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East Africa and Madagascar in the Indian Ocean world

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Abstract The Indian Ocean has long been a forum for contact, trade and the transfer of goods, technologies and ideas between geographically distant groups of people. Another, less studied, outcome of expanding maritime connectivity in the region is the translocation of a range of species of plants and animals, both domestic and wild. A significant number of these translocations can now be seen to involve Africa, either providing or receiving species, suggesting that Africa's role in the emergence of an increasingly connected Indian Ocean world deserves more systematic consideration. While the earliest international contacts with the East African coast remain poorly understood, in part due to a paucity of archaeobotanical and zooarchaeological studies, some evidence for early African coastal activity is provided by the discovery of early hunter-gatherer sites on offshore islands, and, possibly, by the translocation of wild animals among these islands, and between them and the mainland. From the seventh century, however, clear evidence for participation in the Indian Ocean world emerges, in the form of a range of introduced species, including commensal and domestic animals, and agricultural crops. New genetic studies demonstrate that the flow of species to the coast is complex, with more than one source frequently indicated. The East African coast and Madagascar appear to have been significant centres of genetic admixture, drawing upon Southeast Asian, South Asian and Middle Eastern genetic varieties, and sometimes yielding unique hybrid species. The biological patterns reflect a deeply networked trade and contact situation, and support East Africa's key role in the events and transformations of the early Indian Ocean world.

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Introduction

The Indian Ocean world is one that has long fascinated historians, geographers and archaeologists (Chaudhuri 1985; Pearson 2003; Reade 1996). Encompassing an area of enormous size, as well as significant ecological and cultural diversity, the region has nonetheless seen remarkable levels of interaction, trade, migration and species translocation over a very long period of time. However, while more recent, historical activities linking up the Indian Ocean world have received a great deal of attention, the pre- and proto-historical origins of these networks have seen far less systematic study. Furthermore, while the role of much of the Indian Ocean littoral remains unclear for these early phases, that of East Africa is perhaps most enigmatic of all. And yet a significant majority of the early long-distance translocations of plants and animals that provide important clues to the ancient origins of the Indian Ocean world involve Africa (see Table 1). It is now clear that by the second millennium BC, Africa had given a number of important plant crops, including sorghum and pearl millet, to the Indian subcontinent (see Boivin and Fuller 2009; Boivin et al. 2009; Fuller and Boivin 2009; Fuller et al. 2011). Africa has also received an extraordinary number of species from diverse regions of the Indian Ocean, ranging from domesticated crops and animals, to weeds, spices and commensal animals. These include banana, yam, taro, chicken, zebu cattle, black rat, house mouse, and the Asian house shrew, to name just a few. It has been suggested that many of these were translocated westwards at an early date.

East Africa thus offers something of a fascinating paradox. While it is key to understanding the majority of ancient Indian Ocean biological transfers, it has seen less zooarchaeological, archaeobotanical and genetic research than many other regions around the Indian Ocean rim. Furthermore, while historical documents like the classical period *Periplus Maris Erythraei* hint at its early role (Casson 1989), there is virtually no understanding of its maritime and coastal activities until the emergence of the fully urbanised and historically documented trading societies of the Swahili coast. While the cultures, languages and, in some cases, genetic traits of the Swahili and Malagasy-speaking populations of East Africa and Madagascar reflect a rich and ancient set of long-distance linkages with Arabia, India and Southeast Asia, mystery continues to surround the emergence of these connections.

This review therefore aims to explore and update the evidence for East Africa's early role in the Indian Ocean. Given the existence of previous reviews (e.g. Mitchell 2005; Horton and Middleton 2000; Sheriff 2010), the goal is not so much an exhaustive as a critical and more expansive multidisciplinary review of the existing literature. In particular, this study aims to bring to bear more systematically the available biological evidence for early Indian Ocean contacts, including zooarchaeological and archaeobotanical datasets. In addition, it also seeks to examine the various questions and themes related to East Africa's place in the Indian Ocean in light of emerging molecular genetic evidence, primarily plant and animal, but also human. The aim is to offer a synthesis of available information, and to help shape an agenda for future research. The review will suggest a role for a more multidisciplinary approach that also draws upon new molecular genetic techniques, which hold the potential

Table 1 Sample of some key species dispersals in the Indian Ocean

Type	Species	Origin and suggested dates (if available)
Animal (domestic)	Chicken, *Gallus gallus*	South/Southeast Asia; inputs up the Nile and across Indian Ocean
	Zebu cattle, *Bos indicus*	South Asia; in Africa by 1500–2000 BC (?) (Boivin and Fuller 2009)
Animal (commensal)	Asian house shrew, *Suncus murinus*	South/Southeast Asia; now widespread in Indian Ocean (Fuller and Boivin 2009)
	Asian tiger mosquito, *Aedes albopictus*	Southeast Asia; now as far west as Madagascar by early second millennium AD, and on most islands of Indian Ocean; expansion to rest of Africa, Europe, Americas more recent (Vazeille et al. 2001; Benedict et al. 2007)
	Black rat (ship rat), *Rattus rattus*	South/Southeast Asia; now widespread in Indian Ocean (Fuller and Boivin 2009)
	House gecko, *Hemidactylus*	Natural distribution across much of mainland Eurasia; transfer to Indian Ocean islands via natural and anthropogenic means
	House mouse, *Mus musculus*	Asia (probably from northern India to Southwest Asia); we can assess the role of inputs up the Nile vis-à-vis those across the Indian Ocean (Fuller and Boivin 2009)
	Pygmy shrew, *Suncus etruscus*	South/Southeast Asia; transferred west to Madagascar (Omar et al. 2011), perhaps by direct maritime route
Animal (wild)	Feral domestic pig (wild boar), *Sus scrofa*	Eurasia multiple times; now widespread in Indian Ocean (Walsh 2007)
	Javan mongoose, *Herpestes javanicus*	South/Southeast Asia (Walsh 2007)
	Small Indian civet, *Viverricula indica*	South/Southeast Asia; now widespread in Indian Ocean (Walsh 2007)
Plant (domestic)	Areca nut, betel-nut, *Areca catechu*	Southeast Asia, now grown in Madagascar, Tanzanian coast and islands; plausible Malagasy/Austronesian introduction; mentioned by Ibn Battuta, 14th C AD (Zumbroich 2007)
	Asian yam, *Dioscorea alata*	Southeast Asia; now throughout Africa (Harris 1967; Blench 2006)
	Asiatic rice, *Oryza sativa*	South/East/Southeast Asia; now widespread in Indian Ocean, on Pemba by c. AD 1000 (Walshaw 2010); imports to Berenike, Egypt in Roman period (Cappers 2006)
	Banana, *Musa sapientum*	Indonesia/New Guinea; in East Africa by c. 500 BC (?); phytoliths from Cameroun, c. 500–300 BC (Mbida et al. 2006; Blench 2009)
	Baobab, *Adansonia digitata*	West Africa, widespread in East Africa, western Indian Ocean islands, NW Madagascar, India; on Pemba by c. AD 700 (Walshaw 2010)
	Broomcorn millet, *Panicum miliaceum*	East Asia; in South Asia and Arabia by c. 2000 BC; Nubia by c. 1700 BC; absent from Near East until 1400 BC (Fuller and Boivin 2009)
	Cinnamon, *Cinnamomum verum (syn. Cinnamomum zeylanicum)*	South India and Sri Lanka, now widespread in cultivation in the tropics, including in Central Africa, East Africa and on Zanzibar
	Coconut palm, *Cocos nucifera*	Wild in Sri Lanka, coastal Southeast Asia, Seychelles; now widespread in Indian Ocean; on Pemba by c. AD 1000 (Walshaw 2010)
	Cowpea, *Vigna unguiculata*	West Africa; in India by 1700–1600 BC (Boivin and Fuller 2009)
	Drumstick tree, *Moringa oleifera*	India (Asouti and Fuller 2008), now widespread in East Africa
	Finger millet, *Eleusine coracana*	East Africa (Ethiopia), in India by 1700–1200 BC (Boivin and Fuller 2009)
	Hemp, *Cannabis sativa*	China/Central Asia(?), in India by c. 1900 BC (see Fuller and Madella 2001); now widely cultivated in East Africa

Table 1 Sample of some key species dispersals in the Indian Ocean

Type	Species	Origin and suggested dates (if available)
	Hyacinth bean, *Lablab purpureus*	East Africa; in India by 1700–1600 BC (Boivin and Fuller 2009)
	Jackfruit, *Artocarpus heterophyllus*	South India, cultivated by c. 1400 BC (Asouti and Fuller 2008), cultivated from East Africa (Zanzibar, Kenya) through the Congo (Morton 1987; Tate 2000)
	Mango, *Mangifera indica*	India, cultivated by 1400 BC (Asouti and Fuller 2008); now widespread in Indian Ocean; on Pemba by c. AD 1000 (Walshaw 2010)
	Mung bean, *Vigna radiata*	India, on Pemba c. AD 1000 (Walshaw 2010); imports to Berenike, Egypt in Roman period (Cappers 2006)
	Orange, *Citrus aurantium [*sensu lato*]*	Northeast India/Southeast Asia
	Pearl millet, *Pennisetum glaucum*	West Africa; in India by 2000–1700 BC (Boivin and Fuller 2009)
	Rambutan, *Nephelium lappaceum*	Island Southeast Asia (Tate 2000), possibly cultivated in Zanzibar and Pemba since Arab times (Morton 1987)
	Short-staple cotton, *Gossypium herbaceum*	Sub-Saharan Africa; in Nubia by 1st C AD, in India by 13th C
	Sorghum, *Sorghum bicolor*	East Sudanic Africa; in India by 2000 BC (Boivin and Fuller 2009)
	Sugarcane, *Saccharum officinarum*	Papua New Guinea; in India late first millennium BC, import to Mediterranean in classical period; East Africa by Swahili period (?)
	Taro, *Colocasia esculenta*	Southeast Asia; now throughout Africa (Harris 1967; Blench 2006)
	Tree cotton, *Gossypium arboreum*	Indus Valley; widely traded and introduced to NE African agriculture in classical period (?); Swahili coast by 11th C AD (?) (Wild et al. 2007; Fuller 2008; Walshaw 2010)
	Wild banana, *Musa acuminata*	Southeast Asia; currently found on Pemba island, Tanzania and in northeastern Madagascar
Plant (wild)	Buttonweeds, *Spermococe ocymoides, Spermococe pusilla*	Native to India/Southeast Asia; *Spermococe* sp. weed in Neolithic S. India; now widespread in East Africa; Mauritius (Fuller and Boivin 2009)
	Horse purlanes, *Trianthema protulacastrum, T. triquetra*	Native spp. of India; common millet weeds from c. 2500 BC in Gujarat; now weeds in East Africa (Fuller and Boivin 2009)
	Old World Diamond Flowers, *Oldenlandia (Hedyotis) pumila, H. corymbosa*	Native spp. of India, weeds in East Africa
	Silk cotton tree, *Ceiba pentandra*	South America with natural trans-oceanic dispersal to West Africa, onwards dispersal anthropogenic; now widespread in East Africa, western Indian Ocean islands, South and Southeast Asia (see Blench 2007a, b; Dick et al. 2007)
	Witchweed, *Striga asiatica,* (parasitic weed of sorghum)	Native to East Africa(?)/Yemen(?); widespread weed in South, East and Southeast Asia (Fuller and Boivin 2009)

to shed light where archaeology and history have hitherto been recalcitrant. Given the still limited nature of much of the East African research under discussion, the findings and patterns discussed here should be considered preliminary. An outline of the main chronological phases for the East African coast as we define them, along with some key Indian Ocean developments and translocations, is provided in Fig. 1. Our discussion will move through these main chronological phases, with interspersed discussion of some of the region's key species arrivals and translocations.

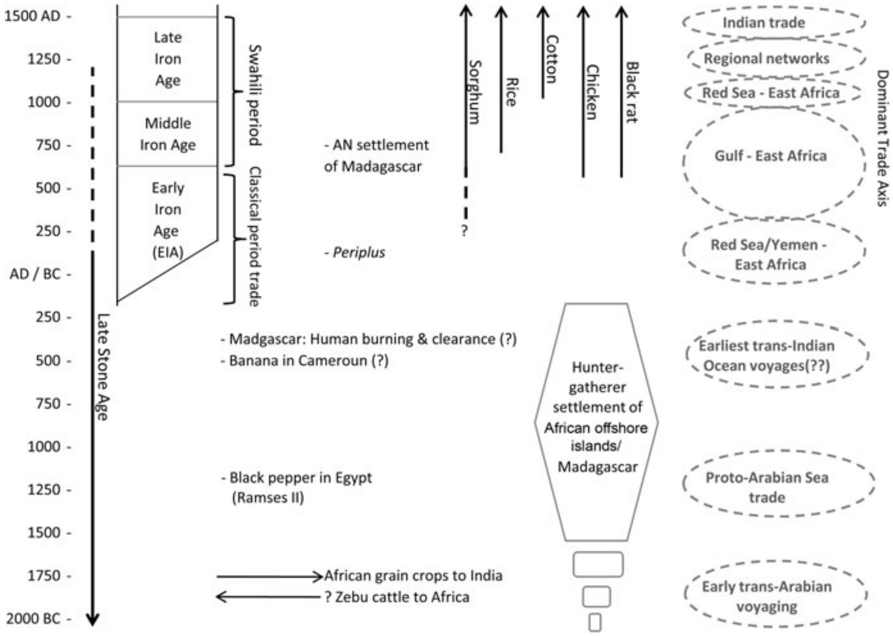

Fig. 1 Approximate chronology for coastal East Africa with key cultural events, introductions, and interactions

Geographical Context

While eastern Africa more broadly (from Egypt to South Africa) has undoubtedly long participated in the Indian Ocean world, the focus of this review is the East African littoral region that extends from around Mogadishu in Somalia to Mozambique (Breen and Lane 2003; see Fig. 2). This section of coastline, over 3,000 km long, is often referred to as the Swahili coast in light of shared linguistic and cultural features that, it has been suggested, reflect the arrival of new Bantu-speaking populations from the early Iron Age. The region includes a number of islands, which may be divided into four types (Mitchell 2005, p. 103): (1) those that lie offshore and became part of the Swahili world—the Lamu Archipelago, Kilwa, Pemba, Zanzibar (Unguja) and Mafia; (2) the island continent of Madagascar, with its own unique flora, fauna, and cultural history; (3) the islands filling the geographical gap between these two categories—the Comoros; and (4) the more distant islands of the western Indian Ocean, generally thought to have been settled at a relatively late date—Mauritius, Reunion, Rodrigues and the Seychelles. Our focus in the present review is on the coast itself and the first three categories of island; we also explore some data from the coastal hinterland, from further inland, and from the more distant western Indian Ocean islands where relevant. We do not address the Horn of Africa or the eastern edge of Africa further to the north of the Horn, except in passing. For us this means leaving aside the issue of the initial transfer of African crops to India, for we do not consider it likely that the region we have defined here as East Africa had a role to play in this story (and do not agree with Wrigley [1997] or Wigboldus [1994–1995, 1996], who suggest a later re-introduction of these species to sub-equatorial Africa, perhaps via the East African coast; see Boivin and Fuller (2009) for a detailed discussion of these translocations).

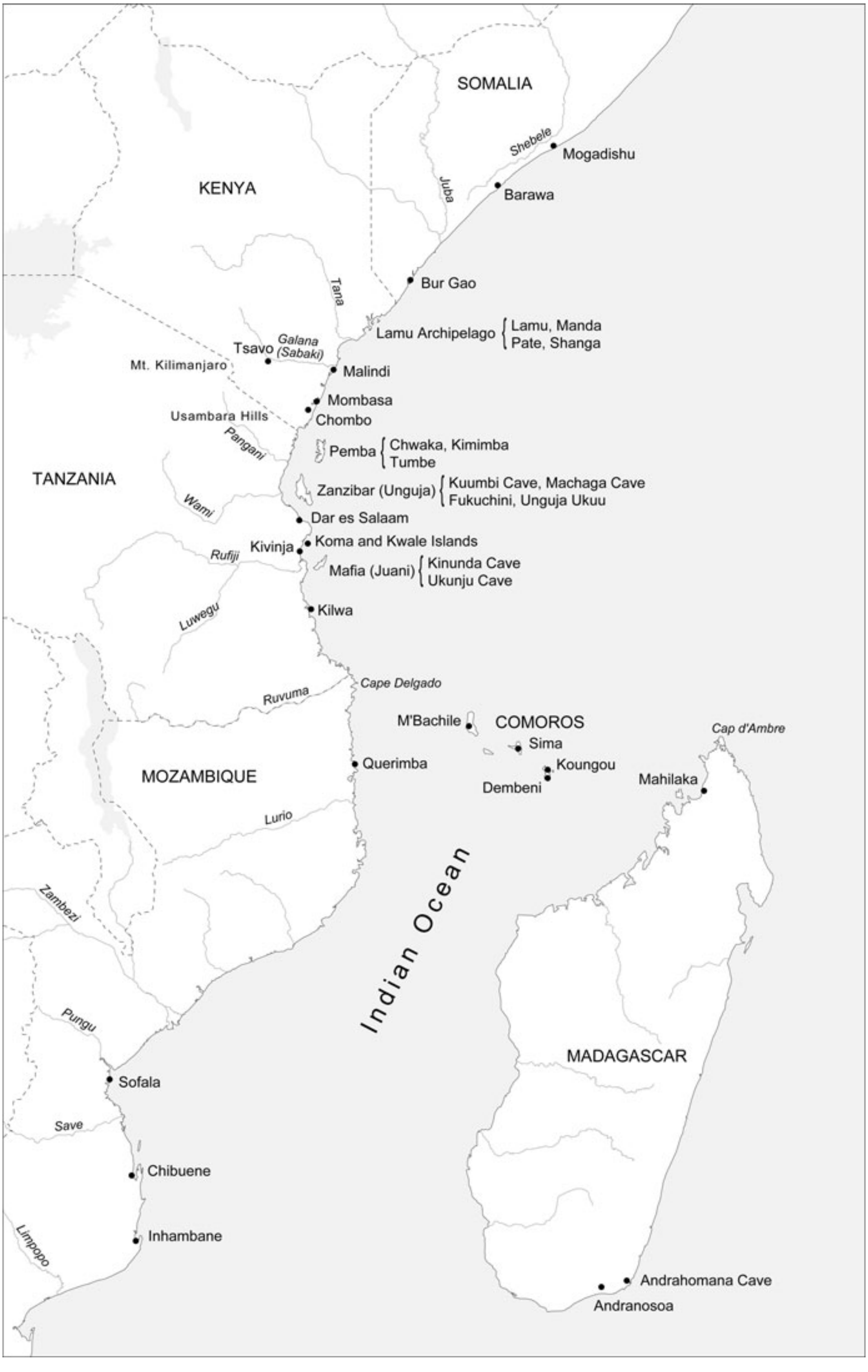

Fig. 2 Map showing East Africa, along with key sites mentioned in text and geographical features

The East African coastal environment is diverse, but dominated in the interior by a low-level coastal plateau. The coast itself is low-lying and ranges in type from sand–dune systems through to coastal mangroves and estuarine areas (Breen and Lane 2003, p. 470; see Fig. 3). While the area to the north of Mogadishu is arid with few harbours, the coast becomes more accessible—if still exposed and fairly barren—to the south (Mitchell 2005, p. 101). Moving further south still, the first of a series of coast-fringing coral reefs begins at Lamu (Mitchell 2005, p. 101). These coral reefs contain warm and shallow waters that support a wide diversity of fish species, but can also make access to the shore by boat somewhat difficult (Breen and Lane 2003, p. 472). Nonetheless, along with several drowned estuaries, these coral reefs offer protected inshore waters with multiple harbours and inlets (Mitchell 2005, p. 101). The ancient marine zone included a wide variety of resources, from productive fisheries and shellfish beds, to shells used for making tools, beads and other items, to the mangroves and coral that came to be extensively used as building materials in the coastal region and beyond. This zone also provided items for trade, like tortoise shell and pearls. Meanwhile, the coastal plain, which extends up to 300 km inland in some areas of Tanzania and Mozambique (Orme 1996, p. 258), supported a variety of agricultural, pastoral and hunter-forager activities. Relatively higher levels of moisture and soil fertility existed on the coast, and the inland creeks, river valleys and forested coastal uplands created ecologically rich environments suitable for cultivation. Further inland, this landscape gave way to a drier, high coastal plain more suitable to livestock keeping. The multiple rivers draining into the Indian Ocean, like the Tana and the Rufiji, helped to link the coast with both the hinterland and the interior, which supplied the Indian Ocean trade with important commodities like ivory and slaves (Alpers 1975; Horton and Middleton 2000; Mitchell 2005; Sheriff 2010). As Mitchell (2005, p. 102) has noted, the connections between coast, hinterland and deeper interior were always crucial to the evolution of East Africa's Indian Ocean ties. These routes would likely also have functioned as species dispersal corridors on occasion, as would other geographic features like the mountain range stretching from the Usambara Hills to Kilimanjaro, which has been suggested as a possible route for the translocation of bananas to West Africa (Fig. 4; see discussion below).

