium* is found in more muddy and wet locations within the mangrove, but not necessarily in shaded areas. Unfortunately no datable artefacts were found at this site. However, a ^{14}C date obtained from a sample of *Telescopium* taken from the surface provided a provisional date[8] of 2800 ± 300 bp. Whilst the presence of *Telescopium* might indicate that the mangrove was once more diverse, the complete absence of this shell on earlier sites, such as KK1, remains to be explained.

Another group of middens is located near the northern edge of the *sabkha*, in an area of quite dense acacias. No datable artefacts have been found at any of these sites. However, a ^{14}C date of 3400 +/- 300 bp was obtained from a sample of *Terebralia* from KK3 and a second date of 3200 +/- 300 bp was obtained from a sample of *Terebralia* collected from KK4. The dates from KK8, 3 and 4 suggest that these middens accumulated during the Bronze and Iron Age periods. As at KK1, the sampling indicates a continued emphasis on mangrove associated species and apart from shells, no other faunal remains have been recovered. However, during the Bronze and Iron Age periods it is easier to imagine how these sites were peripheral to the settlement located further to the north in the cultivated area.

Fig. 5. Rock art from the hillside above KK1.

[7] It should be noted that the number given for *Anadara* represents single, unmatched valves. The actual number of individuals would therefore be lower.

[8] It should be emphasised that all of the ^{14}C dates for the Kalba middens are first-order dates obtained by the methods described by Glover *et al.* 1990.

Early settlement in the cultivated area

In the present day cultivated area of Kalba, evidence for occupation in the Bronze and Iron Age periods has been found concentrated in one place. Over the past few years, excavations have focused on a mound (Fig. 6) referred to as K4 (i.e. Kalba site 4). These have revealed a number of superimposed building phases. The earliest levels so far excavated are associated with a circular tower structure of the same type found at Hili 8, phase I (Cleuziou 1989). At Hili, this building dates from the early third millennium. However, at Kalba it would be unwise at this moment to suggest a date earlier than ca. 2500 BC for the earliest occupation of the site. Sometime around the middle of the second millennium a larger mud-brick tower was built around the earlier one, again similar to the building sequence observed at Hili 8. There was possibly a further period of major rebuilding prior to the early Iron Age ca. 1300 BC when the central part of the site was further enlarged. Still within the Iron Age period, ca.1100 BC, a further large wall was constructed around the settlement. The settlement was probably abandoned around the middle of the first millennium BC. The site of K4 therefore has the potential of providing a sequence of faunal remains. Although it is not possible at this stage to talk in detail, the following general observations can be made about the faunal assemblage from any one period.

The marine resource base of a coastal oasis

Perhaps the most striking feature of the K4 faunal assemblage is the broad range of habitats occupied by the animals within it. The environmental setting described above along with the species-rich boundary regions at their interface provided abundant wild resources, and evidence for their exploitation is well defined in all phases of the occupation so far excavated. This is perhaps an interesting observation in view of the fact that irrigation agriculture was developed in Southeast Arabia by the end of the fourth millennium, as described above. In spite of this, rigorous exploitation of marine resources continued, and may even have supplied the bulk of the community's protein requirements.

Fig. 6. View of Kalba 4 (K4).

Marine species

Fish remains are abundant at all levels of the K4 excavation. For the most part, the species identified in the assemblage correlate well with those fished locally in the waters today, and represent deep-water species as well as those which could have been taken from the shoreline (Beech 2000). *Carangidae* (jacks) and *Scombridae* (tuna) were important species, and probably taken in deeper waters using hooks from boats or drift nets. Smaller seabream present in the assemblage may have been taken from the shore. There is a possibility that the scombrid assemblage reflects the seasonal presence of this species. Some species, such as the narrow barred Spanish mackerel (*Scomberomorus commerson*) are fished today predominantly during the winter months, and are shipped inland and to the Gulf coast of the UAE—a practice that may have been in place in the past (Beech *op. cit*.).

Terebralia shell finds are not restricted to the shell middens, and are ubiquitous at the K4 site. Whereas later phase shell midden deposits may suggest some sort of processing activity such as the harvest of molluscs for preservation (cf. El Mahi 2000), the abundance of *Terebralia* at K4 seems to be food refuse brought to the site from the mangrove. Another mangrove species, the crab *Scylla sp*. has also been identified in the assemblage (Beech, pers. comm.). It is interesting to note that the crab element most frequently found, the *chelae* or pincers, are more developed and robust than any examples seen locally today.

