ISLAND COLONIZATION WORLDWIDE BEGAN in the Indian Ocean when groups of *Homo erectus* from Java reached Flores, and probably Timor, nearly a million years ago. The first substantial sea crossing by *Homo sapiens* was to Australia some fifty to sixty thousand years ago, and long-distance offshore sailing began about 2000 BCE in the northern Indian Ocean, earlier than in the Pacific or Atlantic. The Indian Ocean has some claim, then, to being “by far the oldest of the seas of history.” But therein lies an enigma: By the early second millennium CE, nearly all of the habitable islands in the Atlantic and Pacific Oceans had been colonized by indigenous seafarers, yet discovery and settlement of many Indian Ocean islands does not seem to have occurred until after the arrival of European shipping, beginning around 1500 CE. An interocean
comparison illustrates the difference. The habitable Indian Ocean is a fifth the size of the habitable Pacific, but the occurrence of islands is comparable: about eight and ten per 1,000,000 square kilometers (km²) of ocean, respectively. However, while only 2.5 percent of islands in the habitable Pacific were unoccupied by 1500 CE, the comparable figure was 28 percent in the Indian Ocean.⁴

The particular issue here is why Indian Ocean precedence in maritime technology and offshore experience was not translated into pre-modern colonization of many of its islands. However, this question has more general implications for understanding linkages between island colonization patterns and histories of oceanic seafaring. Differences in the extent or timing of island colonization suggest variance among impul- sions and competencies in seafaring and migration activity. As these tend to be affected most by voyaging distance, it is usually among the remote islands, those more than 250 km offshore,⁵ that remoteness and isolation define the former limits of oceanic colonization, which is indeed the case here.⁶

Among the remote islands of the Indian Ocean, the Maldives were inhabited by 100 BCE, and the Comores and Madagascar by at least 900 CE, but what of the Chagos Islands, Seychelles, Mascarenes, the Cocos-Keeling group, Christmas Island, and other isolated islands, such as Cargados Carajos and Tromelin (near the Mascarenes), or Bassas da India and Europa (Mozambique Channel)? European discoverers of uninhabited, remote islands deduced that an absence of people and a profusion of vulnerable birds and reptiles meant that no one had discovered the lands previously, as John Jourdain wrote of the Seychelles in 1609: “You cannot discern that ever any people had bene there before us.”⁷ The commonsense merit of such reasoning has been supported often enough by an absence of contrary evidence arising during subsequent settlement of the remote islands, but the proposition does not allow for the possibility that some premodern island colonizations might have failed long before European discovery, leaving no obvious traces. As that has happened elsewhere, the application of archaeological and similar methods to defining former colonization episodes becomes necessary.

Archaeological research in the Indian Ocean islands has focused, quite reasonably, on islands where premodern occupation has long been evident, notably near-shore islands, such as Sri Lanka, Zanzibar, Pemba, and Mafia, and to a small extent Socotra and the Laccadive,
Andaman, and Nicobar groups. Apart from the Maldives, Comores, and Madagascar, the remote islands attracted little historical interest until recently, perhaps because their creolized populations did not fit prevailing African or South Asian historical interests. An evidential basis upon which to establish the spatiotemporal pattern of remote island colonization in the Indian Ocean has remained incomplete and the remote islands, at least, continue to exemplify assertions that Indian Ocean “seafaring and maritime activity has been almost disregarded” and that the “Indian Ocean remains much less known than its Atlantic and Pacific counterparts.” Several intriguing questions remain unanswered. Why are Southeast Asian connections manifested in East Africa, including Madagascar and the Comores, but not in islands along potential routeways of migration? How were the Seychelles apparently missed, if there were first millennium BCE direct passages between East Africa and India, not to mention later? Why were the Chagos Islands uncolonized before the eighteenth century despite their relative proximity to the long-settled Maldives? These and other such questions about remote islands in the maritime history of the Indian Ocean prompted Crossing the Green Sea, a project of archaeological and paleoenvironmental fieldwork in 2009–11.

Crossing the Green Sea operated primarily in the Cocos-Keeling Islands, Diego Garcia (Chagos Islands), the inner Seychelles Islands, and southwest Madagascar. The results of earlier archaeological fieldwork on Christmas Island, analysis of archaeological material in the Maldives, collection of tissue samples from commensal and domestic animals in Diego Garcia for investigation of genetic relationships, and research on Indo-Pacific indigenous seafaring technologies and practices were also involved. This multidisciplinary approach from the perspectives of archaeology and natural history complements the “new thalassology” developing in Indian Ocean historiography. With sea-centered approaches organized around sea and ocean basins, the two-thousand-year-old beginnings of an Afro-Asian “world system,” aspects of “deep structure,” such as the monsoons, and cultural “commonalities” in sailing technology and trade languages, the new thalassology rejects a view of oceans and seascapes as broadly isotropic in their dimensions and neutral in character to human intervention, seeing them rather as volatile and varied in time and space and thereby influential agents in histories of “the creation, destruction and re-creation of
communities as a result of the movement, across and around the [Indian Ocean] basin, of people, commodities, cultural practices and ideas.\textsuperscript{18}

Our approach to oceanic research is explicitly comparative, taking the view that interoceanic analysis adds to an understanding of the history of each.\textsuperscript{19} That is especially so for the Indian and Pacific oceans, where the remote islands were colonized at least in part by people of the same Southeast Asian source, Austronesian language family, and canoe-based maritime technology who, in addition, had comparable subsistence economies and experienced similar patterns of late Holocene climatic variability through the connections of El Niño–Southern Oscillation (ENSO) and IOD to the same Indo-Pacific warm pool (IPWP).\textsuperscript{20} The extent of similarity thus prompted us in 2009 to propose three preliminary hypotheses from our Pacific experience to account for the Indian Ocean enigma of comparatively lengthy seafaring experience but an unusually low rate of remote island colonization.