In terms of understanding East Africa's role in the Indian Ocean, however, there is probably no physical feature as important as the monsoon. Pearson describes the monsoon winds as a 'deep structure element' in the Indian Ocean that strongly constrained human movement (Pearson 2003, p. 19), while Fernández-Armesto states that compared to wind patterns 'all other motors of [maritime] history meant very little' (Fernández-Armesto 2000). The monsoon winds have a regular pattern that reverses on a seasonal basis (in contrast to year-long prevailing winds, such as are found in the Atlantic Ocean; see Fig. 5). Hence, in the Arabian Sea, the monsoon blows from the southwest from May to September, and from the northeast during November to March. This pattern is created because heat during the summer warms the continental land mass in the north of the ocean; this causes hot air to rise, creating a low pressure zone at the earth's surface and drawing in moisture-laden air from the sea that rises, cools and so produces clouds and rain (Pearson 2003, p. 19). The regular reversal in the monsoon pattern means that it is easier to complete a round trip by sailing ship in the Indian Ocean than in the Atlantic, whose predictable but unidirectional trade winds ensured that it remained a barrier into the fifteenth century (Mitchell 2005, p. 101; Pearson 2003).

The monsoon tended to favour the northern over the southern Swahili coast, at least in earlier time periods (Datoo 1971; Pearson 2003). This is because it was possible to leave Arabia or India on the northeast monsoon around November–December, and sail back in

Fig. 3 Stands of mangrove adjacent to the ninth–nineteenth century Swahili site of Kilwa Kisiwani, Tanzania. (Photo: Nicole Boivin)

Fig. 4 East Usambara Mountains, Tanzania. The mountains form part of a range considered by De Langhe (2007) to be a possible dispersal corridor for the banana from the eastern African coast. (Photo: Nicole Boivin)

either May or August. But this only worked as far south as Cape Delgado; south of here, two monsoons were required for a round trip. Indeed the far south is, as Pearson (2003, p. 20) notes, really outside the monsoon system, with monsoons decreasing in constancy and strength in this direction (Datoo 1971). Acting alongside the wind systems were the prevailing current systems (see Fig. 5). These are strongest in the western parts of oceanic systems, meaning that currents were more of a problem, or opportunity, off the East African coast than elsewhere in the Indian Ocean (Pearson 2003, p. 24). On the northern Swahili coast, ocean currents like the Somali Current tended to reinforce monsoon patterns, but in more southerly parts, currents could carry ships southwards even when the winds were contrary (Pearson 2003, pp. 24–25). The strongest current in the region is the Agulhas Current, which is created when the South Equatorial Current divides at Madagascar (see Fig. 5). The branch that runs north of Madagascar, and then turns south between Madagascar and East Africa, is known as the Agulhas Current where it runs along the African coast, closer to it than to Madagascar. This current is complemented by a counter-current along the eastern edge of the Mozambique Channel, whose speed and direction is much less constant, and which also varies in intensity, being ordinarily stronger during the southwestern monsoon (Alpers 2007). Between Cap d'Ambre, at the northern tip of Madagascar, the Comoro Islands and the northern coast of Mozambique around Querimba, the current runs west all year long (Alpers 2007). The inclusion of the northwestern coast of Madagascar in the Swahili system begins to make sense in light of the bridge provided by the Comoro Islands and the patterns of ocean currents and winds. These ocean currents, together with the reefs and sandbars along the margins of the Mozambique Channel, made the rest of the channel south of the Comoro Islands more dangerous for sailing (Alpers 2007) and perhaps inhibited inclusion in the Swahili world.

Both ocean currents and wind patterns also certainly played a key role in linking East Africa, and particularly Madagascar, with distant Southeast Asia. Despite the fact that Madagascar lies some 5,600 km west of the Indonesian archipelago, and only 420 km from the southeast African coast (Fitzpatrick and Callaghan 2008), its linguistic, cultural and genetic patterns suggest that, historically, linkages to Southeast Asia were at least as strong

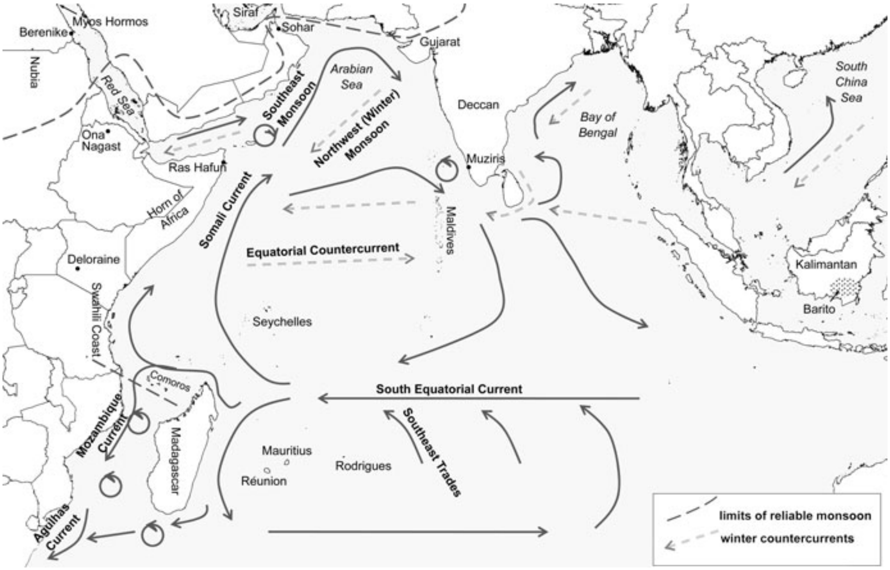

Fig. 5 Current and wind patterns for the Indian Ocean (based on Schott and McCreary 2001; Datoo 1971; Ali and Huber 2010), showing the location of some key Indian Ocean trading sites

as those to Africa (see discussion below). A coastal voyage from Southeast Asia would have involved traversing some 11,000 km (Fitzpatrick and Callaghan 2008). Most evidence would seem, however, to support more direct routes of dispersal, and these would almost certainly have relied upon the southeast trade winds, which lie south of the monsoon system (Pearson 2003; see Fig. 5). These winds are more or less continuous year-round, and enable voyages direct from Southeast Asia to Madagascar. Return voyages would have required heading further south where wild winds of extreme strength have transferred sailors 6,000 km in 3 weeks or less (Pearson 2003). The feasibility of such direct routes at the time of Austronesian colonisation has recently been explored through computer simulation studies (Fitzpatrick and Callaghan 2008; see discussion below).

Pre- and Proto-Swahili East Africa

While recent work suggests that coastally focused lifestyles in Africa may extend back to the Middle Stone Age (Marean 2010; Deacon 1989; Walter et al. 2000), direct evidence for maritime subsistence of this antiquity on the Swahili coast is currently lacking. Our review thus begins with the Later Stone Age (LSA), though it should be noted that the archaeological evidence for initial occupation on the East African coast remains poorly understood. With few exceptions, data is limited to low intensity surveys, trial pits and ad hoc 'secondary' collections retrieved during studies of later coastal periods. While the presence of probable transient hunter-gatherers, utilising a coastal variant of the 'Wilton' microlithic stone tool complex has been confirmed, there has been little or no attempt to collate existing data or to undertake a comparative regional analysis of recovered LSA assemblages. Yet where analyses have been published, considerable chronological and regional variety in hunter-gatherer lifeways is indicated, particularly in terms of manufactured tool types and the available raw resources utilised.

While some preliminary fieldwork has been carried out in southern Somalia (Cotorti and Mussi 1987; Matteucci et al. 2007) and Mozambique (Adamowicz 1990; Morais 1988; Sinclair et al. 1993), a far greater survey intensity has been reported from coastal Kenya (Helm 2000; Helm et al. 2012; Kato 1991; Soper 1966, 1975; Wright 2005) and Tanzania (Chami 1996, 2001a; Chami and Chami 2001; Chami and Kessy 1995; Chami and Kwekason 2003; Kessy 1997; Kwekason 2007; Marean and Shea 1996; Pawlowicz 2011, 2012; Walz 2010), where a range of LSA sites have been identified. Recent investigations of the immediate offshore islands have similarly uncovered evidence for early human colonisation, indicating that at least some early hunter-gatherer communities had sufficient maritime knowledge and sailing craft to navigate difficult offshore currents (Breen and Lane 2003, p. 473). Ongoing research has identified a number of LSA sites off the coast of Tanzania, including on the islands of Kilwa (Chittick 1975; Chami 2006a, b); Mafia (Chami 1999, 2004); and Zanzibar (Chami 2001b, 2006a), though an absence of occupation before the middle of the first millennium AD has been noted on Pemba (Fleisher 2010b). Of particular interest are the excavated sites of Ukunju and Kinunda Caves on Juani Island, Mafia, with deposits radiocarbon dated to between 800 and 400 BC (Chami 2004; the finding of early material at Ukunju Cave could not, however, be replicated by the Sealinks Project). On Unguja Island, Zanzibar, meanwhile, Machaga Cave, has an LSA sequence apparently extending back to c. 2800 BC (Chami 2001b), and at Kuumbi Cave (Fig. 6), hunter-gatherer occupation may go back to 22,000 years ago (Sinclair et al. 2006), though identification of the lower lithic material as human-made artefacts may be questionable.

Definitive Later Stone Age activity on the islands of Madagascar and the Comoros has still to be identified; the earliest archaeological dates for permanent village sites are limited to the mid first millennium AD (Allibert and Vérin 1996; Burney et al. 2004; Dewar 1996; Dewar and Wright 1993), though identification of potentially earlier material culture is claimed (Chami 2006a, pp. 104–105, 2011; Dewar et al. 2013). Other evidence for early human impacts, including the translocation of animal and plant species, and changes to island palaeoenvironments, are also suggested (Blench 2007a; Walsh 2007, p 104). Evidence to corroborate human activity on Madagascar from as early as c. 350 BC is indicated by vegetational changes on the southwest of the island, including the appearance of non-endemic *Cannabis/Humulus*, a sudden rise in carbon particles and increased ruderal species, in addition to evidence for butchered bones of extinct wild fauna (Burney et al. 2003, 2004; Perez et al. 2005). The chronological and taxonomic integrity of many of these proxies has been called into question, however, casting doubt on claims for a human presence on the island before the mid first millennium AD (e.g. Dewar and Richards 2012; but see Dewar et al. 2013). Suggestions that a number of known and proposed translocations of animal species between the mainland and offshore islands (discussed further below) may have begun during the LSA (e.g. Blench 2007a; Walsh 2007) have also yet to be supported by finds from early archaeological assemblages.

Hunted fauna in LSA coastal East Africa comprised a range of wild species, commonly including small and medium sized ungulates, and limited marine species including molluscs and fish (Chami 2001b, 2004, 2006a; Sinclair 2007; Sinclair et al. 2006). Preliminary identification of potential domestic species, including cattle (*Bos taurus*), are still to be confirmed (Sinclair 2007). Particular doubts have been expressed concerning the identification and stratigraphic integrity of recovered chicken (*Gallus gallus*) from Machaga Cave (Lejju et al. 2006; Sutton 2002). Finds of other potential domesticated species,

Fig. 6 Kuumbi Cave, Zanzibar. The cave site features evidence for Later Stone Age and possibly earlier occupation of the island. (Photo: Nicole Boivin)

including cat (*Felis catus*) from Machaga Cave, and a dog canine (*Canis familiaris*) from Ukunju Cave, Juani (Chami 2006a) are also contested (Dueppen 2011; Sinclair 2007).

A number of LSA sites have ceramics in later levels (e.g., Chami 2004; Chami and Kwekason 2003; Helm et al. 2012). Identification of potential Pastoral Neolithic (PN) elements in some of these ceramic assemblages, comparable with early first millennium BC assemblages from the Rift Valley, and the preliminary identification of domesticates, has led some to suggest a 'Neolithic' presence on the coast and offshore islands of Tanzania (Chami 2001b, 2004, 2006a, 2007; Chami and Kwekason 2003; Kwekason 2007; Walz 2010). Such identification holds significant implications for understanding interactions between agro-pastoral groups and existing hunter-gather populations on the coast during the later first millennium BC and early centuries AD, a time which overlaps with that described in the *Periplus* and possibly with the first Early Iron Age, Kwale Ware-using communities of the coast (see below). However, these early Pastoral Neolithic elements have been rightly viewed with caution (Lane 2004; Sutton 2002); in particular, queries regarding the identification of this pottery to inland PN traditions and chronology have still to be resolved (Sinclair 2007, p. 2). Potential PN influences on later coastal Swahili ceramic assemblages have previously been noted in the drier northern coastal regions of Kenya, and a PN origin for early proto-urban Swahili proposed (Abungu 1989; Allen 1993; Horton 1996a, b). Linguistic data supports the presence of an earlier, probably pastoral, Southern Cushitic speaking population on the northern coast before the arrival of the proto-Northeast Coast Bantu speakers, from whom the region's present dominant language groups derive (Ehret 1998; Nurse and Hinnesbusch 1993; but also see Chami 2001c). Some have proposed that it is these Cushitic-speaking pastoralists who are the 'big-bodied men' encountered by classical period traders on the East African coast and described in the *Periplus* (Casson 1989; see below).

The date of the earliest evidence for the Early Iron Age (EIA) communities commonly associated with the spread of Bantu languages on the East African coast is controversial, but some have now pushed it back as far as c. 200 BC (Chami and Msemwa 1997a, p. 674; Chami 2006a, p. 118). While reservations about accepting a direct one-to-one correlation between pottery and culture are recognised, identification of EIA settlement is still commonly determined by the presence of the regional ceramic variant Kwale Ware (Soper 1967), and it is argued that later Swahili pottery, interchangeably labelled Tana or Triangular Incised Ware, derived from this EIA Kwale Ware and that the later Swahili would have originated from these Bantu speaking EIA peoples (Chami 1994; Chami and Mapunda 1998; Helm 2000; Kusimba 1999; Horton and Middleton 2000; Spear 2000). So far, the greatest concentration of EIA sites, and their earliest occurrence, appear to be on the central Tanzanian coast, between the Wami River and the Rufiji river delta (Chami 2001a, 2006a). Adaptation to a maritime environment does not appear to have taken long, with EIA settlement also evident on Koma, Kwale, Mafia and Unguja islands by the third century AD (Chami 1999, 2004; Chami and Msemwa 1997a, b). A rapid southwards movement along the coastal littoral, perhaps by boat, is indicated, with settlement dated as early as the second century AD in Mozambique (Ekblom 2004; Klapwijk 1974; Mitchell 2000; Sinclair et al. 1993). Despite this, maritime resources do not appear to have been intensively exploited until the later first millennium AD (Horton and Mudida 1993; Breen and Lane 2003, p. 475). That these communities represent some of the populations referred to in the first century AD *Periplus* now appears increasingly probable, though refinement of the dating of settlement both on the mainland and offshore is still badly needed (see below).

A slightly later distribution of Kwale Ware-bearing sites in Kenya appears to represent a slower, overland expansion northwards by iron-working agricultural groups by the mid third century AD (Soper 1967). At present, no EIA settlement has been recorded along the coastal littoral of Kenya, the distribution of these sites appearing to be limited to some 15 km inland along the eastern edge of the forested coastal uplands, with sites presently located as far north as the Galana (Sabaki) river (Helm 2000). Reports of a small number of potential sherds of EIA Kwale Ware pottery from Barawa on the southern coast of Somalia cannot be confirmed (Chittick 1969; Jama 1996), but do not seem implausible in light of the evidence for maritime ability now evident from coastal mainland and offshore Tanzania.

There is no evidence that interaction between EIA communities and the existing LSA or 'Neolithic' groups led to any drastic reorganisation of technology or subsistence for the existing communities occupying the coastal regions. In both Kenya and Tanzania, EIA settlement distributions appear to mirror those of existing populations, and a significant degree of overlap and continuity is indicated (Chami 2001a; Helm 2000). Ongoing fieldwork on the coast of Kenya suggests that while new EIA settlement was situated within a few kilometres of existing hunter-gatherer populations, no direct evidence for change on the LSA sites appears until the later first millennium AD, when relatively small numbers of Tana or Triangular Incised Ware ceramics and other direct coastal imports, such as glass beads, are introduced (Helm et al. 2012).

As with other areas of East Africa, a complex 'mosaic' pattern is now emerging on the coast, suggesting varied interactions between different communities utilising the wide range of environmental and resource bases available (Kessy 2005; Kusimba and Kusimba 2005; Lane 2004; Lane et al. 2007; Prendergast 2010; Wright 2005, 2007). Archaeological evidence for contact and exchange between these communities and with the wider world before the later first millennium AD is rare. As discussed below, broader connections with other regions of the Indian Ocean are now hinted at on a number of sites in mainland and offshore Tanzania, but none are dated with confidence, and the quantity of excavated materials remains insufficient to support claims for intensive early trade (e.g. Sinclair 2007). Marine shell, including cowries (*Cypraea annulus*) and mitra (*Strigatella paupercula*), has been recovered from a number of inland localities associated with late first millennium BC PN sites of the Rift Valley, notably Ngorongoro Crater in northwest Tanzania, and Nakuru, Hyrax Hill, Lake Turkana and Tsavo in Kenya (Mutoro 1998; Nelson 1993; Wright 2005). Comparable evidence for the long-distance exchange of marine shell as far as the Great Lakes region has now also been found on some inland mid first millennium AD EIA sites (Giblin et al. 2010, pp. 290–292). Other products, including plant and animal produce, which are as yet insufficiently studied in the archaeological record, might also have been included in these exchanges (Helm et al. 2012). However, the low density of such occurrences seems to point to relatively small-scale, local exchange networks, rather than direct or intensive trade with the coastal communities.

The Arrival of Agriculture on the East African Coast

While the East African coast ultimately welcomes in a whole suite of Indian Ocean species, which help to shape both agriculture and species diversity in the region, indigenous African crops and domesticates (as well as southwest Asian domesticates) also occupy an important place in East African agriculture, particularly in its earliest phases. As these provide the essential background for examining Indian Ocean species translocations, we summarise what is known of their early presence in the East African region here (see Tables 2, 3). These species include three large ungulate taxa (cattle, goat and sheep); three pan-African cereals (finger millet, pearl millet and sorghum); three beans (cowpea, bambara groundnut and hyacinth bean); and, potentially, a number of starchy staples of vegecultural production (indigenous African yams and ensete). As the yams and ensete currently lack any sort of archaeological record they will not be discussed below (but see Hildebrand 2003a, b, 2007 for ethnoarchaeological models of their cultivation and domestication processes in tropical Africa).

In the wider East African region (including modern-day Tanzania, Kenya, Uganda and Mozambique), it has been suggested that the spread of all three pan-African cereals, and agro-pastoralism in general, was associated with the migration of Bantu-speaking agriculturalists (e.g. Holden 2002). However, because the more ancient Bantu languages are located in west Central Africa, across the tropical forest zone where vegecultural crops are more important, it is postulated that sorghum and pearl millet were obtained by Bantu speakers from Central Sudanian (Nilo-Saharan) speaking groups, somewhere around the northern area of Great Lakes Africa (southern Sudan, western Kenya, Uganda) (e.g. Phillippson 1993; Schoenbrun 1993). Such Sudanian groups are postulated to have been migrating southwards from a zone of early farming in the savannahs of northern/central Sudan. Finger millet, meanwhile, is generally regarded as a later addition to the Bantu crop repertoire, on account of its diverse linguistic forms. Ehret (1998) proposes that this crop was moved southwards with Cushitic speaking groups of agro-pastoralists from the Ethiopian uplands, but there is no archaeological evidence for this.

The hypothesis that Bantu farming expansion was the main source of food production in eastern Africa has, however, been called into question. Some of the hypothesized straightforward correlations between artefact styles, the presence of cultivation and livestock, and Bantu-language speakers have been undermined by recovered archaeological associations, with apparently ‘Bantu’ type artefacts associated with hunting, and food production associated with non-‘Bantu’ types (e.g. Robertshaw and Collet 1983; Lane et al. 2007). The earliest dates for pastoralism in interior East Africa (e.g. around Lake Turkana), and the apparent borrowing of livestock terminology into some southern Bantu languages from Southern African Khoisan languages (Ehret 1983; Vossen 2007), certainly imply the dispersal of pastoralism at a much earlier date, before the Iron Age that has been associated with the Bantu. Archaeobotanical evidence remains limited, and most finds of crops come from the first millennium AD and onwards, suggesting that a Bantu association for the spread of cereal farming down eastern Africa remains plausible. What role, if any, introduced Asian vegeculture crops might have played, and whether the Bantu had a role in the dispersal of such crops, are problems we return to below. In what follows, we explore the key species of early East African agriculture in turn.