A similar observation may be made about one of the marine bivalves found in K4 deposits. *Anadara* is a common find in the assemblage. One ceramic pot from Late Bronze Age levels contained some 80 paired *Anadara* valves. Like the crab claws noted above, a striking feature of these shells is their extreme thickness compared to modern specimens collected locally. Two explanations for this are being explored: either *Anadara* individuals collected during the archaeological past were underexploited and therefore attained a greater age than current conditions permit, or some other environmental factor was in play, such as differing mineral content in the sea water. Thin section analysis of the shells from K4 may shed further light on what might be a minor change in environmental conditions over the last four millennia in the Khor Kalba area.

The presence of dugong bones at K4 may also signal changes in the environment at Khor Kalba. Today no dugong is known on the Batinah coast or indeed from the Gulf of Oman, south along the Arabian Sea. Current populations in the Arabian region are confined to the Persian Gulf and the Red Sea (Sheppard *et al*. 1992). Some calmer bays near Masirah Island would be suitable for this species but a survey of local fishermen found that dugong was unknown in the area (*ibid*.). The relict lagoon at Khor Kalba, hinted at by the scope of the current *sabkha* might very well have attracted the sea grass eating sirenians to this part of the Arabian coast in the past. A lagoon large enough to provide food and shelter for a population of dugong would no doubt have attracted other marine species inhabiting a similar ecological niche, most notably the green turtle (*Chelonia mydas*). Green turtles feed on seagrass as well as mangrove (Limpus and Limpus 2000). Bronze Age deposits with a small number of dugong specimens at Ras al-Hadd, at the eastern most tip of the Oman Peninsula, similarly suggest a more extensive lagoon system than is visible at present, a suggestion also supported by molluscan remains from the site (Mosseri-Marlio, n.d, Glover, n.d.).

The remains of sea turtles are also found in the K4 faunal assemblage, but as yet none have been identified to species. The green turtle *(Chelonia mydas*) is known to have the tastier flesh of the marine turtles, but the other locally found hawksbill (*Eretmochelys imbricata*) and loggerhead turtles (*Caretta caretta*) can equally be eaten. Sea turtles have a number of useful body parts and should not be classified purely as food sources (Mosseri-Marlio, in press). Their lustrous scutes, erroneously known as “tortoiseshell” can be used for artisanal purposes, the bony part of their shell can be used as containers, while their leather and fat are equally useful raw materials. Turtle eggs are highly nutritious and easily collected from nesting beaches. The capture of sea turtles may have taken place during nesting season, when the animals can be easily collected, or harpooned and roped from boats in deeper water. The implications for sea turtle distribution and hunting methods in this area of Arabia have been more fully described elsewhere (Mosseri-Marlio *op. cit*.). The presence of sea turtle carapace and limb fragments at K4 suggests that the animals were transported to the site whole[9].

[9] The site K4 is located approximately 2 km from the present shoreline.

The last marine species under discussion here, the dolphin, is present in only small quantities. Unabundant cetacean remains can be misleading since dolphins will most likely have been butchered at the point where they were removed from the water and hence can be invisible archaeologically (Savelle and Friesen 1996, Mosseri-Marlio 2000). The butchery of cetaceans need not remove any bone material, and therefore the presence of even a few bones suggests that elsewhere a processing site was providing cetacean meat and perhaps other raw materials to the inhabitants of K4 (For a discussion of the utility of small cetaceans on archaeological sites in the area, as well as their distribution and other factors relevant to zooarchaeological interpretation see Mosseri-Marlio, in press). A similar conclusion has been made about a fourth millennium dugong processing site in the Gulf (Prieur and Guerin 1990). While the scope of dolphin exploitation cannot be quantified easily, it should not be overlooked as an important resource, both for food and other raw materials such as fat and leather. In one species of small cetacean studied (harbour porpoise) the carcass contained more fat by weight than meat (Savelle and Friesen 1996).

The terrestrial resource base of the coastal oasis

The cultivated areas, gravel plains with woodland, and mountainous uplands in the Kalba area provide a number of suitable habitats for wild and domesticated animals. This section discusses three ongoing research topics: the possibility of copper toxicity in sheep, the provenance of rat colonies established at the site by the second millennium, and the presence of equids, also in second millennium levels. This section ends with a comment on other species present in the assemblage.