Cattle, along with the other major animal domesticates of African pastoralism, were introduced to eastern Africa and subsequently altered through inter-breeding with Indian Ocean varieties. Livestock were both introduced from southwest Asia (sheep [*Ovis aries*], goat [*Capra hircus*], and taurine cattle [*Bos taurus*]), and also probably domesticated in Africa (*Bos africanus*; Wendorf and Schild 1994; Marshall and Hildebrand 2002; cf. Grigson 2000), dispersing south of the Sahara beginning in the middle Holocene. Livestock had reached the region around Lake Turkana in northern Kenya by 4000–3000 BC, but only arrived on the Ethiopian Plateau after 3000 BC. It is not clear when these species reached the East African coast. Faunal records are extremely sparse for Early Iron Age sites of the region, and one of the few examples comes from the Juani Primary School site in the Mafia archipelago, where (perhaps significantly) no domesticates were found but fish

Table 2 Summary of key faunal data from archaeological sites on the East African coast, offshore islands, and Madagascar

Region	**Site**	**Date (century AD)**	**Domestic animals**	*Bos taurus* (taurine cow)	*Bos indicus* (zebu cow)	*Bos sp.* (undifferentiated B. taurus/B. indicus)	*Capra hircus* (goat)	*Ovis aries* (sheep)	Capra/Ovis	*Sus scrofa* (pig)	*Gallus gallus* (chicken)	*Felis catus* (cat)	*Canis familiaris* (dog)	*Camelus dromedarius* (camel)	**Commensal animals**	*Rattus rattus* (Asian rat)	*Mus musculus* (house mouse)	**Translocated wild animals**	*Cephalophus monticola* (blue duiker)	*Potamochoerus larvatus/porcus* (bush pig)	*Tenrec ecaudatus* (common tenrec)	*Numida meleagris* (helmeted guineafowl)	*Eulemur mongoz* (Mongoose lemur)	*Eulemur fulvus* (common brown lemur)	*Colobus kirkii* (Zanzibar red colobus monkey)	*Atilax paludinosus* (marsh mongoose)	*Kinixys belliana* (Bell's hinged-back tortoise)	*Columba livia* (rock dove)	*Geochelone yniphora* (ploughshare tortoise)	*Erymnochelys madagascariensis* (big-headed turtle)	**Notes**	**Reference**
Lamu	Shanga	Late 8th–mid 9th									X	X				X										X						Horton & Mudida 1996
		Mid 9th–early 10th				X			X		X	X				X																
		Early 10th–mid 13th				X			X		X	X	X			X																
		Early 12th–14th				X			X		X	X		X		X																
		14th–15th				X			X		X	X				X				?											*Potamochoerus porcus* (syn. *P. larvatus*) bones found in upper levels, possibly recent (post 15th century?)	
	Pate	Mid 8th–9th				X					X					?															'Rodent' remains intermittent throughout sequence	Wilson & Omar 1997
		Mid 9th–11th				X	X				X					?															Cattle mainly present after c. 850	
		11th–mid 12th				X	X				X			X		?															Chicken mainly present after c. 1000; single cf. *Camelus* bone	
		Mid 12th–mid 13th				X	X				X					?																
	Manda	Mid 9th–early 11th				X			X		X	X		X																		Chittick 1984
		Mid 11th–late 13th				X			X		X	X		X																		
		Late 13th–14th				X			X		X	X		X																		

Table 2 conitnued

Region	**Site**	**Date (century AD)**	**Domestic animals**	*Bos taurus*	*Bos indicus*	*Bos sp.*	*Capra hircus*	*Ovis aries*	Capra/Ovis	*Sus scrofa*	*Gallus gallus*	*Felis catus*	*Canis familiaris*	*C. dromedarius*	**Commensal animals**	*Rattus rattus*	*Mus musculus*	**Translocated wild animals**	*C. monticola*	*P. larvatus/porcus*	*Tenrec ecaudatus*	*Numida meleagris*	*Eulemur mongoz*	*Eulemur fulvus*	*Colobus kirkii*	*Atilax paludinosus*	*Kinixys belliana*	*Columba livia*	*G. yniphora*	*E. madagascariensis*	**Notes**	**Reference**
Kenyan mainland	Mgombani	7th–mid 9th		X					X		X									X												Helm & Mudida 2000
	Chombo	Late 8th–late 10th				X	X	X	X		X					X			X	X		X										Helm & Mudida 2000
	Mteza	Late 8th–late 10th		X					X													X					X				*Bos taurus* present in upper horizon (c. late 10th century)	Helm & Mudida 2000
	Mtsengo	Early 14th–15th		X			X	X	X		X					X			X	X		X										Helm & Mudida 2000
	Mbuyuni	15th–17th			X				X		X		X			X			X	X		X									*Canis* bone from surface	Helm & Mudida 2000
Tanzanian mainland and offshore islands	Mpiji	7th							X		X																					Chami 1994
	Kwale Island	Post 12th					X				X																					Chami & Msemwa 1997a
	Kaole ruins ('beach terrace')	Post 12th		X					X		X	X				X															Imprecise chronological/contextual data	Chami 2002
	Kilwa	Late 13th–15th									?																				'Chicken-sized' bird bones present	Chittick 1974
Mafia	Ukunju (Juani Island)	1st millennium BC?									?	?	?																		Integrity of deposits and taxonomic identifications have been questioned	Chami 2004, 2006
Pemba	Mtambwe Mkuu	Post 9th				X	X				X																					Mudida & Horton in prep.
	Ras Mkumbuu	Post 11th				X	X	X			X	X																				Mudida & Horton in prep.

Table 2 conitnued

Region	**Site**	**Date (century AD)**	**Domestic animals**	*Bos taurus*	*Bos indicus*	*Bos sp.*	*Capra hircus*	*Ovis aries*	Capra/Ovis	*Sus scrofa*	*Gallus gallus*	*Felis catus*	*Canis familiaris*	*C. dromedarius*	**Commensal animals**	*Rattus rattus*	*Mus musculus*	**Translocated wild animals**	*C. monticola*	*P. larvatus/porcus*	*Tenrec ecaudatus*	*Numida meleagris*	*Eulemur mongoz*	*Eulemur fulvus*	*Colobus kirkii*	*Atilax paludinosus*	*Kinixys belliana*	*Columba livia*	*G. yniphora*	*E. madagascariensis*	**Notes**	**Reference**
Pemba	Chwaka	11th				X			X		X	X				X																Fleisher 2003
		12th–13th/early 14th				X	X		X		X	X				X															Remains of entire *Felis catus* individual present; *Rattus rattus* dates to late 13th—early 14th century	
		14th–15th				X	X		X		X	X																				
	Kaliwa	14th–15th				X			X		X	X				X																Fleisher 2003
	Mduuni	13th–15th				X	X		X		X																					Fleisher 2003
Zanzibar (Unguja)	Kuumbi	1st millennium BC?									?	?																			Deposits possibly mixed; taxonomic identifications have been questioned	Chami 2007; Sinclair et al. 2006
	Machaga	1st millennium BC?									?	?																			Integrity of deposits and taxonomic identifications have been questioned	Chami 2001b
	Unguja Ukuu	6th–7th ?									X	X							X	X					X						*Gallus* not common until 13th/14th centuries	Mudida & Horton in prep.
		6th–mid 8th				X	X		X	?	X	?	X			?	?								?						Either '*Sus potamochoerus nyassae'* (wild pig, syn. *P. larvatus*) or *S. scrofa* present; either *Rattus rattus*, *Mus musculus*, or *R. fuscipes* (bush rat) present; *Felis* sp. (cat) present	Juma 2004
		Mid 8th–10th					X			?	X	?				?									?							
		Mid 11th–12th				X	X				X		X			?																
		Mid 15th–17th					X					?				?									?							

Table 2 conitnued

Region	**Site**	**Date (century AD)**	**Domestic animals**	*Bos taurus*	*Bos indicus*	*Bos sp.*	*Capra hircus*	*Ovis aries*	Capra/Ovis	*Sus scrofa*	*Gallus gallus*	*Felis catus*	*Canis familiaris*	*C. dromedarius*	**Commensal animals**	*Rattus rattus*	*Mus musculus*	**Translocated wild animals**	*C. monticola*	*P. larvatus/porcus*	*Tenrec ecaudatus*	*Numida meleagris*	*Eulemur mongoz*	*Eulemur fulvus*	*Colobus kirkii*	*Atilax paludinosus*	*Kinixys belliana*	*Columba livia*	*G. yniphora*	*E. madagascariensis*	**Notes**	**Reference**
Zanzibar (Unguja)	Fukuchani	6th–8th ?					X				X								X	X												Mudida & Horton in prep.
	Tumbatu	14th				X	X	X			X	X	X	X		X			X									X				Mudida & Horton in prep.
Comoro Islands	Koungou (Mayotte)	8/9th–10th				X															X								X			Allibert & Vérin 1996
	Dembeni (Mayotte)	8/9th–10th			X		X		X		X	X				X					X		?	?					X	X		Redding & Goodman 1984; Allibert et al. 1989
	M'Bachile (Grande Comore)	9th–10th					X		X	?							X															Redding & Goodman 1984
	Sima (Anjouan)	9th–10th							X												X											Redding & Goodman 1984; Redding 1992
		11th–12th							X		X					X					X											
	Domoni (Anjouan)	11/12th–13th							X		X										X											Redding 1992
Madagascar	Andrahomana Cave	Late 1st millennium BC/early 1st millennium AD														?	?														Deposits probably mixed	Burney et al. 2008
	Mahilaka	Late 9th–10th			X		X		X		X					X	X				X								X			Radimilahy 1998
		11th–13th			X			X	X		X					X	X				X	X										
		13th–14th			X		X	X	X	X	X					X	X				X						X					
		14th–15th			X		X	X			X					X					X	X					X	X				
	Andaro	10th–13th				X			X		X										X											Parker Pearson 2010

Table 2 conitnued

Region	Site	Date (century AD)	**Domestic animals**	*Bos taurus*	*Bos indicus*	*Bos sp.*	*Capra hircus*	*Ovis aries*	Capra/Ovis	*Sus scrofa*	*Gallus gallus*	*Felis catus*	*Canis familiaris*	*C. dromedarius*	**Commensal animals**	*Rattus rattus*	*Mus musculus*	**Translocated wild animals**	*C. monticola*	*P. larvatus/porcus*	*Tenrec ecaudatus*	*Numida meleagris*	*Eulemur mongoz*	*Eulemur fulvus*	*Colobus kirkii*	*Atilax paludinosus*	*Kinixys belliana*	*Columba livia*	*G. yniphora*	*E. madagascariensis*	Notes	Reference
Madagascar	Andranosoa	10th–13th				X		X	X			X	X							X	X											Rakotozafy & Goodman 2005; Rasamuel 1984 (cited in Parker Pearson 2010)
	Nosy Be	11th–mid 14th				?			?												X										Possible *Bos* sp. & *Capra/Ovis* present	Dewar & Wright 1993
	Rezoky	13th–15th				X	X	X					X							X	X	X									Part of assemblage surface collected	Rakotozafy & Goodman 2005; Dewar & Wright 1993
	Ampahijolike	14th–15th				X			X		X																					Parker Pearson 2010
	Asambalahy	14th–16th				X																X										Rakotozafy & Goodman 2005
	Belo-sur-Mer	15th?											X																			Rakotozafy & Goodman 2005
	Analamanitra	15th?			X																											Rafolo 1986 (cited in Radimilahy 1998)
	Montefeno	16th–17th				X			X		X																					Parker Pearson 2010
	Lohavohitra	16th–18th			X																											Rafolo 1986 (cited in Radimilahy 1998)
	Laparoy	17th–19th									X											X										Rakotozafy & Goodman 2005
	Ambaro	19th						X			X																					Rakotozafy & Goodman 2005

Table 2 conitnued

Region	Site	Date (century AD)	**Domestic animals**	*Bos taurus*	*Bos indicus*	*Bos sp.*	*Capra hircus*	*Ovis aries*	Capra/Ovis	*Sus scrofa*	*Gallus gallus*	*Felis catus*	*Canis familiaris*	*C. dromedarius*	**Commensal animals**	*Rattus rattus*	*Mus musculus*	**Translocated wild animals**	*C. monticola*	*P. larvatus/porcus*	*Tenrec ecaudatus*	*Numida meleagris*	*Eulemur mongoz*	*Eulemur fulvus*	*Colobus kirkii*	*Atilax paludinosus*	*Kinixys belliana*	*Columba livia*	*G. yniphora*	*E. madagascariensis*	Notes	Reference
Mozambique	Chibuene	7th—c. 10th/14th		X			X	X	X		X																					Sinclair 1982, 1987; Ekblom 2004; Badenhorst et al. 2011
		Mid 15th—18th/19th		X				X	X		X								X													
	Massingir	9th?									?																				'Domestic fowl' present	Duarte 1976 (cited in Morais 1988)
	Manyikeni	Mid 12th—mid 14th				X			X																							Barker 1978
		Mid 14th—mid 15th				X			X		?																				'Domestic fowl' present	
		Mid 15th—mid 16th				X			X		?																					

Table 3 Summary of key archaeobotanical finds from sites on the East African coast, offshore islands, and Madagascar

Region	Site	Date (century AD)	**African crops**	*Sorghum bicolor* (sorghum)	*Pennisetum glaucum* (pearl millet)	*Eleusine coracana* (finger millet)	cf. *Vigna unguiculata* (cowpea)	*Adansonia digitata* (baobab)	**Asian crops**	*Oryza sativa* (Asian rice)	*Setaria* cf. *verticillata*	*Setaria* cf. *italica*	cf. *Setaria*	*Vigna* cf. *radiata*	cf. *Vigna mungo*	cf. *Macrotyloma*	*Sesamum* cf. *indicum* (sesame)	*Papaver somniferum* (poppy)	*Cocos nucifera* (coconut)	*Triticum* (wheat)	cf. *Triticum/Hordeum* (wheat/barley)	*Pisum* sp. (pea)	*Gossypium* (cotton)	cf. *Rutaceae* (citrus)	**Other**	*Vigna* sp.	Notes	Reference
Kenya	Mgombani	7th–mid 9th		X	X	X		?																		X	*Vigna* sp. present in upper levels; *Adansonia* possibly present	Helm et al. 2012
Tanzania	Kilwa	11/12th		X																								Chittick 1974
	Songo Mnara	Late 14th—early 16th		X	X			?		X									X				X			X	*Vicia faba* (broad bean) also present	Walshaw & Pistor 2011
	Misasa	6–7th																	X									Chami 1994, 2001
	Mpiji	7th																	X									Chami 1994
	Kaole ('Kaole Hill')	9th–19th																	X									Chami 1994:57
	Mikindani (16 sites)	1st millennium AD		X	X			X													X	X	X					Pawlowicz 2011
		1st –2nd millennium transition			X					X												X					Single *Oryza sativa* grain only	
		First half of 2nd millennium		X	X	X		X														X	X					
		Mid 2nd millennium		X	X	X		X														X	X				Bean also present but species not indicated	
Pemba	Tumbe	7th–10th		X	X	X				X				X			?		X		X		X				*Sesamum* possibly wild; direct date on pearl millet to 7th C AD	Walshaw 2005, 2010
		18–19th			X					X									X				X					
	Kimimba	8th–10th			X			?								X			X				X				Other Fabacae also present	Walshaw 2005
	Chwaka	11th–15th		X	X	X				X		X			X			X	X		X	X	X			X	Possible wild *Setaria megaphylla* present	Walshaw 2005, 2010

Table 3 Summary of key archaeobotanical finds from sites on the East African coast, offshore islands, and Madagascar

Region	Site	Date (century AD)	**African crops**	*Sorghum bicolor*	*Pennisetum glaucum*	*Eleusine coracana*	cf. *Vigna unguiculata*	*Adansonia digitata*	**Asian crops**	*Oryza sativa*	*Setaria* cf. *verticillata*	*Setaria* cf. *italica*	cf. *Setaria*	*Vigna* cf. *radiata*	cf. *Vigna mungo*	cf. *Macrotyloma*	*Sesamum* cf. *indicum*	*Papaver somniferum*	*Cocos nucifera*	*Triticum*	cf. *Triticum/Hordeum*	*Pisum* sp.	*Gossypium*	cf. *Rutaceae*	**Other**	*Vigna* sp.	Notes	Reference
	Kaliwa	14th–15th			X	X				X									X				X					Walshaw 2005
Zanzibar	Unguka Ukuu	c. 7th–9th		X	X			X		X				X						X								Crowther et al., unpublished data
	Fukuchani	c. 7th–9th		X	X																							Crowther et al., unpublished data
Comoro Islands	Dembeni (Mayotte)	8/9th–10th								X	X		X				X		X								Unidentified Poaceae grains and a single *Paspalum* grain (recent?) also present	Hoffman 1984; Allibert et al. 1984
	M'Bachile (Grande Comore)	9th–10th								X																	Unidentified Poaceae grains also present	Hoffman 1984
	Sima (Anjouan)	9th–10th								X			X											X			Unidentified Poaceae grains, one legume (cf. *Cajanus*?), and one Chenopodium seed also present	Hoffman 1984; Johnson 1992
		11th–12th																	X									
	Domoni (Anjouan)	13th								X																		Johnson 1992
Madagascar	Mahilaka	Late 9th–10th								X																		Radimilahy 1998
		11th–13th								X																		
		13th–14th								X									X									
	Nosy Be	11th—mid 14th																	X									Dewar & Wright 1993
	Fanongoavana	Late 15th/early 16th					X			X																		Wetterstrom & Wright 2007
	Lohavohitra	16th–18th					X			X																		Wetterstrom & Wright 2007
	Ambohinanjakana	17th—early 18th					X			X																		Wetterstrom & Wright 2007
	Amboatany	18th—early 19th								X																		Wetterstrom & Wright 2007
Mozambique	Chibuene	7th—c. 10th		?		?																					One cf. *Sorghum* and one cf. *Eleusine* grain present in early occupation phase.	Sinclair 1982, 1987; Ekblom 2004
	Xakota (Nampula)	7th		X																								Sinclair et al. 1993

Fig. 7 Zebu cow being loaded on to a boat at Unguja Ukuu, Zanzibar (photo courtesy of Mark Horton). Genetic patterns in modern African cattle suggest significant zebu influence via Indian Ocean maritime routes (Gifford-Gonzales and Hanotte 2011)

dominated (Chami 2004). The earliest evidence for these domesticates is thus at the Middle Iron Age site of Unguja Ukuu on Zanzibar, where cattle (*Bos taurus/indicus*), sheep and goat have all been identified in contexts dating from the sixth to mid eighth centuries AD (Juma 2004). They appear at mainland sites from around the seventh to eighth centuries AD onwards, and in the first urban settlements found on the Comoro Islands and Madagascar, dating to the late ninth—early tenth centuries (although the presence of sheep on these islands prior to the eleventh century has yet to be confirmed) (Table 2). Notably, the faunal assemblages at Shanga, one of the few coastal sites to have good chronological resolution, suggests that cattle, sheep and goat appeared about a century after other domesticates such as chicken, which were present from first occupation of the site in the late eighth century (Horton and Mudida 1996). The sequence from nearby Pate, on the other hand, records the infrequent presence of both cattle and chicken from earliest occupation levels (mid eighth to ninth century AD), although neither becomes established until the late tenth—early eleventh century (Wilson and Omar 1997) (Table 2).

The process of cattle hybridization with introduced Indian zebu cattle (*Bos indicus*; Fig. 7), which produced the Sanga breeds, appears to have taken place in the Great Lakes region of East Africa, beginning before the end of the first millennium BC (Marshall 1989). Zebu cattle were probably first introduced to Africa through the Horn via early Arabian Sea contacts, most likely at some point prior to c. 1500 BC (Magnavita 2006; Boivin and Fuller 2009). This introduction is likely to have involved only a small number of cattle, while a major input of zebu may have taken place later, again via maritime routes (see also Gifford-Gonzalez and Hanotte 2011), starting in the Swahili period. This process of hybridization may have been important for the genetic adaptation of cattle to the dry tropical environments of East Africa (Fuller and Boivin 2009). Well-reported bone assemblages with diagnostic criteria (such as bifid vertebrae or skull crests) are still rare in eastern Africa, posing a major impediment to the archaeological reconstruction of dispersal patterns. The only *Bos indicus* remains from the coastal region that pre-date the mid second millennium AD are from sites on the Comoro Islands (Allibert et al. 1989) and northwest Madagascar (Radimilahy 1998; Table 2), where zebu cattle appear to have been introduced by the early urban settlement phase in the ninth and tenth centuries AD. Widely cited archaeological evidence suggesting that *Bos indicus* was present in western Kenya by the end of the first century AD (Marshall 1989) has been recently challenged (Grigson 1996), while the claim of even earlier remains dating to 2,000 or 3,000 BP, also from western Kenya, has been withdrawn (Marshall 2000).

Other domesticates, including pig (*Sus scrofa*), dog (*Canis familiaris*), cat (*Felis catus*) and camel (*Camelus dromedarius*), have been reported less frequently at sites on the East African coast. The only confirmed evidence for the presence of domestic pig (domesticated in Eurasia and North Africa) in the study region is at Mahilaka on Madagascar, where the earliest remains were recovered from the second occupation phase (Ib), dating to around the eleventh–thirteenth centuries AD (Radimilahy 1998; Table 2). Tentative finds have been reported at Unguja Ukuu on Zanzibar (sixth to mid eighth century) (Juma 2004) and M'Bachile on Grande Comore (ninth–tenth centuries) (Redding and Goodman 1984; see also Table 2). The widespread absence of pig at sites on the coast and islands is most likely related to Islamic prohibitions on its consumption. Camel, which was probably domesticated on the Arabian Peninsula (Boivin and Fuller 2009; Gifford-Gonzalez and Hanotte 2011), is also largely absent from the study region, being reported mostly from sites in the Lamu Archipelago, including Shanga, Manda and Pate, where it first occurs in the ninth century AD but is most common by around the eleventh century AD (Chittick 1984; Horton 1996a; Wilson and Omar 1997; Table 2). This pattern is somewhat unsurprising, however, given that Lamu is at the southernmost margin of the present-day distribution of camels, with the exception of their recent introduction to Zanzibar (Horton 1996a). It was also noted by al-Mas'udi that camels were absent from the coastal settlements that he visited in the early tenth century (Horton 1996a, b). The only archaeological camel finds outside Lamu are from Kilwa (Chittick 1974), but their chronology has been questioned (Horton 1996a, b).

Small quantities of cat (a Southwest Asian domesticate) and dog (which is of Eurasian origin) (Gifford-Gonzalez and Hanotte 2011) were reported from the earliest occupation phase at Unguja Ukuu, indicating that both were present at coastal settlements by the sixth–seventh century AD (Juma 2004). Cat remains were found in the earliest occupation levels at Shanga, dating from the late eighth century AD, whereas dog does not appear at the same site until at least the early tenth century, and was much less common overall (Horton and Mudida 1996; see Table 2). Cat is also found at the ninth–tenth century Dembeni site in the Comoro Islands (Allibert et al. 1989), while dog has yet to be recovered archaeologically from these islands. The earliest occurrence of both on Madagascar is at the Andranosoa site, dating from the tenth to the thirteenth century (Rakotozafy and Goodman 2005). Horton and Mudida (1996, p. 385) suggest that the domestic cat was a ship-borne introduction to the East African coast, while dog is thought to have spread into eastern and southern Africa with early farming (Bantu) groups, arriving in the latter region by at least the seventh century AD (Mitchell 2002, p.275; cf. Horsburgh 2008).

The three major African cereals introduced to East Africa have distinct geographical origins. The origin of sorghum (*Sorghum bicolor*) is usually placed in the northeastern savannahs of Africa, such as Chad, Sudan or Ethiopia (Fuller 2003; Stemler et al. 1975), present by perhaps 2000 BC, although actual evidence documenting its domestication process or early cultivation is still unavailable. Meanwhile pearl millet (*Pennisetum glaucum*) comes from the Sahel zone of West Africa (Brunken et al. 1977; Fuller 2003; Kahlheber and Neumann 2007), with confirmed archaeobotanical evidence from the second half of the third millennium BC in northeast Mali (Manning et al. 2011). Finger millet (*Eleusine coracana*) was probably brought into cultivation somewhere between the uplands of Ethiopia and the Great Lakes region of East Africa, although there has been little advance on this inference of Harlan's (1971) in the past 40 years. The distribution of the wild progenitor *Eleusine africana* takes in much of Africa (Hilu and De Wet 1976; De Wet et al. 1984). Elsewhere in Africa, the earliest finds of finger millet come from the first–second century AD in Ethiopia (at Ona Nagast: D'Andrea 2008) and in Nigeria (at Kursakata: Klee et al. 2000). Recent sampling at cave sites in Rwanda indicates that finger millet was a widespread crop from at least the eighth century AD (Giblin and Fuller 2011). Elsewhere in East Africa, a single grain of domesticated finger millet was reported from Deloraine (near Nakuru) in Kenya from cal AD 800 deposits (Ambrose et al. 1984), and finds by this date are also known from eastern South Africa (see references below and review in Giblin and Fuller 2011).

Recent archaeobotanical evidence from coastal Kenya indicates that all three of the major native pan-African cereals were being locally consumed, and presumably cultivated, by the ceramic era, certainly by the Middle Iron Age and probably by the Early Iron Age (Helm et al. 2012). Finds include grains of sorghum (*Sorghum bicolor*), pearl millet (*Pennisetum glaucum*), and finger millet (*Eleusine coracana*), all apparently domesticated (Table 3). Although direct dating evidence is still lacking, ceramic typologies date the finds to at least the seventh century AD (Helm et al. 2012). Tentative finds of sorghum and finger millet have also been reported at the Chibuene site on the southern coast of Mozambique, also from around the seventh century AD (Ekblom 2004). The earliest archaeobotanical evidence from the offshore islands of East Africa (Table 3) suggests that an African, or 'Bantu', farming package was introduced to these islands prior (on current evidence) to any Asian introductions from across the sea. For example, the evidence on Pemba Island at the site of Tumbe included the three pan-African cereals from the earliest levels, also dating back to the seventh century AD (Walshaw 2005, 2010). Similar patterns occur in seventh–ninth century levels at Unguja Ukuu on Unguja Island, and first to early second millennium sites in the Mikindani area of southern Tanzania, although finger millet is thus far absent from the Zanzibar assemblages (Crowther et al. unpublished data; Pawlowicz 2011). Interestingly, initial evidence for the African crops at sites in southeastern Africa either pre-dates or is contemporaneous with the east coast data. For example, pearl millet has been reported at Silverleaves in South Africa in the fourth century AD (Klapwijk 1974); finger millet at Kadzi River, Zimbabwe in the fifth century AD (Jonsson 1998; Pwiti 1996); sorghum, pearl millet and finger millet at Magogo in South Africa in the sixth–seventh century AD (Maggs and Ward 1984); and sorghum at Nampula (Mozambique) (Sinclair et al. 1993) in the seventh century AD. These data, combined with the recognised lack of systematic archaeobotany at earlier coastal sites (particularly those dating to the EIA/Kwale period), suggest that a seventh century date for the arrival of African crops on the east coast should be considered a *terminus ante quem*. More recent finds at sites from this region are also sparse and include pearl millet from the eighth–tenth century site of Kimimba on Pemba (Walshaw 2005); an eleventh–twelfth century deposit of sorghum at Kilwa (Chittick 1974); and all three African crops at the eleventh–fifteenth century Swahili site of Chwaka (Pemba) (Walshaw 2010), as well as at second millennium Swahili sites in the Mikindani region (Pawlowicz 2011), and the late fourteenth–early sixteenth century site of Songo Mnara (Walshaw and Pistor 2011)

(Table 3). On Pemba, the importance of these African cereals declined with the rise of Asian crops (rice, mung bean, cotton) from around the eleventh century (Walshaw 2010), while current cultivation practices have been heavily transformed by the spread of maize (mainly since the nineteenth century AD) and tree plantation crops. Of interest is that these African cereal finds occur outside the range of modern cultivation, especially of finger millet (as mapped by Hilu and De Wet 1976), which is today restricted to more interior and upland zones of Africa. In contrast to the pattern seen on the coast and offshore islands, in Madagascar and the Comoros, preliminary evidence suggests that African crops are absent from initial settlement onwards, with Asian crops dominating instead (Table 3; see below).

In addition to the three cereals just described, three major pulse crops of African origin are also introduced to the East African coast. The cowpea (*Vigna unguiculata*) is the most widespread of these crops, and it is believed that it is most likely to have been domesticated in West Africa (Fuller 2003; D'Andrea et al. 2007), although its wild progenitor is widespread across most of sub-Saharan Africa (see Ba et al. 2004; Feleke et al. 2006 for recent discussion). Although this species had reached South Asia by the early/mid second millennium BC (Fuller 2003; Fuller and Boivin 2009), the earliest evidence from eastern Africa, broadly defined (specifically Uganda), is closer to the early centuries AD, and it is not yet possible to rule out wild collecting in the region (Giblin and Fuller 2011). There is as yet no confirmed archaeological finding of cowpea at any site on the East African coast, and only tentative finds dating from the late fifteenth century have been reported from Madagascar (Wetterstrom and Wright 2007; Table 3). Hyacinth bean (*Lablab purpureus*) is broadly of East African origin, but was most likely brought into cultivation in Ethiopia, where two divergent genotypes appear to have been domesticated (Maass et al. 2005). The bambara groundnut (*Voandzeia subterranea*) comes from forest margin habitats in West-Central Africa, and it is not widely cultivated in eastern Africa today; its traditional cultivation on Madagascar and its likely replacement in recent centuries by the American groundnut (i.e. peanut, of South American origin) through most of eastern Africa may be misleading as to the importance of Bambara groundnut in the past. Like cowpea, neither hyacinth bean nor bambara groundnut has thus far been recovered from any archaeological site in coastal East Africa, although finds of cowpea and bambara groundnut have been reported from sites in Zimbabwe (e.g. Lanlory and Leopard's Kopje), in contexts dating from at least the eighth–ninth centuries, and possibly even the seventh century (Huffman 1972, 1974; Jonsson 1998).

Like pearl millet and cowpea, the baobab tree (*Adansonia digitata*) is a species apparently introduced to East Africa from the West African savannahs. The baobab tree is of major economic and cultural importance across most of the savannah regions of Africa. It has edible seeds and fruits; the latter can be dried for storage and used to produce nutritious drinks (Baum 1995; Wickens 1982). Baobab pods may be regarded as an easily transportable food resource of mobile pastoralists (Blench 2007b). While Blench (2007b) postulated that this species originated in Madagascar, where six congeneric relatives occur wild and are frequently used (Baum 1995; Du Puy 1996), recent genetic research suggests that the most primitive haplotypes are actually restricted to West Africa, and only more derived lineages are found throughout East Africa, Madagascar, the Western Indian Ocean islands and Yemen (Pock Tsy et al. 2009). It is suggested that the various wild species in Madagascar represent an adaptive radiation after natural dispersal from an African common ancestor, which in turn had its origins in South America, where related genera occur (Baum et al. 2004; Pock Tsy et al. 2009). The dry pods of these species are known to be buoyant, and seeds remain germinable after being soaked in salt water (Du Puy 1996; Pock Tsy et al. 2009), a characteristic that allowed the ancestors of a wild species, *Adansonia* *gregorii*, to reach Australia, probably from Madagascar. The low genetic diversity of baobab in eastern Africa and its presence on Madagascar and the Comoros, and in Arabia, also strongly implicates human translocation. Even in parts of West Africa, especially in the more northerly savannahs, its distribution appears highly anthropogenic and associated with human settlement (Duvall 2007). A modern population growing near the ancient Indian Ocean port site of Mantai, in Sri Lanka (Vandercone et al. 2004), is also likely to be the result of human translocation, although it is uncertain whether this occurred in antiquity. Archaeobotanical evidence puts the use of the baobab in West Africa back to a period associated with early pearl millet cultivation, such as the Final Stone Age (or West African Neolithic: >1000 BC), while wood charcoal finds at sites such as Ti-n-Akof, Oursi and Corcoba (all in Burkina Faso; Kahlheber and Neumann 2007) and seed evidence put this species in the far west of Africa (Senegal) in the mid first millennium AD (Murray 2008). Recent archaeobotanical finds of baobab seed fragments and fruit rinds from sites on the coast of Kenya (Helm et al. 2012) and the islands of Pemba (Walshaw 2010) and Zanzibar (Crowther et al. unpublished data) date its dispersal to the east coast to at least the seventh century AD.

Wild Animal Translocations

While most of the species translocated anthropogenically to East Africa, whether from elsewhere in the continent or from other parts of the Indian Ocean, were domesticates, there has been recent interest in the translocation of wild species in eastern Africa (see Fig. 8). We will save discussion of commensal animals and weeds for later sections, and here focus on evidence for the potential maritime translocation of wild animal species *around* East Africa, which may have begun at an early date. These translocations include both known and proposed human-mediated dispersals of wild animal species and are likely indicative of patterns of local connections between the East African coast, its offshore islands and Madagascar. They can be grouped broadly into movements of species from: (1) the mainland to the offshore islands; (2) Madagascar to the Comoros; (3) Comoros to Mafia, Zanzibar and Pemba; and (4) Zanzibar to Pemba. While some have suggested that these movements may have begun during the Later Stone Age (Blench 2007a; Walsh 2007), direct archaeological evidence can only confirm a more recent time frame, beginning with or after the first appearance of urban settlements on the East African islands (that is, around the mid–late first millennium AD for Zanzibar, and the ninth or tenth centuries AD for Madagascar and the Comoros) (see Table 2). This pattern should be interpreted with a degree of caution, however, given the general lack of faunal assemblages from stratified Later Stone Age or pre-urban contexts in many regions. It is nonetheless significant that, at least on Madagascar, a wide range of late Holocene sub-fossil deposits have thus far failed to yield secure evidence for any non-endemic taxa on the island prior to the establishment of the first trading ports in the mid ninth century AD (e.g., Burney et al. 1997, 2008; MacPhee and Burney 1991; Rakotozafy and Goodman 2005; Simons et al. 1995). On the other hand, translocations of wildlife by prehistoric hunter-gatherers are not unheard of, and indeed the creation of 'transported landscapes' (Kirch 1982) has been traced in Melanesia as far back as 20,000 BP, when people clearly began to move both animals and raw materials by sea in order to overcome local constraints (Gosden 1995). The *Periplus* records the presence of sewn boats and dugout canoes on the East African coast in the early first millennium AD, providing at minimum a means for moving animals in that region by this time period. It is thus feasible that further zooarchaeological studies

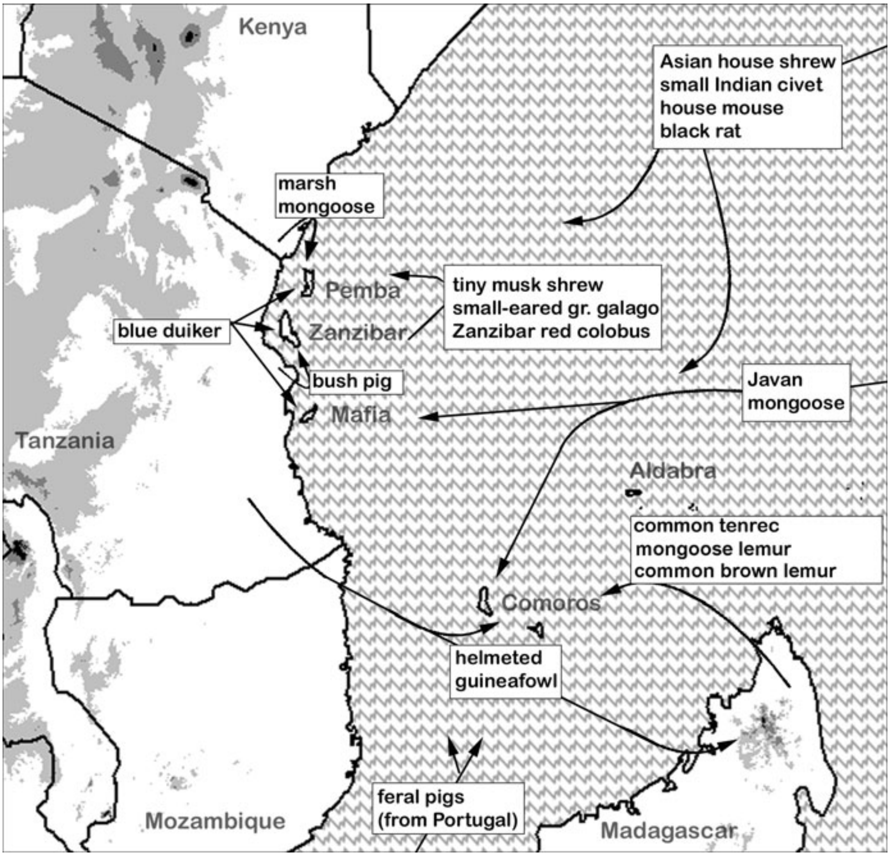

Fig. 8 Map summarising some known and proposed wild and commensal animal translocations for East Africa (based on Walsh 2007)

will reveal evidence for the pre-Swahili maritime transport of wild animals on the East African coast.

A range of endemic mainland species are known or thought to have been transferred to and between the offshore islands, including the wild bush pig (*Potamochoerus larvatus*) to Zanzibar, Mafia and Madagascar; helmeted guineafowl (*Numida meleagris*) and blue duiker (*Cephalophus monticola*) to Zanzibar, Pemba, Mafia, Comoros and Madagascar; marsh mongoose (*Atilax paludinosus*) to Pemba; Bell's hinged-back tortoise (*Kinixys belliana*) to Zanzibar and Madagascar; and rock dove (*Columba livia*) to Madagascar (Radimilahy 1998; Walsh 2007; see Fig. 8). The earliest evidence for these translocations occurs on Zanzibar, where remains of wild bush pigs have been recovered at Unguja Ukuu and Fukuchani, dating from at least the sixth—mid eighth centuries AD, and possibly earlier (Juma 2004; Mudida and Horton, in prep.). The same species does not appear on Madagascar until the tenth–thirteenth centuries, at Andranosoa in the island's south (Rakotozafy and Goodman 2005), and has yet to be attested archaeologically at sites on the Comoros beyond a single fragment of possible pig incisor recovered at M'Bachile on Grande Comore, dating to the ninth–tenth centuries (Redding and Goodman in Wright 1984). Evidence for the exploitation of *P. larvatus* (sometimes referred to as *P. porcus*) at coastal sites on the mainland appears to be slightly more common (Table 2). The general absence of suids at sites along the East African coast, particularly after about the ninth century AD, is probably linked to the rise of Islam and its prohibition of the consumption of pork (Blench 2006). This taboo would seem to increase the likelihood that translocations of suids to the offshore islands were carried out at an early date and/or by hunter-gatherers. On Madagascar, the name for wild pig, *lambo*, appears to derive from the Proto-Malayo-Polynesian term for bovine, which, it is suggested, was transferred from the domesticates familiar to Austronesians to the larger pigs of East Africa (Beaujard 1998; Blench 2006).

The appearance of other translocated wild taxa on the islands seems to have been delayed. Helmeted guinea fowl, for example, has only been tentatively identified in deposits pre-dating the eleventh–thirteenth centuries on Madagascar (Radimilahy 1998), but is common thereafter (Rakotozafy and Goodman 2005; see Table 2). On the other hand, Walsh (2007, p. 102) suggests that linguistic evidence supports a translocation of guinea fowl from Africa to Madagascar by the earliest Malagasy settlers. It is thus far absent from assemblages on Zanzibar, Pemba, and the Comoros, even though it appears to have been exploited by mainland communities on the Kenyan coast from the late first millennium AD (Helm 2000). The transfer of the hinged-back tortoise and the rock dove to Madagascar appears to have occurred only in the thirteenth–fourteenth centuries; evidence for this is currently restricted to Mahilaka in the island's northwest (Radimilahy 1998). Meanwhile, the presence of marsh mongoose has not been demonstrated archaeologically on any of the offshore islands, and blue duiker has only been recorded on Zanzibar (Mudida and Horton in prep.); both are notably rare at sites on the mainland (see Table 2).

At a more local scale, there is evidence that a range of endemic Madagascan fauna were moved to the Comoros, beginning in the mid ninth century AD, highlighting the importance of the cultural and maritime link between these islands. These include the common tenrec (*Tenrec ecaudatus*); two species of lemur (the common brown lemur, *Eulemur fulvus,* and the mongoose lemur, *E. mongoz*); and two species of tortoise (the ploughshare tortoise, *Geochelone yniphora*, and the Madagascan big-headed turtle, *Erymnochelys madagascariensis*) (Allibert 1989; Allibert et al. 1989; Allibert and Vérin 1996; Walsh 2007). All species have been recovered at least once from a range of archaeological sites in the Comoros dating to the ninth–tenth centuries AD (see Table 2) (Allibert 1989; Allibert and Vérin 1996; Allibert et al. 1989; Redding in Wright 1992; Redding and Goodman in Wright 1984), although it is unclear whether they were collected by hunting parties travelling to Madagascar by boat, or were actually kept and hunted on the Comoro Islands at this early time (Allibert et al. 1989; Walsh 2007, p. 100). Interestingly, both species of lemur and both species of tortoise are indigenous to the northwestern region of Madagascar (Walsh 2007), which faces the nearby Comoro Islands, and in some cases are not found elsewhere in Madagascar. As noted, this area appears to have been an early zone of trade and interaction between the two regions, and to have provided an important connection between Madagascar and the mainland (also Sinclair 1991; Radimilahy 1998). Indeed, given that initial settlement of the Comoros and northwest Madagascar was more or less contemporaneous, one plausible scenario is that this part of Madagascar was first settled from the mainland via the Comoros. This would make sense in light of the wind and current patterns in the Mozambique Channel, discussed in a previous section. Several of the species that were imported to the Comoros were also exploited at Mahilaka, including tenrec and *Geochelone* from the first occupation phase (ninth–tenth centuries), and lemur and *Erymnochelys* from the thirteenth–fourteenth centuries (Radimilahy 1998).

Recently, is has been suggested that a number of wild species were introduced from the Comoros variously to Mafia, Unguja (Zanzibar) and/or Pemba (Cheke 2011). These include the Comorian flying-fox (*Pteropus comorensis*), introduced to Mafia; the red-headed fody (*Foudia eminentissima*) to Unguja; the grey-headed lovebird (*Agapornis canus*) to Unguja and Mafia; and a gecko species (*Phelsuma dubia*) to Pemba and Unguja, as well as to the Tanzanian coast (Cheke 2011). While it is suggested that the birds might have been translocated in relatively recent centuries by Comorian immigrants, the time periods at which the Comorian flying-fox and gecko species were moved are unknown; indeed, at this stage it is only conjectured that the Comorian flying-fox was translocated at the hands of human agents (Cheke 2011).