Copper poisoning

The presence of copper in the Kalba environment raises questions about copper toxicity in sheep. Unlike other common domesticates such as cattle and goats, sheep are very susceptible to excess levels of copper. This metal can be taken in through herbage, associated soil consumption and water. Excess copper is stored in the liver. A sudden stress (dietary or environmental) triggers a massive release of this stored copper into the bloodstream. As this copper ruptures the red blood cells, there is an initial anaemia followed by jaundice and death within two to three days. While sheep can survive a “chronic” phase of copper poisoning where the animal appears unaffected, once the haemolytic crisis occurs the animals quickly perish. Copper in small amounts is, however, necessary in the diet of sheep. Appropriate and safe levels of copper are therefore restricted to a narrow range. While goats are not sensitive to copper poisoning, young kids can be vulnerable (Bruere and Wesl 1993: 123-143).

Sensitivity to copper in sheep is mitigated by the presence of the heavy metal molybdenum, an uptake modifier, in the environment. It is “copper hungry” and attaches itself to dietary copper molecules, allowing the animal to pass some of the excess copper as waste. Molybdenum in soils will thus protect against copper sensitivity in sheep on a local level, depending on concentrations. In modern flocks, molybdenum supplements are used to treat sheep that have been accidentally exposed to toxic levels of copper. The presence of molybdenum locally is therefore important in understanding the toxic potential of copper in any given area.

There is a strong genetic component to the sensitivity of certain sheep breeds to copper toxicity (Bruere and Wesl *op. cit.*). For example, one of the most sensitive breeds is the Ronaldsay sheep, which live confined to the tidal areas on the island of Ronaldsay, Scotland. The marine diet they consume (consisting mainly of seaweed) is copper poor. By natural selection they have become very efficient at loading the tiny amounts of copper they require from their marine diet. If Ronaldsay sheep should stray onto the pasture areas of the island where they are exposed to higher copper levels, or are moved to the mainland, they can succumb to copper toxicity.

The environment around Kalba is an area that may have been inhospitable to sheep. Copper and other metals washing down from the Wadi Ham would have been incorporated into local herbage and water supplies. Sheep flocks may not have been stable as a result of this. In order to test this hypothesis, soil and positively identified sheep bone samples were tested for the presence of copper and molybdenum. Soil samples from stratigraphically datable mudbricks of third and second millennium levels were used. Second millennium and later Iron Age levels provided sheep bones for testing. The same element, a metacarpal, from a control sheep was also part of the test. This sheep originated from a farm with no history of either copper toxicity or deficiency. In addition to copper and molybdenum, the soil and bones were tested for arsenic, cadmium, cobalt, chromium, nickel, lead and zinc (Appendix 1)

The soil samples showed a high concentration of copper, with a range of 28-83 ppm (parts per million). Sandy soils in Holland and New Zealand have a copper content of 0.1 to 1.6 ppm, and in Ontario, Canada, where copper levels are known to be high, mean levels are 25 ppm (John Martin, pers. comm.). Molybdenum, which as mentioned helps prevent copper poisoning, was not detected in the samples (less than 1 ppm).

The bone samples from the second millennium and Iron Age showed high concentrations of copper, with 12 ppm and 20 ppm respectively. These high values are considered toxic, and suggest that the Kalba sheep had been accumulating copper in their bones and may well have been subject to chronic or acute copper poisoning, particularly since there is no evidence of molybdenum in the environment to modify copper uptake. In extreme conditions, there may have been a flock catastrophe, but even under favourable conditions a trickle of deaths might be expected. The deposition of copper in the sheep bone is considered to be an antemortem process and is not affected by the post-mortem environment.

Fig. 7. Equid astragali from K4 . Top left specimen has cut marks on medial tuberosity. See Fig. 8 for detail.

A final comment should be made on the study described above. The Kalba sheep bones show very high concentrations of chromium, as well as moderate levels of zinc, both of which would have been picked up from the environment in the same manner as the copper. This combination of metals may make a useful tool for identifying nomadic populations that may have spent part of the year in the Kalba area. Thus, trace element analysis of animal bones might be a useful indicator of animal import when found in areas where the trace elements do not occur.

The rodent remains

A second millennium refuse pit revealed a large quantity of animal bones, of which some 40% showed rodent gnaw marks. Rodent remains from this area as well as other similarly dated contexts from K4, can be identified as *Rattus rattus* on the basis of mandible fragments as well as long bones (femora and humeri). Other smaller rodents such as *Meriones sp*. (jird) are present in the assemblage only on a sporadic basis. *R. rattus* seems more likely to have caused the observed rodent gnaw marks not only based on the calibre of the gnaw marks themselves, but also because this species is actively commensal whereas the jirds are shy of human contact and prefer an open desertic habitat (Gross 1987). *R. rattus* would have thrived on the fruit of the date palm, since its preferred diet is that of fruits, seeds and vegetables (Armitage pers. comm.).