The final group of proposed translocations were from Zanzibar to Pemba; species include the tiny musk shrew (*Crocidura fuscomurina*); small-eared greater galago (*Otolemur garnetti*); and Zanzibar red Colobus (*Colobus kirkii*) (Walsh 2007). There is currently no archaeological evidence for the antiquity of this group of translocations, although it is noted that the introduction of Zanzibar red Colobus to Pemba was only very recent (1974) (Walsh 2007). Overall, these various translocations and patterns of wild animal consumption are of interest not only for what they tell us of intra-African anthropogenic species dispersals and the early development of African maritime capabilities, but also, potentially, for what they suggest with regard to Africa's contacts with Southeast Asia. Walsh (2007), in particular, has argued that some translocations and patterns of wild animal consumption in East Africa hint at Southeast Asian practices. The consumption of bats, which occurs, for example, on Pemba, Madagascar and in the Comoros, is a practice widespread among Austronesian speakers in Southeast Asia, including the Barito-speaking Ma'anyan of Indonesian Borneo (Walsh 2007, p. 103). In contrast, bats (and certain other wild animals like terrapin and marine turtles) are not normally consumed by Swahili speakers because their meat is considered haram by Islamic authorities (Walsh 2007, p. 90).

The Azanian Coast and the *Periplus*: Classical Period Contact with East Africa

If much of East Africa's early past, and initial contact with the Indian Ocean world, remains elusive, even to archaeology, some light is nonetheless shed by an alternative source: classical period texts. These provide a view of life on the coast in the late BC/early AD period that seems at odds with what is presented in the archaeological record. Whether this is because archaeological data is simply currently inadequate or because there are problems with the accuracy, dating or interpretation of the texts is at present unclear. Undoubtedly the key, and seemingly most informative, text is the *Periplus of the Erythraean Sea*, widely accepted to date to the first century AD (Casson 1989). It provides a mariner's account of trade activity and ports in the Indian Ocean, and includes discussion of Azania, as the East African coast was known in the classical world (Casson 1989). The work seems to reflect knowledge of the East African coast as far as Zanzibar and possibly the Rufiji Delta and Madagascar, and indicates the presence of a coastal trading port called Rhapta, which scholars have variously located in Kenya or Tanzania. The text describes the trade of iron objects, glass beads, wine and grain in exchange for African ivory, rhinoceros bone and turtle shell. It suggests that Azania, at least in parts, is under the control in some way of Yemen-based authorities, who trade regularly with it, sending large ships. Arab seafarers are said to know the coast and local language well through continual interaction and inter-marriage, suggesting that the trade described in the *Periplus* is already well-established (Horton and Middleton 2000, p. 33). It is clear from the description that offshore islands are inhabited by the first century AD, and that indigenous communities engage in fishing and, as indicated above, make use of both dug-out canoes and sewn boats.

Interpretation of the few passages about Azania, and particularly Rhapta in the *Periplus* has led to significant discussion and debate. The description of coastal topography and provision of sailing times and distances in the *Periplus* has frequently been used to identify the locations of key sites addressed by the work. The island of Menouthias, with its rivers, birds, mountain tortoises and harmless crocodiles (probably large lizards) has been identified as Pemba or Zanzibar (Casson 1980; Horton 1990; Horton and Middleton 2000). Rhapta has been more widely situated, with such locations as the Rufiji Delta, Dar es Salaam, Tanga and the Lamu archipelago being proposed (Chami and Msemwa 1997a; Horton 1990). More controversial still is the interpretation of the description of the inhabitants of Rhapta as 'big-bodied', and the translation of the term *oratoi* that is used to describe them. The problem with the latter is that the term is a *hapax legomenon*, meaning that it does not occur anywhere else in ancient Greek sources (Vansina 1997). This has led many scholars to suggest that the word must be a corruption, the result of a scribe's error. Thus the alternative of *peiratai*, that is pirates, was for many years a popular translation, while more recently *horatai*, translated as inspectors or overseers, has been offered (Wrigley 2010). The term *arotai*, translated as farmers, ploughmen, or tillers of the soil, has been popularised in the Casson edition of the *Periplus* (Casson 1989).

The debate over whether indigenous peoples in coastal East Africa at the start of the first millennium BC practised some form of plant cultivation is one that goes back several decades, and links to arguments about the ethnic groups who initially populated the coast. As mentioned above, the description of 'big-bodied' men has been used to support an argument for the presence of southern Cushitic pastoralists at this time (Casson 1989; Horton 1990; Sutton 1994–1995). The emendation of *oratoi* to mean farmers, however, has been taken to support an early Iron Age Bantu presence already by this period (Chami 1994, 1994–1995). Vansina makes a convincing argument that for various reasons *oratoi* is probably not a corruption, but argues that farming may nonetheless be indicated elsewhere in the *Periplus* (Vansina 1997). He notes the Azania-related passage in the *Periplus* that mentions the import, 'to certain places, [of] wine and *grain* in considerable quantity, not for trade but as an expenditure for the good will of the Barbaroi' (Vansina 1997, p. 396; italics ours). If grain were imported for the consumption of the long-distance traders, Vansina argues, then we might expect a passage in the *Periplus* like the one that refers to south India: '… grain in sufficient amount for those involved with shipping, because the [local] merchants do not use it' (Vansina 1997, p. 396), though this seems debatable. Also in support of the view that farming was practised on the coast at the time of the *Periplus* is the argument put forward by Horton and Middleton (2000, p. 33) that the Pyralaoi Islands mentioned in the text (which they suggest might be the modern Lamu archipelago) may have been so named because they were being cleared for farming when first seen (and thus appeared to be 'on fire'). This is an interesting possibility that might be testable through a palaeoenvironmental coring programme on these and other East African offshore islands. Certainly the import of iron is no indication that local communities were not iron-producing, since the *Periplus* describes Iron Age societies elsewhere that nonetheless import iron goods (Mitchell 2005). An Early Iron Age agricultural presence on the coast is thus a possibility and would fit with the earlier, if still unconfirmed, dates that have been proposed recently for the beginning of the EIA (see discussion above). As Horton and Middleton (2000, p. 38) note, the chronology for the EIA is mainly based on just a handful of radiocarbon dates processed in the early days of radiocarbon testing and with an error margin sufficiently large to permit habitation back to the BC/AD transition. On the other hand, we should not rule out the possibility that *Periplus*-era trade simply involved exchange with foraging and fishing peoples of the East African coast, who would certainly have been able to provide the various exports mentioned in the first century guide.

Other historical sources also address Azania, though in less detail. Ptolemy's second century AD *Geography* mentions Rhapta, albeit providing a different description of its setting, as well as the island of Menouthias, now located far to the south, perhaps in the region of present-day Madagascar (Horton and Middleton 2000, p. 36). Classical knowledge of the East African coast subsequently appears to decline, however, and the next reference is not until the sixth century account of Cosmas Indicopleustes, where passing reference is made to Zingium, which is almost certainly the East African coast (Horton and Middleton 2000, p. 37). Given the evident earlier classical knowledge of the region, it is surprising that archaeology has so far been largely silent in corroborating the contacts suggested in these accounts. Attention has frequently been drawn to finds of Greek/Roman coins on the coast, but as Horton and Middleton have noted, further investigation inevitably reveals that these are either unprovenienced stray finds, or components of collections that also contain younger coins (Horton 1996a, b; Horton and Middleton 2000, p. 32).

More recently, archaeological excavations have begun to turn up occasional (if still rare) stratigraphically situated trade finds that relate to pre-Swahili trade. For example, fifth or sixth century AD deposits from the site of Unguja Ukuu in southern Zanzibar have yielded two sherds of apparent Mediterranean pottery, as well as blue-green glazed Sassanian–Islamic wares (Juma 1996; Horton and Middleton 2000; interestingly the earliest black rat remains identified to date on the East African coast also derive from these deposits; see discussion below). At the site of Fukuchani, on the northern coast of Zanzibar, fragments of Mediterranean pottery, in this case amphorae, probably dating to the fifth century, have also been unearthed (Horton and Middleton 2000, p. 32). Meanwhile, further down the East African coast, the site of Kivinja, located 20 km north of the Rufiji Delta, has yielded radiocarbon dates spanning the fifth and sixth centuries AD, and fragments of glassware suggested to be comparable to finds from the Graeco-Roman site of Fayum in Egypt, as well as sherds of a type of green and blue-glazed pottery produced in the Middle East from the third century AD (Chami and Msemwa 1997a) and considered similar to pottery from the Ras Hafun Main site (Horton and Middleton 2000, p. 32; see below). Another Rufiji site, Mkukutu, has yielded four beads suggested to be Roman and dated by radiocarbon to somewhere in the mid third–sixth century AD range (Chami 1999). In southern Mozambique, the basal levels of the coastal site of Chibuene have yielded a sherd of green-glazed ceramic that is argued to parallel ceramics found at the Ras Hafun site, as well as the trading site of Sohar on the coast of Oman (Sinclair et al. 1993). As celebrated as these finds have been, however, it should be emphasised that they represent a time period later than that described in the *Periplus*. Most of the finds date to the fifth and sixth centuries AD, and even some of these are problematic. For example, the identification of the Mkukutu beads as Roman has been strongly critiqued (Wood 2011, pp. 24–25), and both the dates and the stratigraphic integrity of the site need to be looked at critically in light of the fact that all dated levels give the same radiocarbon ages, which are derived from unidentified charcoal. Evidence for later occupation phases in the overlying layers at both Kivinja and Mkukutu raises the distinct possibility that some of these 'early' finds represent contamination from younger levels. Thus, the first definitively foreign objects found on the East African coast in stratified and well-dated contexts do not appear to date to earlier than the fifth, and more probably sixth, century AD.

The best evidence for classical period trade on the Azania coast comes, then, not from its central and southern regions, but rather its northern flanks. Here, on the Horn of Africa in modern day northern Somalia, Chittick excavated two sites at Ras Hafun (Chittick 1976, 1979; Horton and Middleton 2000; Smith and Wright 1988), which may represent the site described as Opone in the *Periplus* (Horton and Middleton 2000). As Horton and Middleton (2000) summarise, Hafun West contained pottery from the Eastern Mediterranean, the Nile Valley, Mesopotamia, and India, and was occupied from the first century BC into the early first century AD. The Hafun Main site was larger and occupied in the second and third centuries and again in the third and fifth centuries. The pottery from this latter site indicates a shift in the trade axis, since during both phases of its occupation the majority of the imports came from the Persian Gulf, accompanied by a small quantity of Indian wares, plausibly via the Gulf as well. There is very little Red Sea or Mediterranean material to be found in this phase.

Overall, however, and particularly south of the Horn, there is a notable paucity of evidence for Indian Ocean trade prior to the well-documented rise of the Swahili trading cultures from the seventh century AD. What this lack of evidence means is not yet clear. It may reflect inadequate survey and excavation, especially given that sites of this period may have been far fewer and far more ephemeral than those of the later first millennium AD. Wright has suggested that prosperity came to East African coastal settlements only periodically prior to 800 AD (Wright 1993), so it may be that the earliest East African coastal trading sites were infrequent developments that were not occupied over long periods. Horton and Middleton (2000) have additionally argued that the still elusive Rhapta may not have had any fixed location, being instead simply the term used to describe whatever location was then most prominent for the exchange of goods between local inhabitants, in their sewn boats, and foreign traders. It has also been noted that trade with the East African coast was far more straightforward for Arab traders than for those from the Red Sea/Mediterranean world (Horton and Middleton 2000, p. 37), and indeed this is backed up by the *Periplus*. It may thus be inappropriate to expect any more significant quantity of Graeco-Roman material culture than the coast has so far yielded. On the other hand, early evidence for contact with the Arabian Peninsula or Persian Gulf is equally lacking, and this does seem at odds with what is described in the *Periplus*. Perhaps tellingly, the recent discovery of another once elusive *Periplus* site—Muziris on the southwestern coast of India (Cherian et al. 2009; Shajan et al. 2004, 2008)—demonstrates how difficult it can be to trace even large trading ports with rich remains in the fertile tropics. The much smaller-scale and less intensive trade on the East African coast, which involved exchange with small-scale, stateless, and potentially semi-sedentary or quite mobile societies (of either early farmers or, as seems increasingly possible, foraging and fishing groups) is unlikely to have left any significant remains. Understanding of the earliest phase of Indian Ocean trade on the East African coast can but be improved by more systematic survey, sampling and dating in the coming decades.

The Arrival and Spread of the Black Rat

Interestingly, in light of the links described in the *Periplus* and the remains from sites like Ras Hafun, evidence for contact with the Arabian Peninsula and Gulf region appears to be present in the genetic signatures of several commensal species in eastern Africa. While these genetic links may simply reflect later Swahili coast trading connections, the possibility of earlier connections should also be entertained. While data remain extremely limited for many key regions, the patterns—both genetic and archaeological—as they are currently known are worth considering.

Commensal animals are those that are adapted to a human-created niche—the species of rats, mice and sparrows that thrive in towns and cities are well-known examples. Commensal species, which often 'hitch-hike' with human travellers, are useful to archaeologists because they act as 'bioproxies', providing insights into shared geographical movements and migrations (Jones et al. 2013). In Africa, neither the black rat nor the house mouse is native; the introduction of these commensals into the continent therefore offers clues to ancient contacts, trade activities and migration events. Of the two species, the black rat (*Rattus rattus*) is the more commonly found on African archaeological sites. The earliest evidence for the black rat in Africa comes from the Egyptian site of Tell el-Dab'a, and dates from the seventeenth–sixteenth century BC (Middle Kingdom) (Boessneck 1976), though the contextual integrity of the remains has been questioned in light of the burrowing habits of rats (Armitage 1994; Ervynck 2002). Black rats were apparently nonetheless widespread in Egypt by the Ptolemaic period (fourth to first century BC), as attested by the presence of their remains in the stomachs of mummified raptorial birds at a number of ceremonial centres (Lortet and Gaillard 1903, cited in Armitage et al. 1984). Roman period remains have been found at Quseir el-Qadim (Myos Hormos) on the Red Coast, where the remains of at least six rats were found in the stomach and faecal contents of a mummified cat in a context dating to the first or second century AD (von den Driesch and Boessneck 1983). At this time, Quseir el-Qadim was a flourishing harbour town with close mercantile ties to the Indian spice trade (Armitage et al. 1984). There are few other archaeological reports of black rat outside northeastern Africa prior to the late first millennium AD, when it becomes widespread at sites along the East African coast.

Black rat first appears in the archaeological record of the East African coast at the site of Unguja Ukuu on Zanzibar, where it is recorded from the first occupation phase (sixth–mid eighth century AD). It also appears in the early habitation levels at sites in Lamu, including Shanga (Horton and Mudida 1996) and possibly also Pate (Wilson and Omar 1997), which date from the mid–late eighth century AD. The absence of black rat from the nearby, contemporaneous site of Manda is probably an artefact of sampling methods, as bones were collected by the workmen as they excavated, rather than by sieving (Chittick 1984), and this would easily bias the faunal assemblages against fragments of small rodents. Black rat appears at a similar time period further down the Kenyan coast, where it is first documented at Chombo in the coastal hinterland between the late eighth and the tenth century AD (Helm 2000). The earliest *R. rattus* finds on Pemba are at Chwaka, where they occur from the late thirteenth–early fourteenth century AD (Fleisher 2003). Faunal reports have not been published for the late first millennium AD Pemban sites of Tumbe and Kimimba, where rat might also be expected to occur, given its earlier presence on nearby Zanzibar. Archaeological evidence from Mahilaka on Madagascar (Radimilahy 1998), as well as sites such as Dembeni on the neighbouring Comoro island of Mayotte (Allibert et al. 1989; Redding and Goodman 1984), supports the suggestion that the black rat may have arrived in Madagascar with the first urban settlers (Duplantier et al. 2003; Hingston et al. 2005); however, it is notably absent from contemporaneous ninth–tenth century middens on the islands of Anjouan and Grande Comore, at least until the eleventh–twelfth century (Redding and Goodman 1984; Redding 1992). Its absence from recently excavated sites in the Andaroy region of southwest Madagascar (Parker Pearson 2010) may reflect the generally poor preservation of faunal remains, which appeared to favour larger, more robust skeletal elements overall (e.g. sheep/goat and cattle).

Rat occurs in archaeological sites in southern Africa from the eighth century AD, including at Bosutswe in Botswana by c. AD 700 (Plug 1996); Pont Drift in the northern Limpopo Valley between the eighth and twelfth centuries AD (Plug 2000); and perhaps most surprising, Ndondondwane in the inland valleys of KwaZulu-Natal, South Africa, also by the eighth century AD (Voigt and von den Driesch 1984). Interestingly, domestic chicken (*Gallus gallus*) co-occurs with black rat at many of these sites, suggesting that the two may have been introduced to the east coast and subsequently spread into southern Africa at about the same time (see discussion below). Indeed, the presence of *Rattus* at a range of southern African sites from the late first and early second millennium AD is seen to reflect trade links with communities on the east coast (see, for example, Armitage 1994, p. 235; Plug 2000).

While archaeology can provide evidence as to the timing of the arrival of the black rat on the East African coast, it does not enable us to distinguish between the various possible source populations; for this we must turn to genetic analyses. At present such studies are limited, and results accordingly preliminary. Work on the phylogeography of the Pacific rat, *Rattus exulans*, which has been successfully used as a proxy for studying the early movements of human populations in the Pacific (Matisoo-Smith and Robins 2004), nonetheless hints at the kinds of insights that will eventually be possible. For the moment, analyses of East African samples are extremely limited but more work has been conducted on Madagascar rats. This indicates that of the two varieties of *R. rattus*, each bearing a different number of chromosomes—the Asian cytogenetic group with $2n = 42$ and the Oceanic group with $2n = 38$ (Baverstock et al. 1983; Yoshida 1980)—only the Oceanic type is found on Madagascar (Duplantier et al. 2003; see also Aplin et al. 2011). This lineage is native to south India, and is also found in the Mediterranean and northern Europe, a pattern that has been hypothesised to reflect Roman period trade between south India and the Red Sea region (Armitage 1994; see also Ruffino and Vidal 2010). Initial mitochondrial DNA studies also support an ultimately Indian-subcontinent ancestry for the black rats of Madagascar, as well as a low degree of genetic diversity, probably due to a bottleneck or founder effect (Hingston et al. 2005). Subsequent sampling of populations from the East African coast and the Arabian Peninsula also relates Madagascar populations of *R. rattus* to those on the Arabian Peninsula; mtDNA haplotypes from both India and Oman were all found in basal positions of the phylogenetic tree for samples from the Arabian Sea region (Tollenaere et al. 2009). This pattern fits with an introduction of south Indian-derived black rats via the Arabian Peninsula, with archaeological findings suggesting this occurred in the latter half of the first millennium AD. Another finding was that western Indian Ocean islands showed distinct *R. rattus* genetic compositions, suggesting different colonization histories; in particular, haplotypes from Madagascar and the Comores group separately, suggesting independent colonization events (Tollenaere et al. 2009).

The apparent tidiness of the genetic story outlined here is belied by several complicating factors. Sample numbers for most genetic studies remain disappointingly low, and geographic coverage is furthermore inadequate. Entire countries or regions are sometimes represented by a dozen samples, or even just one or two. Another caveat is that commensals like the black rat would have been regularly transported around the Indian Ocean, and the make-up of rat populations in ports would reflect this; rat colonisations of East Africa and Madagascar may therefore have derived, at least partially, from these intermediary sources (Searle 2008). Geneticists are also interpreting their data in the light of inadequate knowledge of the archaeological and historical data. Tollenaere and colleagues, for example, state that no archaeological remains of *R. rattus* have been found in East Africa and that it was only introduced to South Africa within the last 100 years (2009, p. 405). Our summary of the evidence shows both statements to be inaccurate.

Rats are an invasive species and have had significant detrimental effects on a variety of ecosystems and human societies worldwide; the history of their presence in eastern Africa is therefore of interest across a broad range of disciplines. As adept climbers that are capable of attacking both birds' nests and reptiles, anthropogenically introduced black rats have significantly altered the natural environments of a range of western Indian Ocean islands (Cheke 2010; Goodman 1995). *R. rattus* is also the main reservoir for the bubonic plague, which still claims lives in Madagascar and East Africa (Duplantier et al. 2003). It has been suggested that the Justinian Plague of AD 541–767, which swept through the eastern Roman Empire, may have derived ultimately from a source in eastern Africa, travelling with ship rats on ivory-carrying boats (e.g. Horton and Middleton 2000, p. 37). Recent genetic studies, however, place the origin of the bubonic plague in China, and suggest that it spread to other regions on multiple occasions (Morelli et al. 2010). These phylogenetic studies of *Yersinia pestis* may indicate that the Justinian Plague reached the Roman Empire via a Silk Road route of transmission instead (Morelli et al. 2010).