Rodents are known at other sites of this period in Southeast Arabia (Cleuziou & Tosi 2000, Uerpmann & Uerpmann 1994, Stephan 1995). At this point, little comment has been made concerning the provenance of rats identified in the area. Being an allochthonous species whose probable origins lie in South Asia, some light may be shed upon the trade relations of Magan by considering how *R. rattus* established itself at Kalba. Rats may for instance have arrived with shipments of foodstuffs or other materials from Meluhha, Dilmun or Mesopotamia. There are two known karyotypes: 2n=42 (Asian) and 2n=38 (Oceanian). The former is thought to originate in the Indus Valley, the latter in southern India (Armitage 1994). It is hoped that further investigation into the rodent remains from Kalba can add more to the discussion of rat dispersal in the Old World as well as providing proxy evidence for exchange and trade in the area.

Equids and camels

Equid remains from K4 may contribute something to the discussion of the domestication of this animal in Southeast Arabia. In particular, three relatively complete equid astragali have been recovered (Fig. 7). One of these showed cut marks associated with skinning (Fig. 8). In addition to this, one smaller but unfortunately broken equid astragalus was recovered from a later level. No measurements could be taken from this smaller specimen[10]. The domestication status of equids is vital to our understanding of their role in Southeast Arabia, because it is important that the issue of pack animals be addressed. It is difficult to envisage an economy driven by the extraction of raw materials from the nearby mountains that did not rely on animals for transportation of goods. While the camel immediately comes to mind in discussions of goods transport in Southeast Arabia, it is not necessarily best suited to the kind of terrain associated with stone and copper ore extraction. In the mountains that characterise the Kalba hinterland, the equids remain the most likely beasts of burden. It is still an open question whether the equid astragali pictured in Fig. 7 are indeed the bones of domesticated animals or hunted wild animals. Discussion of this subject can continue as more equid bones from Southeast Arabia are published.

Only a small number of camel remains have been identified from K4, and at this point add little to the discussion of this species' domestication. Whilst camel remains are numerous at Umm an Nar in the third millennium (Hoch 1977), the faunal remains from Tell Abraq show that full domestication is only evident at the end of the second millennium (Uerpmann in press).

[10] See appendix 2

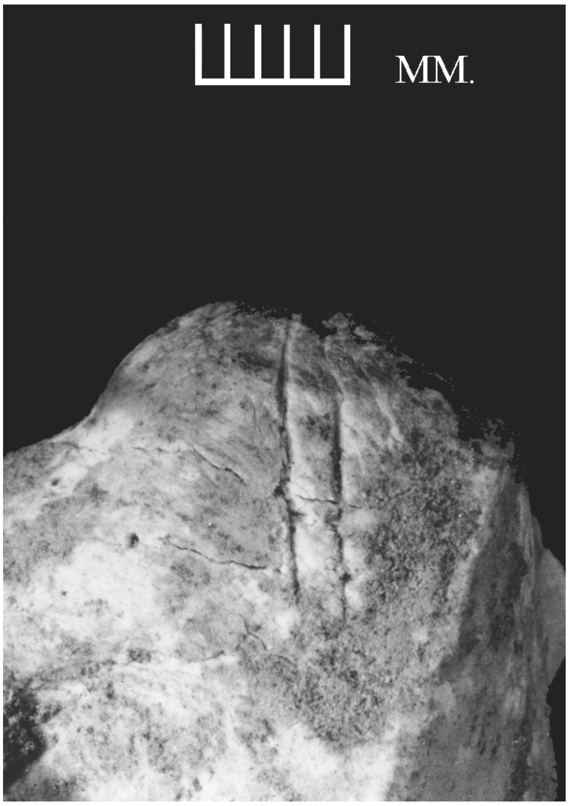

Fig. 8. Details of cut marks on a Equid astragalus

Other terrestrial species

The remains of cattle are found at all levels of K4, although in quantitative terms they are far outnumbered by the small ruminants. In size, the cattle bones compare favourably with the smaller Indian varieties found locally today. However, no elements have been found which enable certain distinction between taurine and zebu cattle. In addition to being meat and milk providers, cattle could also have served as draft animals for ploughing and drawing water.