The Spread of the House Mouse

The house mouse, *Mus musculus*, is another key commensal species that is native to neither East Africa nor Madagascar, and appears likely to have been introduced to the area by maritime routes. The commensal house mouse is widespread globally, but native only to Eurasia and North Africa. It is divided into a number of lineages (which are variously defined as either separate species or sub-species): *domesticus* in Western Europe, North Africa and the Middle East; *musculus* in Eastern Europe and northern Asia; and *castaneus* in Southeast Asia (Boursot et al. 1996; Prager et al. 1998; Cucchi et al. 2005; geographic ranges vary amongst scholars, probably because they have been inadequately studied). The status of a fourth lineage, *bactrianus*, focused on south-central Asia (from Iran to northern India), is debated; it may be a variant of *castaneus*. More recently, an additional lineage, *gentilulus*, has been defined from samples from Yemen (Prager et al. 1998). On the basis of morphometric criteria, this lineage may extend across the whole of southern Arabia and into the western Gulf region (Harrison 1972) and beyond, though genetic studies have not yet been done to clarify its distribution.

Relevant for understanding Indian Ocean maritime contacts has been the recent discovery that house mice on Madagascar are of the *gentilulus* lineage (Duplantier et al. 2002). These mice exhibit limited genetic variability, suggesting a recent and possibly single origin (Duplantier et al. 2002). Whether this suggests a direct connection with the Arabian Peninsula, or, more likely, a route via the East African coast, currently remains unknown because mice in East Africa have not yet been sampled. A recent report summarising biodiversity for the Ngezi-Vumawimbi Forest on Pemba Island identifies the presence of *Mus musculus* of the *gentilulus* variety, albeit without any data to support this nomenclature (see Nahonyo et al. 2005). It would certainly not be surprising to find *gentilulus* on the East African coast in light of the Madagascar finding and the region's long history of Arabian contacts.

Given the centrality of Iran and its ports (such as Siraf) in later Swahili coast trade (see below), it is perhaps surprising that mice of the *domesticus*, *musculus* or *castaneus* lineages (all documented in Iran; see Prager et al. 1998) are not documented on Madagascar, where only *gentilulus* has so far been identified. Egyptian links (e.g. with the Fatimids) also appear not to be represented, since Egyptian commensal mice are of the *domesticus* variety (Ferris et al. 1983; Prager et al. 1998). The apparent strong southern Arabian signature for

Madagascar mice is interesting in light of the marked southern Arabian, and specifically Yemeni, trade and intermarriage links with East Africa described in the *Periplus*, and might suggest the possibility of a classical period translocation of the species. However, further study may demonstrate that there is actually a wider array of *Mus* lineages represented on the mainland than on Madagascar and that the reduced variety on the island is a result of a population bottleneck. Until *M. musculus* is genetically sampled over a wider geographic area, including the East African coast and the rest of the Arabian Peninsula and Gulf region, interpretations of the preliminary mouse genetic data will remain speculative at best.

As with the black rat, the earliest known *M. musculus* remains in Africa are from the site of Tell el-Dab'a in Egypt, dating to c. 1750 BC (Boessneck 1976); these have been identified as belonging to the subspecies *praetextus* (i.e. *domesticus*). Like the rats, their contextual integrity may be questionable owing to the potential for burrowing. No other finds are reported in Africa until the late first millennium AD, when evidence emerges around the East African coast (Table 2). Even there, however, evidence is relatively minimal, being restricted to finds of only five individuals at two sites: a single incisor recovered from a ninth–tenth century midden deposit at the site of M'Bachile on Grande Comore (Redding and Goodman 1984), and the remains of four individuals found at Mahilaka in northwest Madagascar, only one of which dates from the first occupation phase (ninth–tenth century) (Radimilahy 1998). Tentative finds have also been reported from the first occupation phase (sixth–mid eighth century AD) at Unguja Ukuu (Juma 2004), while remains of both *M. musculus* and *R. rattus* from Andrahomana Cave in the southeast of Madagascar, dating to between the third and the second millennium BC, are considered dubious owing to possible stratigraphic mixing (Vassy and Burney 2007; cited in Blench 2007a).

Interestingly, there are as yet no reported *M. musculus* finds from any mainland sites on the East African coast, including those where substantial faunal assemblages have been recovered, such as Shanga (Horton and Mudida 1996) (Table 2). Whilst absence should be treated cautiously, especially given the extremely low frequency at which *M. musculus* occurs overall, the archaeological data would seem to support a mid–late Iron Age introduction of the house mouse to Africa via Madagascar and the Comoros. This might imply a direct Southeast Asian introduction that is in contrast to the genetic patterns discussed above, although a direct introduction by Arab ships is also possible. On the other hand, the low frequency of mouse at archaeological sites on the East African coast could also reflect their competitive exclusion from sites by rats, which are the dominant rodent species and appear archaeologically to be both much more widespread and much more abundant than *M. musculus*. Numerous studies have shown that *M. musculus* populations are negatively affected by the presence of *Rattus*, which forces them out of 'shared' habitats and into refuge areas, thus affecting their presence and density in favoured niches, such as resource-rich, urbanised settlements (e.g. Harper and Cabrera 2010; Yom-Tov et al. 1999).

The Emergence of Urban Settlements on the Swahili Coast

As hinted at previously, the second half of the first millennium AD saw the emergence of a new cultural phenomenon in East Africa, characterised by the rise of increasingly urbanised and culturally distinctive settlements focused very tightly on the coast. With the beginnings of what has become known as the Swahili culture from around the seventh century AD (Horton and Middleton 2000), we enter a period that is far better studied than any that preceded it. Understanding of this culture, which has links to contemporary peoples inhabiting the East African coast, not only draws upon more abundant and systematic archaeological investigation, but is assisted significantly by historical, ethnohistorical and ethnographic findings. The Swahili cultural region is linked by a shared language, belonging to the Bantu language family, called Kiswahili, and a widely shared religion, Islam. At its maximum range, the cultural region extended along the coast from Somalia to southern Mozambique, including the islands of the Lamu archipelago, Pemba, Zanzibar, Mafia, the Comoros and the northern tip of Madagascar (LaViolette 2008).

The origins of the Swahili have been a significant source of contention (Abungu and Mutoro 1993; Horton 1996a, b; Robertshaw 2003; Spear 2000). The Swahili have long stressed differences between themselves and their neighbours, emphasising putative descent from Arab and Persian immigrants to the East African coast (Abungu 1989; Allen 1993; Chami 1994; Horton and Middleton 2000; Kusimba 1999; Spear 2000). The notion of the Swahili as foreign transplants (e.g. Kirkman 1964) should also be seen in the context of racist notions of Africa as incapable of producing anything like the urbanised and worldly societies of the East African coast. Early archaeological research suggested that Swahili towns and styles emerged abruptly in the eleventh and twelfth centuries, with no known local antecedents (Spear 2000). Similarly, early linguistic studies emphasised the large number of Arabic terms in Swahili, and the fact that it was written in Arabic script (Spear 2000). Past decades have, however, seen significant reconceptualisations of Swahili origins across a range of disciplines. Archaeological work has demonstrated that Swahili towns have clear indigenous roots (e.g. Horton 1996a, b; Horton and Middleton 2000; Kusimba 1999), while linguistic studies have shown that Swahili is definitely a Bantu language, both structurally and lexically, with borrowing from Arabic limited largely to certain cultural fields, and occurring relatively late in the development of the language, when Arab influence was stronger (Nurse and Spear 1985; Spear 2000). It is now clear that Swahili settlement on the coast extends back to the seventh century AD, and the view that these Middle Iron Age sites can be linked to Early Iron Age occupation in the coastal hinterland and coast is becoming increasingly prevalent (e.g. Chami 1994; Chami and Msemwa 1997a; Helm 2000). A picture of long-term cultural continuity is finally beginning to emerge for the East African coast, though further research is needed in order to understand fully the inter-relations between what, as we have noted, increasingly appears to be a mosaic of farmers, pastoralists and hunter-gatherers in the region in the first millennium AD (Helm 2000; Helm et al. 2012; Horton and Middleton 2000).

Whatever their precise origins, its is clear that by the seventh century, Swahili settlements had begun to emerge on the coast and offshore islands, as attested through archaeological work at sites like Shanga, Unguja Ukuu, Tumbe, Kilwa, and Chibuene. These villages were occupied by people who grew pearl millet and other crops (Walshaw 2005, 2010), and who also drew upon marine resources and kept chickens, and later other domesticates like sheep, goats and cattle (Horton and Mudida 1993; Horton 1996a). They built houses of earth, wood and thatch, and lived in permanent villages (Horton 1996a; Horton and Middleton 2000; LaViolette 2008). They also worked iron, crafted beads out of shell, and produced a triangular incised pottery known as Tana ware, the form and surface decoration of which remains similar from the Lamu archipelago down to the southern coast of Mozambique (Horton and Middleton 2000; LaViolette 2008; Sinclair et al. 2012; Wright 1993; Fleisher and Wynne-Jones 2011). On the Comoro Islands, this phase has become known as the Dembeni period (Wright 1984, 1993). The same type of Tana ware is found on these islands, at sites with mud-plastered pole-and-bamboo houses ranging in size from small hamlets to large villages of 5 ha (Wright 1984, 1993). Madagascar displays a different ceramic repertoire at this time, but a variety of sites that are otherwise similar in scale and economy (Wright 1993).

Evidence for Islamisation in this early period is present, but variable (Wright 1993; Horton 1996a, b; Horton and Middleton 2000), arising initially in some settlements and not others, and also probably initially amongst elites as a means of promoting trade with the Arab world (LaViolette 2008). Apparent from the earliest Swahili settlement phases, however, is evidence for significant Indian Ocean trade activities (Wright 1993). The presence of the remains of Sassanian Islamic ware, white-glazed bowls, sometimes with splashes of blue, green or lustre glaze, from the Near East, and even small quantities of Chinese pottery suggests that traders visited the East African region, offering craft products from the Middle East and lands beyond (Chittick 1984; Horton and Middleton 2000; LaViolette 2008; Sinclair et al. 2012; Wright 1993). Glassware (probably transporting perfume and oils), stone and glass beads from the Gulf, India and beyond, fine metalwork, and probably other organic goods like textiles, perfumes and incense were all imported as well (Chittick 1984; Horton and Middleton 2000; LaViolette 2008; Wright 1993). Trading at this time was primarily with the Gulf, in particular the ports of Sohar and Siraf (Horton and Middleton 2000). Exotic items that flowed through these ports from across the Arab world, Persia, and on occasion further afield were drawn upon by the Swahili to create an increasingly distinct identity (Horton and Middleton 2000; LaViolette 2008). In exchange for these goods, Africa exported tortoise shell products, pearls, rhinoceros horn, ambergris, and items of chlorite-schist, but of particular value were ivory, timber (from mangrove forests) and slaves (Horton and Middleton 2000; Wright 1993). The Swahili operated at the intersection of two vast trading spheres, enabling and encouraging the movement of goods between the African interior and coastal hinterland on the one hand, and the Indian Ocean world on the other. The increasing intensity of this trade helped to fuel the growing wealth on the coast, and encouraged the formation of numerous urban centres from the ninth and tenth centuries onwards (Horton and Middleton 2000; LaViolette 2008). During the tenth century, the trade axis may have shifted back to the Red Sea; Gulf coins from this period are absent (Horton and Middleton 2000). The Egyptians under the Fatimids sought in particular gold, ivory and rock crystal from East Africa (Horton and Middleton 2000).

The post-1000 AD period on the Swahili coast saw a number of significant changes. Settlement patterns became more hierarchical, and settlements increased in size, perhaps due in part to depopulation of the countryside (Fleisher 2003). Building in coral began, a practice apparently derived from methods employed in the Red Sea (Horton and Middleton 2000). This material was initially used primarily in constructing mosques and other important buildings, but eventually characteristic ‘stone towns’ were being built on the Swahili coast (Horton and Middleton 2000). From the eleventh century, there is good evidence for the widespread adoption of Islam (Wright 1993). This appears to be linked to the assumption of new culinary patterns (Fleisher 2010a), including a new focus on rice-based dishes (Walshaw 2010; as discussed below). Cotton and coconut also became important crops; cotton was produced locally as well as imported from India, while coconut products were increasingly used for food, fibre, tools and potentially fuel (Walshaw 2010; Horton 2004). The consumption of fish seems to have increased at this time (Horton and Mudida 1993). Sheep/goat and cattle appear in the faunal record from the ninth century, but are present in significant quantities only from the eleventh century (Horton and Mudida 1993).

The decline of centralised authority in the Muslim world from the eleventh century altered patterns of trade in the Indian Ocean, enabling the entry of new groups and leading to a shift from long oceanic voyages to regional networks linked by entrepôts (Horton and Middleton 2000). According to Horton and Middleton, the Swahili were able to exploit these new patterns by playing off different trading partners at their regional entrepôts (Horton and Middleton 2000). The period accordingly saw a significant increase in imports of Indian and Chinese ceramics, probably via the Gulf (Horton and Middleton 2000; Horton 2004). Archaeological evidence from imported ceramics furthermore suggests that towns varied in terms of their Indian Ocean links, with different ports favouring Gulf, Indian or southern Arabian merchants (Horton and Middleton 2000; also Wright 1993). Also serving to increase trade was the explosion, between the tenth and thirteenth centuries, in the use of ivory in Europe; this was to be supplanted by gold as the key commodity (Horton and Middleton 2000; Mitchell 2005). From the fifteenth century, there was a decline in the Islamic trade with East Africa, which was replaced by Indian trade, leading to the establishment of Indian trading communities in Swahili towns like Malindi, Mombasa, Kilwa and Pate (Horton and Middleton 2000; Horton 2004).

Overall, it is clear that with the advent of Swahili settlement on the coast, East Africa finally became fully integrated into Indian Ocean trading systems. The timing of this integration can be linked to wider Indian Ocean economic and political patterns. While commerce in the western Indian Ocean likely contracted in the first half of the first millennium AD, the rise of Islam from the seventh century, and the Arab conquests and rapid demographic diffusion and political integration of Egypt, Syria, Iran and North Africa, created a new extremely powerful zone of economic consumption (Chaudhuri 1985, p. 36). The growth of the great Islamic urban centres, and the ability of Islamic rulers to offer protection to traders and merchants all helped to increase the flow of a variety of commodities and exotic goods in Islamic lands. Pendulum shifts in trade volume through the Red Sea and Persian Gulf were linked to the relative importance of certain political and cultural capitals in the Islamic world (Chaudhuri 1985, p. 45), which in turn probably helped to produce shifts in the balance of particular regions and towns along the Swahili coast. At the same time, Swahili demand for goods and African agency also helped shape patterns of trade in ways that are only more recently beginning to be investigated (Presholdt 2008). As Islamic maritime supremacy waned, East Africa benefitted from more complex trade patterns involving a wider variety of players (Horton and Middleton 2000). Swahili communities continued to thrive through Portuguese expansion and the initial phases of Omani colonization, declining only in the nineteenth century with the abolition of the slave trade and the emergence of new forces as part of East Africa's entry into a wider world trade system (Horton and Middleton 2000).

Arrival of the Chicken to East Africa

The emergence of the Indian Ocean-oriented trading culture of the Swahili along the East African coast probably encouraged the translocation of a number of new species into the region. One possible example is the chicken. Domestic chickens (*Gallus gallus*) are originally a South and Southeast Asian species (Clutton-Brock 1993); they were domesticated several times (Kanginakudru et al. 2008), including in the Indus Valley by the third millennium BC and possibly in Neolithic China.

As with the black rat and house mouse, the earliest evidence for domesticated chicken in Africa comes from Egypt. The earliest reported osteological finds are from an 18th Dynasty (c. 1567–1320 BC) context in Thebes (Darby et al. 1977); however, these have been disputed upon re-examination (MacDonald and Edwards 1993). Pictorial evidence, in the form of a painted limestone fragment featuring a cock, nonetheless similarly suggests the presence of the domesticated chicken in Egypt by the New Kingdom period (possibly 19th Dynasty). MacDonald and Edwards (1993) appropriately emphasise the rarity of these early finds, however, noting that the chicken in pre-Ptolemaic Egypt was in all likelihood a rarely encountered 'exotic'. Definite osteological evidence of the domestic chicken in Egypt does not appear until the beginning of the Graeco-Roman period, and even then ritual and symbolic uses may have been more important than consumption (MacDonald and Edwards 1993).

The finding of domestic chicken remains of a single individual in a ritual context at Qasr Ibrim, dating to the late fifth century AD, suggests a possible Nile corridor route of dispersal for the chicken into sub-Saharan Africa (MacDonald and Edwards 1993). The earliest finds of domestic chicken from sub-Saharan Africa to date come from the sites of Kirikongo in Burkina Faso (sixth century AD, possibly as early as first century AD) (Dueppen 2011), and Jenne-Jeno in Mali, where the species first appears in a phase dating to AD 450–850 (MacDonald 1992), although it has been suggested that the latter finds most likely date to the eighth or ninth century AD (Dueppen 2011, p. 149). The earliest find of domestic chicken in the Swahili coast region comes from Unguja Ukuu, from deposits dating to the sixth—mid eighth century AD (Juma 2004) and possibly earlier (Mudida and Horton in prep.). Chicken is well established at a range of sites across the region by the eighth–ninth century AD (see Table 2), including Shanga, Manda and Pate in Lamu, Dembeni in the Comoros, and Mahilaka on Madagascar. An earlier finding has been suggested by Felix Chami for the site of Kuumbi Cave on Zanzibar (Chami 2001a, b), but further analysis of the remains refutes this identification (Paul Sinclair, pers. comm.). Interestingly, both *Gallus gallus* and *Rattus rattus* consistently appear together from their earliest occurrence at several East African sites—for example, Shanga (Lamu, late eighth century AD); Chombo (Kenya hinterland, late eighth–early tenth century AD); Chwaka (Pemba, eleventh–fifteenth century AD); Dembeni (Comoros, ninth–tenth century AD); and Mahilaka (Madagascar, ninth–tenth century AD)—suggesting that they may have been introduced together and by the same mechanism. If we accept that *Rattus* was a ship-borne introduction, then it seems plausible to attribute the earliest chicken remains in East Africa to a coastal route of introduction. The presence of both taxa at a number of sites on the coast and islands dating from the mid–late first millennium AD, as well as several sites in southern Africa at a similar time (see Plug 2000), suggests an Iron Age influx resulting from intensifying Indian Ocean trade. The introduction of chicken to the East African coast might reflect contact with northeastern Africa, though the Arabian Peninsula, Persian Gulf, South Asia or Southeast Asia are also plausible sources.

Recent analysis of mtDNA from modern chicken stock in East Africa (Kenya, Ethiopia, Sudan and Uganda) suggests the presence of significant genetic diversity and multiple origins for domestic chicken in this region (Mwacharo et al. 2011). Five genetically distinct mtDNA D-loop haplogroups have been identified, with haplogroups A and D being the most common (B and C are rare and probably represent introgression of commercial haplotypes, while the origins of E remain unclear) (Mwacharo et al. 2011). The oldest and most diverse haplogroup is D, of South Asian origin; it is found in all four countries and has also been found in chickens from West and southern Africa, including Madagascar (Adebambo et al. 2010; Muchadeyi et al. 2008; Razafindraibe et al. 2008). It is difficult to say by what route this haplogroup reached East Africa, given the paucity of samples from many areas of Africa, although on the basis of zooarchaeological finds, as discussed above, a maritime route seems most plausible. An Iron Age arrival, coincident with the emergence of the Swahili trading culture on the East African coast, seems most likely, based on the faunal evidence, though a somewhat earlier arrival, via the classical period Red Sea/Arabian trade with Azania, is also possible (though not yet supported by any archaeological evidence) and would fit with the genetic evidence as it now stands.

The A haplogroup, meanwhile, is of East or Southeast Asian origin (Mwacharo et al. 2011). It was only found in Kenya in the Mwacharo et al. (2011) study, but has also been identified in samples from Zimbabwe and Madagascar (Muchadeyi et al. 2007; Razafindraibe et al. 2008). It is, however, so far absent from western Africa (Adebambo et al. 2010). It is argued from the distribution patterns that the A haplogroup reached Kenya via a maritime route (Mwacharo et al. 2011), and it has been speculated that it reflects Austronesian influence on Madagascar, where the haplogroup is dominant (Razafindraibe et al. 2008). It is linked to the fighting cocks of the Indonesian archipelago (Blench 2006; Razafindraibe et al. 2008), and suggests that chicken diversity in East Africa derives from multiple sources of Indian Ocean contact, including perhaps trans-oceanic contact with Southeast Asia.

Southeast Asian Contacts

Along with clear Arab influences on the East African coast, we also find indications, as the chicken genetic findings may suggest, of another key strand of interaction. This other link, particularly apparent on the island continent of Madagascar, is with Southeast Asia. The recognition of a Southeast Asian element in Malagasy culture and, particularly, language, goes back to at least the sixteenth century (Allibert 2008), but it was the pivotal demonstration by the linguist Dahl (1951) of the close links between Malagasy, the language spoken on Madagascar, and Maanjan, which belongs to the Southeast Barito group of languages of Southeast Kalimantan (Borneo) (Dahl 1951), that set the stage for subsequent research into Austronesian dispersals to Madagascar. These dispersals have long fascinated scholars, not only because they must have involved a significant maritime journey, but also because the lack of any historical record of their occurrence suggests that the journey, or series of journeys, happened a very long time ago.

Beyond language, however, a variety of other sources of evidence also attest to Austronesian presence, or at least influence, in Madagascar and beyond. Allibert (2008) summarises a number of cultural elements that are shared between Madagascar and the Austronesian world, including the special role of the maternal uncle in a child's rites of passage, secondary burial, the link between the number eight and death, the use of the canoe as a coffin, and the ritual pairing that associates a child with a reptile. As outlined earlier, Walsh (2007) has similarly highlighted various animal translocations and hunting practices on the Comoros, Madagascar and other islands of East Africa that suggest Austronesian influence in the region. Various material culture similarities reinforce this impression, in particular as regards maritime technology and musical instruments, as first noted over a century ago (see review by Blench 1996). The stick zither and leaf-funnel clarinet, for example, appear to represent Austronesian introductions to Africa, whereas the higher diversity of xylophone types in Africa compared to Indonesia would seem to suggest an ethnomusicological dispersal in the other direction (Blench 1996). The maritime technological similarities are most apparent in the use of the outrigger canoe, very likely of Austronesian introduction, all along the East African coast, where the Swahili term for the technology strongly parallels the Malay one (Blench 1996). Iron-working technology in Madagascar similarly shows some elements that are more Southeast Asian than African, and evidence from linguistic terms supports these links (Radimilahy 1988, 1993; Vérin and

Wright 1999). Then there are the crops: as discussed below, banana, yam and taro are all Southeast Asian cultigens that, through processes still not understood but undoubtedly anthropogenic, were translocated at some point in the past to Madagascar and the rest of Africa. Genetic studies also indicate that certain varieties of rice were transported to Madagascar from Southeast Asia, along with the distinctive agricultural techniques that are used to grow rice in that part of the world (see discussion below). Beaujard (2011) discusses parallels between Southeast Asia and Madagascar for linguistic terms and ritual practices relating to several key crops, including rice, coconut and the greater yam. Other molecular genetic studies—of humans, coconuts and chickens for example—are additionally increasingly demonstrating a whole suite of links that could only be suggested previously. Recent computer simulation studies also add to the picture: they show that it was possible to reach Madagascar from Indonesia by pursuing a strategy of downwind sailing and starting from December to March, breaking the journey in the Maldives and sometimes also Sri Lanka, depending on the starting location (Fitzpatrick and Callaghan 2008).

While a Southeast Asian element in East Africa and particularly Madagascar is not contentious, however, much debate has surrounded discussion of the timing and nature of Southeast Asian migration to the region. An early date has been hypothesised on the basis of various lines of evidence. For example, researchers studying African bananas have suggested, based on linguistic (Blench 2009; De Langhe 2007) and archaeological (Lejju et al. 2006; Mbida et al. 2000) evidence, that bananas arrived in Africa sometime in the first millennium BC (see below), suggesting an early Austronesian connection. Historical sources, such as Pliny’s first century AD *Natural History*, have also been drawn upon to suggest an early date. Various scholars have argued that Pliny’s reference to cinnamon trafficking on the East African coast by men who cross vast seas on ‘rafts’ reflects contact with Austronesians (Blench 1996; Miller 1969), though this seems dubious, not least because Southeast Asian traders would almost certainly have arrived in large ships (Manguin 1993, 2010) rather than outrigger canoes. Other possible lines of evidence include the apparent early presence of the black rat and common house mouse on Madagascar (at Andrahomana Cave; Burney et al. 2008; Vassy and Burney 2007, cited in Blench 2007a), and the chicken on Zanzibar (Chami 2001b), although, as we have noted, caution is warranted with regards to the stratigraphic integrity of all of these finds (Blench 2007a, p. 72; Sinclair 2007; Sinclair et al. 2006), as well as the identification of the latter (Sinclair 2007, pers. comm.). Evidence for palaeoenvironmental changes on Madagascar from 2300 BP has been associated with human-induced impacts, but these have also been challenged (Dewar and Richards 2012; see previous discussion). Furthermore, even if these proxies are accepted, such palaeoenvironmental changes are equally, if not more, likely to reflect an early African presence in Madagascar. Ultimately then, the evidence to suggest an arrival of Austronesians in Madagascar and East Africa more generally in the BC era or even early first millennium AD is highly problematic. Accordingly, some have argued that the findings support visitation rather than colonisation of the East African coast by Austronesian sailors and traders prior to actual colonisation in the later first millennium AD (Blench 2008; but see Beaujard 2011).

If we are to problematise the evidence for an early colonisation of Madagascar, however, it is also necessary to emphasise that direct archaeological evidence for Austronesians is lacking on the island even at the time when most scholars would agree that they were probably there. The first settlement sites on Madagascar and the Comoros—which might date from the eighth century (Allibert 2008)—have commonly been associated with the arrival of Southeast Asians, yet there is little in the sites or their assemblages to provide concrete evidence of such a connection. The material assemblages of these sites have not been seen to differ significantly from those of other, definitively African, sites on the East African coast of the same late first millennium AD time period. Malagasy names for domesticated animals are furthermore inevitably of either Swahili, or later English or French, derivation (Blench 2008; Walsh 2007). One of the few proposed material links to Southeast Asia on the earliest settlement sites of Madagascar and Comoros is a style of pottery that is decorated with large shell impressions; it decreases in frequency on archaeological sites as one travels from Madagascar to the East African mainland and has been seen as a potential Austronesian or proto-Malagasy marker (Allibert 2008). However, this is a far cry from the identification of definitive Austronesian pottery types in East Africa, and such hard evidence is entirely lacking. Evidence for the date of colonisation of Madagascar by Austronesian-speaking peoples thus rides significantly on the linguistic data. The presence of Sanskrit loanwords in Malagasy, apparently borrowed via Malay or Javanese, would seem to suggest a *terminus post quem* of the seventh century for the colonization of East Africa/Madagascar, coincident with the emergence of the maritime polity of Srivijaya in south Sumatra (Adelaar 2009). It is worth pointing out that the linguistic evidence has also been used to suggest that the proto-Malagasy spent time on the East African coast, and then in the Comoros, before they settled on Madagascar (Adelaar 2009; Blench 2007a; Deschamps 1960, Simon 1988; Walsh 2007; but see Beaujard 2011).

Human Genetics and the Colonisation of Madagascar and the Comoros

While linguistic and anthropological studies have for many years suggested that Madagascar was colonized by Austronesian-speaking populations from Southeast Asia, it was only with the advent of genetic studies that this could finally be demonstrated unequivocally. Studies of Y-chromosome polymorphisms and mitochondrial sequence diversity in Malagasy populations have now indicated approximately equal African and Indonesian contributions to both paternal and maternal Malagasy lineages (Hurles et al. 2005). Moreover, in striking confirmation of linguistic interpretations, the closest match to Malagasy Y-chromosomal haplogroup distributions has been found in Borneo (Hurles et al. 2005). Subsequent genetic studies have confirmed and extended these observations (Capredon et al. 2011; Cox et al. 2012; Dubut et al. 2009; Razafindrazaka et al. 2010; Reiguero et al. 2008; Ricaut et al. 2009; Tofanelli and Bertoncini 2010; Tofanelli et al. 2009). The frequency of a Southeast Asian-derived mitochondrial ‘Polynesian motif’ has been shown to be variable amongst different Malagasy populations, appearing at 50 % among the Merina, and only 13 % among the Mikea, for example (Razafindrazaka et al. 2010). The founding Southeast Asian population appears to have been a mixed-sex one: it is estimated that the colonization of Madagascar involved some 30 women, the majority of Indonesian ancestry (Cox et al. 2012). Evidence for an Indian component to Malagasy ancestry has also been revealed, though whether this reflects an Indian stopover on the Austronesian migration route, or a later, independent Indian migration is not yet clear (Dubut et al. 2009).

The first studies of genetic diversity on the Comoro Islands have also now been published, and suggest that these islands possess a similar highly mixed ancestry (Gourjon et al. 2011; Msaidie et al. 2011). While the Comoros, like Madagascar, reveal evidence of admixture between Southeast Asian and African populations, however, they also possess a significant western Asian component, reflecting long-term trade links and gene flow with the Arab world. Admixture analysis of the maternal and paternal contributions indicates the gene pool to be predominantly African (72 %) with contributions of 17 % and 11 % from western and Southeast Asia respectively (Msaidie et al. 2011, p. 93). The presence of a Middle Eastern signal, currently lacking in Madagascar populations, may reflect differences in the culture and colonization histories of the islands. Certainly the Comoros display a very different linguistic pattern, with Bantu rather than Austronesian languages being spoken. Genetic markers furthermore suggest that the Comoros' history of gene flow from Southeast Asia is distinct from Madagascar's (Msaidie et al. 2011, p. 93). On the other hand, the absence of a strong Middle Eastern signal on Madagascar could simply reflect sampling bias, given that it was the northwest coast of Madagascar that was integrated into the Arab-dominated Swahili trading network, while genetic sampling has thus far largely focused on populations from the centre and south of the island. At any rate, the presence of an Arab genetic signal is a novel if not surprising finding; it is the first time an unambiguous genetic signal from the Middle East has been detected in East Africa south of Ethiopia (Msaidie et al. 2011, p. 90). This genetic signal is in obvious agreement with descriptions of Arab settlement and Arab–East African intermarriage in the *Periplus*, as well as later archaeological, historical and linguistic evidence for Arab trade and migration on the East African coast. Also noteworthy is the presence of a Southeast Asian signal; it is the first time this has been identified in East African populations outside of Madagascar, and it suggests that Southeast Asian gene flow extends beyond the island into Bantu-speaking African populations (Msaidie et al. 2011). Further sampling in East Africa, particularly of under-represented coastal mainland populations, will undoubtedly provide further insights into the complex population dynamics and cultural history of the region.

Crops from Southeast Asia and India

Another important source of information on Africa's historical Indian Ocean connections are the numerous Southeast Asian plants that have come to be widely used in tropical Africa. Of particular interest has been a suite of three tropical Southeast Asian crops—banana (*Musa paradisiaca*), greater yam (*Dioscorea alata*) and taro (*Colocasia esculenta*)—for all of which suggestions of a prehistoric introduction have been made (Blench 1996, 2006, 2009; Fuller and Boivin 2009; Harris 1967, p. 100). Early interest in these distant transfers was demonstrated by Murdoch (1959, p. 222), who referred to them as the 'tropical food kit', and suggested a coastal route for their dispersal around the Indian Ocean. Some authors have related the translocation of these domesticates, so central to Island Southeast Asian and Pacific subsistence, to the Austronesian peopling of Madagascar (e.g. Simmonds 1962, pp. 144–145). Ethnohistorical evidence suggests that tubers, particularly varieties like the Southeast Asian greater yam, were previously much more important to Malagasy subsistence (Beaujard 2011). In contrast, the historian Watson (1983) argued for an introduction of these species to Africa from Arabia, up the Nile and across to West Africa even later in the Arab period. Recent archaeobotanical evidence in the form of banana phytoliths in Iron Age pits in Cameroon has suggested that bananas reached western Africa prior to the colonization of Madagascar, perhaps by c. 500 BC (Mbida et al. 2000, 2006), though replication of these findings at other sites in the region is desirable. Claims for even earlier bananas in Uganda, at Munsa (Lejju et al. 2006), are certainly dubious, in particular as a result of stratigraphic dating issues as well as questions about preserved morphology (Hildebrand and Neumann 2009). Linguistic evidence, however, also points to the early arrival of these three crops in Iron Age central Africa, as discussed by Martin (1976, p. 10) for *D. alata*, Williamson (1993) for taro, and Blench (1997, 2009) for both of these and bananas.

Banana is the best studied botanically of these three Southeast Asian crop introductions. Unravelling the story of banana dispersal is, however, complicated by the species' genetic complexity, which results from a reticulate pattern of evolution through hybridization (De Langhe and de Maret 1999; Kennedy 2009). All cultivated bananas in India and Africa, which include both dessert bananas and cooking bananas (plantains), belong to the single species *Musa paradisiaca,* of hybrid origin. While wild banana species have diploid genomes, cultivars are generally (though not always) triploid, combining two different ancestral genomes, usually termed A and B (Simmonds 1962). Most plantains are AAB, and most sweet bananas are AAA. In India most bananas, now extensively grown through the plains, are AAB or ABB. The inclusion of the B-genome in these bananas widens their ecological tolerance beyond the wet tropical forests, adapting them to the seasonal drought of savannah environments. While some have postulated that the hybridization of A and B types occurred in northern Southeast Asia (e.g., Perrier et al. 2011), it seems equally plausible that it took place in eastern India where the B types are also wild, or in Sri Lanka, where both types are wild (Fuller and Madella 2009). That bananas truly are wild in Sri Lanka is supported by terminal Pleistocene (or at latest early Holocene) finds of *Musa* seeds from Beli-Lena cave in Sri Lanka, which include two types, one plausibly *M. acuminata* and the other *M. balbisiana* (Kajale 1989; on dating, see Deraniyagala 1992), both significantly pre-dating the arrival of agriculture in the island. In addition *Musa* phytoliths occur in the Pleistocene cave of Betadomba-Lena (Perera et al. 2011b). The intriguing evidence for *Musa* phytoliths from the Indus valley by c. 2000 BC (Fuller and Madella 2009; Lawler 2012) could relate to an early dispersal of bananas, although the presence of another introduced *Musa* as a source of raw material (e.g. textile fibre, paper) cannot be ruled out (Fuller and Madella 2009). It is accordingly possible that bananas reached Africa via India rather than directly from Southeast Asia. Linguistic data suggest that the banana reached Madagascar from Africa rather than Southeast Asia (Beaujard 2011), which may also argue against an Austronesian translocation.

The route or routes of entry for the banana into Africa are currently unclear. Bananas in western Africa show great morphological variation, and cultural 'embeddedness', leading to the suggestion that West Africa (with mainly AAB genomes) saw earlier banana cultivation than East Africa (where mainly sweet AAA types are found) (Blench 2006, p. 134, 2009; De Langhe 2007; De Langhe and de Maret 1999). This, along with the Cameroon phytolith evidence mentioned above, has led to the hypothesis that plantains reached West Africa by 3000 BP. De Langhe (2007) has argued for a trans-African dispersal route, from the East African coast, through the forest patches of the Usambara and Pare mountain ranges, and along the northern fringe of the equatorial rain forest, into West Africa, from where plantains are argued to have possibly helped fuel the Bantu expansion. Blench (2009) has meanwhile advanced a more daring continental circumnavigation hypothesis, based on the lack of evidence for ancient plantain cultivation in East Africa, and the problems of a dispersal route through the dry regions between the coast and central African rainforest. Nevertheless, others question the reliability of the single context from which *Musa* phytoliths have been reported from West Africa (e.g. Neumann et al. 2012).

Still mysterious is the presence of wild-type, seeded bananas on Pemba Island (Fig. 9), apparently AA types, which have a close relationship to wild bananas from Java and/or the Molucca islands (Simmonds 1962, pp. 22, 57) Wild bananas have also been recorded in northeast Madagascar (De Langhe pers. comm.; Beaujard pers. comm.) but these have yet to be described in publication. Whether these isolated occurrences are connected to the

Fig. 9 Stand of wild bananas, Ngezi Forest, Pemba. (Photo: Alison Crowther)

same introduction that brought AAB bananas to Africa is by no means clear. The other crops of the tropical trio, taro (or cocoyam) and Asian/greater yams, are much more poorly known, lacking either archaeobotanical evidence (although see van der Veen 2011 for Islamic-period evidence of both taro and banana at Quseir al-Qadim in Egypt) or large scale genetic studies. Ethnohistorical data for Madagascar suggest that several Southeast Asian yams, and particularly the greater yam, were previously of significant ritual and social significance in Madagascar. ‘White yams’ (probably the greater yam) were gifted at royal inaugurations, and giant yams appear to have been prestige items (Beaujard 2011), as seen today in Melanesia (Beaujard 2011; Coupaye 2009). Taro is ritually planted in the corner of rice paddies prior to the planting of rice in Madagascar (Radimilahy pers. comm.; Beaujard pers. comm.). Such observations, along with linguistic data, would seem to suggest the antiquity of the arrival of Southeast Asian yam and taro to Madagascar. Beaujard (2011) argues that taro was amongst the first crops transported by colonizing Austronesians, while yam was an indirect and somewhat later arrival via Africa, but in general our understanding of the routes and timing for the spread of these crops is limited by a near absence of archaeological or genetic studies.

Another crop that transferred to East Africa via Southeast Asia, at least in part, was rice (Fig. 10). The species *Oryza sativa*, or Asian rice, appears to have been domesticated at least twice, resulting in the establishment of two major variety groups, *japonica* and *indica* (Fuller et al. 2010; Garris et al. 2005; Londo et al. 2006; Purugganan 2010). The *japonica* subspecies appears to have been originally domesticated in the Middle to Lower Yangtze

Fig. 10 ‘Transported landscape’ on the island of Pemba. Rice, the crop pictured, was first introduced from Asia, perhaps via the Arab world. Other Indian Ocean introductions to eastern Africa include zebu cattle and coconut palm, also shown. (Photo: Alison Crowther)

basin of China in the Middle Holocene (Fuller et al. 2009), spreading subsequently to Southeast Asia with foxtail millet after 2500 BC (Castillo and Fuller 2010; Fuller et al. 2010). By contrast, the subspecies *indica* had ancestors (‘proto-*indica*’) that were likely brought into cultivation independently in northern India, but with domestication alleles introduced by hybridization with *japonica* in prehistory (the ‘combination model’ of *indica* origins: Kovach et al. 2007), probably when Chinese rice and other crops like broomcorn millet were introduced to the region via central Asia (Fuller and Qin 2009; Fuller et al. 2010).

Both *japonica* and *indica* varieties of rice are present on Madagascar (Khush 1997; Koji 1997; Mather et al. 2010), suggesting at least two separate introductions of rice to the island, one from Southeast Asia, and another from India (Koji 1997). Recent genetic sampling of varieties in the Merina region of the central Madagascar Highlands indicates additional divisions, including both temperate and tropical *japonica* as well as a distinctively Madagascan genetic group of lowland rice, referred to by local names such as *Rojo*, *Botra*, and *Tsirka* (Radanielina et al. 2013). This local rice appears to derive from either local selection from introduced *indica* varieties or evolution from *japonica*-*indica* hybrids that arose in Madagascar. Traditionally these *Rojo*-*Tsirka* rices are grown mainly in lowland settings, as are many *indica* rice varieties and temperate *japonica*. Tropical *japonica* landraces, on the other hand, are grown in upland settings. This conforms generally to the ecological divisions of these varieties elsewhere in eastern Africa (e.g. in Tanzania and Zambia, de Kochko 1987) or indeed in mainland Southeast Asia, where *indica* dominates lowland irrigated/flooded rice fields and *japonica* is found primarily in the rainfed uplands (Castillo and Fuller 2010).

The *japonica* variety of rice appears to have been introduced to Madagascar first; linguistic data seems to support a direct introduction from Southeast Asia (Beaujard 2011), and both linguistic (Beaujard 2011) and preliminary archaeobotanical data (see below) suggest that it was brought over during initial Southeast Asian colonization. Subsequent introduction to Madagascar of more northern varieties of *japonica* via the Arab and Swahili coast trading networks also seems likely, and may explain the greater genetic diversity of *japonica* in comparison to *indica* varieties on the island (Mather et al. 2010). Walshaw's morphometric analysis of charred rice remains from eleventh to fifteenth century deposits on Pemba island, which indicates that they were likely of the *japonica* variety (Walshaw 2010), may support the possibility that this variety was being traded in from the north, although an alternative possibility is that this Southeast Asian variety was introduced to Pemba via Madagascar and the Comoros.

Indica rice seems to have arrived later into the region than *japonica*. A few *indica* varieties in Madagascar appear to group closely in genetic terms with landraces from India (Mather et al. 2010; Table S1), suggesting that they arrived there more or less directly from the Indian subcontinent (Mather et al. 2010), rather than deriving from the *indica* varieties that became established in lowland Southeast Asia (Mather et al. 2010; on the still poorly understood history of *indica* and *japonica* in Southeast Asia, see Castillo and Fuller 2010; Fuller et al. 2010, p. 126). Interestingly, Mather et al. (2010) show geographic patterning of the two varieties on Madagascar: tropical *japonica* is found with greater frequency towards the east coast, whereas *indica* is more frequent in the central areas of the island—although geographical coverage of the island in the survey that demonstrated these patterns was incomplete (Mather et al. 2010). This could be the product of different geographical pathways of introduction and infiltration of the island, although further details are needed about the topographic setting of the varieties. Especially fascinating is the fact that this structuring corresponds to cultural variation in agricultural practice, with techniques of clear Malay origin traditionally practised in the east where *japonica* predominates, while a more mixed Malay/Indian combination of techniques is used in the central areas where *indica* is the main variety (Koji 1997; Mather et al. 2010). This may reflect a late introduction of *indica*, with it being taken to the less intensively cultivated interior habitats. It should also be noted that rice irrigation might have been a later arrival to Madagascar, preceded by swidden cultivation of hill rice (Dahl 1991). Dahl (1991) reports the transfer of Southeast Asian swidden cultivation techniques to maize production amongst the Sakalava of western Madagascar.