In the K4 faunal assemblage, hunting is indicated by the presence of wild ungulates (gazelle, oryx). Carnivores and birds are also present and remain under study at this time. A full quantitative analysis of the faunal assemblage incorporating these taxa will follow at the end of the excavation.

Conclusions

In the introduction, it was indicated that a major change in the economic orientation of Southeast Arabia occurred towards the end of the fourth millennium. This saw renewed evidence for contacts with Mesopotamia and the development of a trade network which extended from Mesopotamia to the Indus Valley. Perhaps simutaneously this was accompanied by changes in the regional subsistence economy. The change from a hunting, herding and fishing economy to a mixed farming economy has led to an emphasis being placed on the oases of the interior which emerge at this time. However, it has been shown how at Kalba the range of environments is such that this transformation could also have taken place in some coastal locations. Therefore the idea of the “coastal oasis” can be seen as a further extension of the *niche packing* advocated by Durante and Tosi (1980: 139) which enables the maximization of early coastal communities. Such changes are suggested by the distribution of sites in the Kalba area and evidence from K4.

Imported pottery finds from Kalba can be dated as early as 2750 BC, based on Mesopotamian parallels. Starting ca. 2500 BC, Iranian and Indus Valley pottery is also present. In addition to this the majority of pottery is of locally produced types. There is evidence for copper working at the site, alongside evidence for the manufacture of stone vessels and shell objects. This general picture is maintained until the site is abandoned in the Iron Age ca. 500 BC. The site therefore has all the characteristics of a settlement actively engaged in local and long distance trade and a wide range of associated activities.

The major addition to the economy of Kalba in the third millennium would have been the introduction of agriculture. The date palm was clearly important and dates have been found in all periods at the site. As at other sites in Southeast Arabia, evidence for other crops has been more difficult to retrieve. Plant remains are present in many of the mudbricks used in all the building phases, but none of these have been identified to species. We might assume that the same range of cultivars identified from mudbricks at other sites, such as Tell Abraq, would have been present (Willcox and Tengberg 1995). These include wheat and barley.

It is difficult to envisage how one will be able to assess the relative importance of plants foods and animal foods to the overall subsistence economy and the extent to which it might have been necessary to import food. One thing is already clear from the faunal assembleage of Kalba: the introduction of agriculture did not diminish the importance of previously important economic niches. The clear example here is the continued economic importance of the mangrove and coastal resources. This represents one food source that was not so available to the inland oases.

As well as the abundance of marine resources, the range of terrestrial mammals evident at Kalba is comparable with that from other sites in Southeast Arabia and represents the first such evidence from the Batinah/Shimailiyah region (cf. the chart published by Potts 1997: 38). Clearly, in any final quantification and interpretation of the faunal remains, individual contexts will have to be taken into consideration and the site considered in the context of its varied environment. It is probable that in the Bronze and Iron Ages, Kalba was not characterised by a single nucleated settlement built in the vicinity of K4, but rather a constellation of sites. This would include the campsites of pastoralists as well as specialised fishing sites. Such a reconstruction would thus, represent in microcosm, the larger picture that must be formulated for Southeast Arabia as a whole.

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Appendix 1. Determination of metals found in samples from Kalba **(unit=ppm ???)**

Sample	As	Cd	Co	Cr	Cu	Mo	Ni	Pb	Zn
Soils:									
Wadi Suq	ND	ND	23	95	83	ND	352	ND	26
Iron Age	ND	ND	27	112	36	ND	390	ND	31
3rd Mill	ND	ND	23	90	28	ND	350	ND	25
Sheep bone									
2nd Mill	ND	ND	ND	133	12	ND	ND	ND	71
Iron Age	ND	ND	ND	474	20	ND	ND	ND	82
Control	ND	ND	ND	ND	ND	ND	ND	75	
ND									

ND= not detected

As, Mo <1.0µg/g; Cd < 0.5µg/g; Co <2.5µg/g; Cr, Cu, Ni, Pb < 5.0µg/g

Appendix 2. Measurements of equid astragali from Kalba.

Measurement	Specimen no.	350	351	352
GH		50.4	50.2	54.0
GB		51.6	--	--
Bfa		39.3	39.5	42.2
LmT		48.2	49.7	53.1
Dfa		28.6	29.5	30.5

All measurements given in mm as per A. Von den Driesch (1976) except for Dfa, as described by H.-P. Uerpmann (1991).