Archaeobotanical evidence for rice in East Africa is still relatively limited (see Table 3), but some patterns of potential interest are already suggested. While recent archaeobotanical evidence from Pemba and Zanzibar suggests that rice is present from early in the Swahili period, it is a rare find at the earlier Swahili sites of Tumbe and Unguja Ukuu (both dating between the seventh and tenth centuries AD), and only becomes a staple after AD 1000, as demonstrated at the later site of Chwaka on Pemba (Crowther et al. unpublished data; Walshaw 2010). Admittedly preliminary and partial archaeobotanical records from Madagascar and the Comoros, on the other hand, are dominated by rice from initial urban settlement at around the ninth–tenth century AD, and the frequency of rice appears to increase at Mahilaka during the thirteenth–fourteenth century AD, concomitant with an overall increase in population density (Radimilahy 1998, p. 103). This fits with the genetic and linguistic evidence suggesting that rice was an early arrival on Madagascar. African crops, on the other hand, are near absent in assemblages from Madagascar and the

Comoros. The main exception is in the central highlands of Madagascar, where rice is notably absent until the late fifteenth century (Wetterstrom and Wright 2007). Interestingly, African crops are also absent in earlier assemblages from the highlands (where settlement dates from the twelfth century AD), which are dominated instead by wild sedges and rushes.

Sites on the East African mainland have yet to offer direct evidence for rice cultivation, although this pattern probably reflects a sampling bias, given that most archaeobotany has been undertaken on the offshore islands, the Comoros and Madagascar. Recent work in the Kenyan coastal hinterland, at mainly cave/rockshelter and Early Iron Age sites, however, has so far produced no evidence for rice (Helm et al. 2012). While archaeobotanical evidence from mainland sites is rare, both ethnohistorical and ethnographic evidence support the impression that as Swahili stone towns increased in number and influence, rice became the staple grain of choice (LaViolette 2008). The shift to rice-based foodways after the eleventh century on Pemba appears to correlate with increasing urbanisation and new forms of pottery, and the evidence as a whole has been taken to suggest the emergence of new forms of ritual feasting that served to advance political and trade activities (Fleisher 2003; Walshaw 2010) and further differentiate the Swahili from inland communities (LaViolette 2008). The consumption of rice on the Swahili coast is possibly also linked to increasing conversions to Islam and other processes of 'Arabisation' that would have facilitated and promoted Indian Ocean trade (LaViolette 2008; Walshaw 2010).

Another crop that appears to have arrived in the East African region from both Southeast Asia and South Asia via two distinct pathways is the coconut, *Cocos nucifera* L. (Fig. 10). As a portable source of both food and water, the coconut played a critical role in the ability of humans to voyage, establish trade routes and colonize new lands, and its present pan-tropical distribution may be in significant measure attributed to human translocation (Gunn et al. 2011). Linguistic studies indicate the arrival of coconut to Madagascar with early Austronesian settlers (Allibert 2008; Beaujard 2011), while archaeobotanical analyses support its presence on Pemba, the Comoros and mainland Tanzania by the sixth to eighth centuries (see Table 3). A variety of genetic studies have suggested the presence of two genetically distinct coconut groups, corresponding to the Pacific Ocean basin on the one hand and the Indian and Atlantic Oceans on the other (Gunn et al. 2011; Lebrun et al. 1998; Perera et al. 2003; Teulat et al. 2000). This genetic isolation is consistent with long-term evolutionary divergence between coconuts in the Pacific and Indian Oceans. Against this background of population separation is a distinctive pattern of genetic admixture peculiar to the western Indian Ocean, where Pacific coconut introgression is observed in Indian Ocean varieties. Admixture appears to be the result of direct East African–Austronesian contact, with admixed coconuts predominating along the trade route connecting East Africa and Madagascar to Southeast Asia; no admixture is evident in the more northerly Seychelles, which fall outside the trade route (Gunn et al. 2011). A second route of introgression corresponds with the regular voyages between the Arabian Peninsula/Persia and the East African Swahili world, and is also supported by linguistic (Allibert 2008) and genetic (Perera et al. 2011a) evidence. The admixture evident in the coconut trees of East Africa and Madagascar is also apparent in Madagascar rice, where hybridisation of *indica* and *japonica* varieties has led to the emergence of novel hybrid landraces (Ahmadi et al. 1991; Mather et al. 2010; Purugganan 2010). Hybridization between *indica* and *japonica* has also occurred elsewhere in Africa, although these subspecies appear to be largely maintained due to differing ecological preferences, with tropical *japonica* typical of upland settings and *indica* in the lowlands (de Kochko 1987).

Several other crops from Asia, probably all coming from India via the Swahili network, also came to parts of East Africa, the most prominent species of which are listed in Table 1. These include the mung bean (*Vigna radiata*), a Neolithic domesticate of South India (Fuller and Harvey 2006), and the mango (*Mangifera indica*), which is native to southwest and northeast India and was first cultivated in the north and south Indian plains prior to the Iron Age (Asouti and Fuller 2008). Although there is relatively little in the way of archaeobotanical or detailed genetic information, tentative finds of other translocated species have also been reported from a number of sites on Pemba, Zanzibar and the Comoros (Table 3), suggesting that these crops begin to arrive around the eighth or ninth centuries AD or soon thereafter (Allibert et al. 1989; Crowther et al. unpublished data; Hoffman 1984; Johnson 1992; Walshaw 2005, 2010). These finds include possible Asian millets (*Setaria* cf. *verticillata, Setaria* cf. *italica*, and cf. *Setaria*) at Chwaka, Dembeni and Sima; Indian legumes *(Vigna radiata/*cf. *radiata* and cf. *Macrotyloma*) at Tumbe, Kimimba, Chwaka and Unguja Ukuu; sesame (*Sesamum cf. indicum*) at Tumbe and Dembeni; poppy (*Papaver somniferum*) at Chwaka; and possible citrus (cf. Rutaceae) at Sima. Although the presence of wild *Sesamum* and *Setaria* in East Africa complicate the identification of the imported Asian varieties, these data nonetheless indicate that a range of Asian species were potentially introduced during the mid to late Iron Age, and that further systematic archaeobotany to confirm these identifications is therefore critical. Southwest Asian crops, including Triticeae cereals (wheat/barley), pea (*Pisum*) and cotton (*Gossypium*) have also been found at sites on Pemba and Zanzibar (Crowther et al. unpublished data; Walshaw 2005). Cotton is found in particularly large quantities from around the eleventh century AD (Walshaw 2005). These plant data support the evidence from archaeology suggesting that right from their origins in the second half of the first millennium AD, the Swahili cultures of the East African coast were involved in Indian Ocean trade networks.

While domesticated crops would have been carried and then propagated intentionally, many more plant species, including agricultural weeds, have probably been moved around the Indian Ocean inadvertently. Elsewhere (Fuller and Boivin 2009) we have reviewed evidence for a few potential weeds that have been translocated from Africa to Asia or Asia to Africa, apparently via the Indian Ocean based on their absence from the flora of intervening land regions (Egypt, Mesopotamia, Iran); these include *Trianthema* spp., *Spermococce* spp. and the witchweed (*Striga asiatica*). The diamond flowers (*Oldenlandia* spp.) can probably be added to this list, as plants originating in India but occurring in secondary habitats in Africa. In general, we know less about weeds than about crops, and more research on this topic is warranted. In the case of the horse purslane (*Trianthema portulacastrum*), we do have an archaeological record, at least in Asia. This record enables us to trace it from its probable origins in western India (Rajasthan, Gujarat) in rocky areas and hill slopes (that is, naturally disturbed habitats) (Shetty and Singh 1987, p. 355; Singh et al. 2001, II, p. 89; Tadulingam and Venkatanarayana 1985, pp. 143–145), to its emergence as a recurrent weed of millet fields in Harappa era Gujarat (Reddy 1994; Weber 1991), along with the related *Trianthema triquetra*. By the Chalcolithic period (after 1400 BC), it had spread to the Ganges plains, having probably become a weed of rain fed rice fields (Fuller and Qin 2009), and both *Trianthema* species were added to South India's weed flora in the Iron Age, or by Early Historic times (c. 300 BC), perhaps as weeds of both rice and millet. Subsequent eastward spread is indicated by the occurrence today in dry rice fields in mainland Southeast Asia (Noda et al. 1985). At some stage both *Trianthema* species also came to the millet and sorghum fields of the African savannahs, where they persist as weeds to this day, but their absence from Arabia, Mesopotamia and

Egypt implies that they arrived by sea from Asia. On Madagascar, it appears that only the more widespread of these horse purslanes is known as a weed: *Trianthema triquetra* is absent from the *Catalogue of Vascular Plants of Madagascar*, compiled by the Missouri Botanical Garden (http://www.tropicos.org/Project/MADA). By contrast, *T. portulacastrum* is widespread in northwest, west and southern Madagascar. Further work is needed to determine the extent to which this is due to ecological barriers in climate (which seems unlikely), cultivation practices, or a historical legacy of having been introduced from Africa rather than directly from Asia.

Dispersal of Shrews, House Geckos and a Mosquito

Several shrews have also been translocated to East Africa and Madagascar as a result of human activities. The Asian house (or musk) shrew, *Suncus murinus*, is a ship-borne invasive species that was introduced to East Africa at some still indeterminate point in the past (Walsh 2007). Mitochondrial DNA studies suggest that the species originated in South Asia (Kurachi et al. 2007a; Yamagata et al. 1995), from where already differentiated populations dispersed, probably as commensals of early human populations (Kurachi et al. 2007a). The main population groups are the Continental type (found on the South Asian mainland), the Island type (found in the islands of Southeast Asia) and the Malay type (found in the Malay Peninsula). The Island type of *S. murinus* is argued to have diverged from a South Indian/Sri Lankan population, from where it colonised island Southeast Asia by maritime routes (Kurachi et al. 2007a, b). The Asian house shrew has also reached Arabia, the East African coast and the islands of the Indian Ocean as a result of anthropogenic dispersal. It is argued to have reached Madagascar by an East African route (Duplantier et al. 2003; Hutterer and Tranier 1990). High morphological variability in shrew populations from the Arabian Peninsula and from Africa (including Madagascar), suggests multiple importations from different origins (Hutterer and Tranier 1990). The Asian house shrew has not yet been reported from archaeological sites in coastal East Africa.

More recently, another shrew—the pygmy shrew—has also been identified as an Asian introduction in the region. While Hutterer (2005) identified *Suncus madagascariensis* as endemic to Madagascar, recent analysis of the cytochrome *b* region of the mitochondrial genome for this and closely related species indicates that it is an Asian introduction, taxonomically synonymous with *S. etruscus* (Omar et al. 2011; see also Meegaskumbura et al. 2012). Pygmy shrews from Italy, France, Sri Lanka, Madagascar and Malaysia form a monophyletic clade, suggesting that the Madagascar population colonised the island from the Indian subcontinent or Southeast Asia. *S. etruscus* also appears to have colonised remote islands in the Mediterranean region as a maritime commensal (Omar et al. 2011). The pygmy shrew is also found in the Comoros (Walsh 2007).

Mention should also be made of the house gecko, another animal of historical interest in the Indian Ocean. Geckos are a family of lizards, and many geckos, including the house gecko, are commensal (Vences et al. 2004). As with rats and mice, commensal lizards have previously been used to trace human colonisation—for example, the lizard species, *Lipinia noctua*, is argued to have spread rapidly throughout the Pacific islands in prehistoric times as a passenger on outrigger canoes (Austin 1999). The phylogeography of this lizard has been used to argue for an ‘express train’ or rapid colonisation from New Guinea to the far reaches of the Pacific Ocean. In the Indian Ocean, a number of species of the genus *Hemidactylus*—a type of house gecko—are also commensal, and their phylogeography may hold similar clues to colonisation patterns. *Hemidactylus* occurs naturally throughout much of tropical Asia and Africa, but also reached various Indian Ocean islands by both natural and anthropogenic means (Cheke 2010; Rocha et al. 2010).

Preliminary studies of *Hemidactylus* on the more remote islands of the western Indian Ocean, including Madagascar, suggest the presence of at least four variously distributed species, *H. mabouia/mercatorius*, *H. platycephalus*, *H. frenatus* and *H. brooki* (Rocha et al. 2010; Vences et al. 2004). On Madagascar, all but *H. brooki* occur, but it is probable that *H. frenatus* and *H. platycephalus* arrived as human commensals (Vences et al. 2004). *H. platycephalus* probably arrived from the African mainland, though an origin in the Comoros can not be ruled out (Vences et al. 2004). *H. frenatus*, on the other hand, showed similar haplotypes across Madagascar, the Mascarenes and Sri Lanka (Vences et al. 2004: Fig. 3). *Hemidactylus* on the Comoros appear to have arrived, both naturally and as commensals, from East Africa as well as Madagascar (Cheke 2010). Much wider sampling of house geckos for molecular genetic analyses is required to clarify the diverse origins of the different species in East Africa and the western Indian Ocean and to shed light on patterns of human colonization and trade. Discussion of these species in zooarchaeological reports, which is currently absent, would also be useful.

A variety of other species moved around the Indian Ocean, for most of which little is known in terms of chronologies and routes of dispersal; these are summarised in Table 1. One species worth mentioning is the Asian tiger mosquito (*Aedes albopictus*), which, while not archaeologically visible, is of interest because it is a vector for a variety of pathogens (including those that cause dengue and chikunguya fevers, and lymphatic filariasis [elephantiasis]). Prior to the mid twentieth century, the Asian tiger mosquito was found in South, Southeast and East Asia, as well as some Pacific islands, but also in Madagascar and a number of smaller Indian Ocean islands (Knudsen 1995; Enserink 2008). More recently it has spread much more widely and rapidly, to the Americas, Africa, Middle East and across the Pacific, largely through the international trade in used tyres (Knudsen 1995; Benedict et al. 2007; Enserink 2008). Its early presence in Madagascar is intriguing, and potentially links it to other species that moved from the region of Southeast Asia and South Asia along maritime trade routes. Finally, while not yet identified in East Africa, it is worth noting the possibility of human-mediated land snail translocations (Christensen and Weisler 2013) across the Indian Ocean, especially as these can be traced archaeologically.

Conclusions

Chaudhuri's pivotal and widely-referenced study of the historical Indian Ocean, *Trade and Civilisation in the Indian Ocean*, describes it as 'an area of social and cultural diversity rooted in four different civilisations: the Irano-Arabic, the Hindu, the Indonesian, and the Chinese' (Chaudhuri 1985, p. 21). The absence of Africa from this register (as also noted by Alpers 2007) is telling, and reflective of a wider failure to give much consideration to the region's place in the wider Indian Ocean world. This may in part be blamed on a relative lack of historical data, at least in comparison with other regions, and so the archaeological, and, in particular, species-focused, approach that we have taken here may be seen as an important remedy to the imbalance suggested by Chaudhuri's statement. The sheer number of Indian Ocean biological translocations that involve Africa very much highlights the important role that the continent's eastern seaboard has played in the Indian Ocean world. The potentially notable antiquity of some of these translocations also points to the likelihood of a significant time depth to this involvement. A combined zooarchaeological, archaeobotanical and genetic approach to East Africa's past, linked of course to a wider programme of systematic survey, excavation, dating and material culture studies, offers an important new means of addressing a long-standing tendency to overlook Africa's active and important role in the Indian Ocean world.

In this paper we have sought to outline what the disciplines of zooarchaeology, archaeobotany and genetics in particular have to tell us about the connections between eastern Africa and the rest of the Indian Ocean world. We would emphasise that the story that these disciplines tell at present is still a limited one. Too few sites have been studied in detail using the methods of archaeological science to acquire a clear picture, and much may change when more, and particularly earlier, sites are studied. The majority of non-indigenous plant and animal species are first documented on the East African coast only from the Swahili period, but pre-Swahili faunal and botanical assemblages are almost completely unanalysed. Genetic studies of some species hint at the possibility of earlier arrivals, but are also difficult to interpret in the absence of good faunal and botanical evidence. In addition, genetic studies are for the most part highly preliminary, and geographical coverage is inevitably biased to one area or another. Only when more genetic studies involving more even coverage are conducted will anything approaching a clear story be possible. We accordingly emphasise the tentative nature of the interpretations offered here; as we have said, we present here more a series of hypotheses to be tested than a conclusive analysis.

In spite of the limitations, we may nonetheless offer some interesting preliminary observations based on the data as it now stands. One is that genetics in particular reveals that for a significant number of the species anthropogenically introduced to East Africa, multiple origins are indicated. Inputs from the Arabian Peninsula, South Asia, and Southeast Asia are revealed for a variety of species, highlighting the complexity of the Indian Ocean story, and Africa's place within it. The observed biological diversity precludes any straightforward picture, and will demand that we ultimately construct more nuanced and complex narratives about eastern Africa and its links across the Indian Ocean. These links probably extend back further than is currently clear, and were likely multidimensional and in many cases unexpected as well. This is, in fact, as clear from the historical texts as it is from the genetics. The *Periplus*, for example, records some key linkages and connections, but not all of them; it is apparent from the author's description that there is a whole Indian Ocean world, thriving and busy, about which he (or she) provides only a few limited facts.

We may also, once again, underline the importance of small-scale societies to the activities of trade, exchange, contact and colonisation that took place in the Indian Ocean world. Several of the authors have already highlighted this for other parts of the Indian Ocean world (Boivin and Fuller 2009; Boivin et al. 2009; Fuller and Boivin 2009; Fuller et al. 2011). The richness of the material remains of large-scale, state-level societies, as well as the greater attention that has generally been paid to them by archaeologists, not to mention their attendant historical records, mean that these 'complex' societies have generally been the focus of attempts to study both the ancient and the more recent historical Indian Ocean world. Yet for at least some Indian Ocean species translocations, it is very difficult to find evidence for the involvement of state-level societies. A significant portion of the economic and biological exchanges that took place in the Indian Ocean probably involved smaller-scale, stateless and sometimes mobile societies (see also Horton 1997). These include the societies that provided goods and species, the societies that accepted them at the other end, and the communities involved in their transport. In East Africa, it is clear that the emergence of fully urbanised coastal trading entrepôts was preceded by at least a millennium of smaller scale trading societies, including most likely early hunter-gatherers, maritime foragers and fishermen, pastoralists and farmers. These kinds of societies, whose role is highlighted by the African record, were found all around the Indian Ocean, and were an integral feature of an emerging complex trading network that relied on obtaining things, often biological products and species, and exchanging them across an extraordinary diversity of ecological zones. The archaeological and historical invisibility of the Southeast Asian agents who may have been responsible for some of the most spectacular translocations of the Indian Ocean world is also telling, and may reflect, if not the absence of states, at least the participation of less traditionally hierarchical and centralised societies (Hall 2011), and possibly also of more mobile, sea-oriented (Andaya 2008) populations in manning and sailing vessels voyaging to Africa as part of Southeast Asia's extraordinary seafaring and sea trading activities (Manguin 1993, 2010; Wolters 1967). Small-scale societies were an integral part of the complex map of linkages that brought the Indian Ocean world together.

With recognition of the less obvious players in the Indian Ocean networks must also come acknowledgement of their role as active agents in the exchanges that took place. Jeremy Prestholdt's fascinating study of the active role of African communities in nineteenth century trade relationships widely assumed to be deeply asymmetrical (Presholdt 2008) highlights the importance of considering African agency in earlier time periods as well. We can be relatively certain that the fact that Africans were (contrary to what was and continues to be widely assumed) not satisfied with procuring any old baubles in their trade with the outside world (Presholdt 2008) is as true for the more distant past as for the nineteenth century. The desire for, and import of, particular goods and species must be understood within specifically eastern African frameworks of social activity and symbolic meaning. Species (other than the commensals and weeds that were accidentally translocated) were probably often deliberately obtained exotic goods. While we tend to think of domesticates in relatively utilitarian terms today, their novelty and exoticness in the ancient past should not be underestimated (Hayden 2003; Boivin et al. 2012); and the societies that accepted them made a deliberate choice to do so, and to adapt them into novel economic, technological and social contexts. The ability of small-scale societies to create 'transported landscapes', as may be revealed on East African islands by evidence for the relatively common maritime movement of wild species to non-endemic habitats, should furthermore not be overlooked. This is not to ignore the asymmetries and forms of exploitation that also characterised the Indian Ocean world and its trade, highlighted by the slave raiding and trading that were a fundamental feature of Indian Ocean networks from their origins, and impacted African and other societies (Campbell 2004). However, narratives of exploitation, along with core-periphery models, insufficiently balanced by recognition of agency and dynamism will necessarily lead to a biased picture of an early Indian Ocean world whose similarities to later colonial-dominated trading systems need to be investigated rather than assumed.

With new theoretical and methodological approaches then, we look forward to welcoming eastern Africa as one of the defining civilisations of the ancient Indian Ocean world. The East African archaeological record and its species diversity offer rich datasets for study that will yield insights not only into the early Indian Ocean world and its historical antecedents, but also the cultural, social and evolutionary stories that have unfolded and interacted in the region. The new studies being initiated by various projects, and the training being undertaken by a new generation of African archaeologists in the important methods emphasised here, are likely to lead to significant alteration and enrichment of our current picture of coastal eastern Africa. If we have helped through the synthesis and analysis presented here to define an agenda for this ongoing and future research, then the aims of this paper will have been realised.

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