The first was that the high frequency of colonization absence might be more apparent than real. Archaeological fieldwork in the remote islands had focused largely on Madagascar and to a lesser extent the Comores and Maldives. Was it possible that fieldwork in other remote islands, employing a range of techniques, could discover evidence of premodern colonization that had not survived up to 1500 CE? As investigation in the Pacific has uncovered twenty-eight remote islands that were uninhabited at European arrival but concealed archaeological remains of prehistoric colonizations, the proposition seemed plausible.

A second hypothesis was that the physiography of remote Indian Ocean islands might have predisposed many of them to rejection by potential colonists. Leaving aside Madagascar, remote Indian Ocean islands average only one-third the size of remote Pacific islands (excluding New Zealand), and relatively more of the former are low coral islands that have limited resources and are prone to natural disasters. Still, the high islands of the Seychelles and Mascarenes, with their diverse and abundant resources, were eminently habitable. Moreover, as habitability depends also upon external interaction, the remote Indian Ocean islands had a general advantage of lying only 700 km distant from continental shores, on average, versus 3,300 km for remote Pacific islands.

Thirdly, we thought that the remote islands enigma might reflect one conspicuous difference in the circumstances of seafaring between the oceans: Long-distance sailing for trade was relatively uncommon.
in the Pacific, reflecting the similarity of commodities between many islands and the virtual absence of contact with Asian commerce, although there were several oceanic networks in which ritual, social, and commodity exchanges were formally enacted. Long-distance seafaring in the Pacific was primarily about migration. Overpopulation, resource pressure, and endemic interlineage competition are causes, specified in oral tradition, that often resulted in maritime exile, with duress imposing few limitations upon time, distance, or the privations that might be accepted in searching for new land. In the Indian Ocean, conversely, seafaring is understood as primarily about mercantile marine networks developed by Mesopotamian, Harappan, Roman, Arab, Dravidian, Southeast Asian, and Chinese seafarers, to mention only some of the continental interests involved. The trade networks extending around the northern Indian Ocean from East Africa to the Straits of Melaka created some multicultural communities in coastal ports and towns, notably in Swahili East Africa. The Pacific, then, was an ocean for colonization in which some trade followed, while the Indian was an ocean for trade in which some migration followed, and the difference between them had profound consequences for habitation of remote islands.

In this chapter, we review evidence of initial colonization in the remote Indian Ocean islands, focusing on Madagascar, then consider aspects of paleobiology and seafaring in the matter of transoceanic migration, and conclude with some thoughts on what the deep history of the remote islands suggests about the premodern construction of the Indian Ocean.

INITIAL COLONIZATION OF REMOTE INDIAN OCEAN ISLANDS

This review moves counterclockwise from the Mascarenes, ending with a more detailed discussion of Madagascar, which is, by consensus, the key to understanding how, when, and to what extent the remote islands were colonized before the modern era and involved in the greater Indian Ocean interaction sphere.

The Mascarenes comprise Réunion, Mauritius, and Rodrigues Islands, first recorded by the Portuguese in 1510, 1516, and 1528, respectively. All are large high islands that had abundant and varied fauna and flora at European arrival. The first explorations were by the Dutch from
1598 to 1612 and neither indigenous inhabitants nor any signs of them were reported. Rats, mice, and other small terrestrial mammals were absent and, of course, the birds, flightless or not, were famously tame. However, pre-European extinctions of reptiles on Mauritius indicate an earlier arrival of rats, and radiocarbon dates of $590 \pm 27$ before present (BP) years (calibrated to 1369–1413 CE) were obtained from both a black rat $Rattus$ aff. $rattus$ mandible collected from the Mare aux Songes, and from a rat-predated extinct terrestrial snail, $Tropidophora carinata$. This evidence suggests at least one landing on Mauritius. However, that landing is not recorded in pollen analysis, showing that the natural vegetation experienced no anthropogenic perturbation, at least in the uplands, until after the beginning of permanent settlement in 1638, and an archaeological project has encountered no sign of premodern habitation. It can be assumed, for the moment at least, that there was no attempt at colonization.

The Cocos-Keeling Islands, all atolls, were seen by William Keeling in 1609, visited from about 1750, and first inhabited in 1825. Sedimentary coring and survey by GPR (ground-penetrating radar) on North Keeling Island in 2010 located no signs of premodern cultural stratigraphy or remains. Christmas Island, a substantial high island, heavily wooded, lies 340 km south of Java and was first recorded in 1643. William Dampier landed in 1688, but neither his visit nor any subsequent observations suggested human colonization until settlement began in 1888. Our excavations in 2002, in cave and sinkhole sites and on the beach ridge at Flying Fish Cove, found no cultural material older than the nineteenth century. We recovered remains of the native shrew ($Crocidura attenuata$) and rats ($Rattus macleari$, $R. nativitatis$), and radiocarbon dates on native rat bone were up to 2,200 years old. It is assumed that these long-established terrestrial mammals reached the island by natural rafting from Indonesia. Conversely, recent research on bones of $Rattus rattus$ that we recovered from the same sites has shown them to be of an Indian lineage and dated to the fourteenth century. These rat bones are more plausibly evidence of human contact than natural rafting.

In the Maldives, a Buddhist culture of Sri Lankan origin existed from about the fourth century CE and Islamic settlement from the twelfth century, both investigated archaeologically. There is mention of the Maldives by Ptolemy (c. 130 CE) and Roman coinage dating
to 90 BCE, while Hindi traditions suggest initial occupation around 500 BCE. Many historical accounts emphasize the collection of cowries (*Cypraea moneta*) used widely as currency in the ancient Indian Ocean and Middle East. Cowry currency was in existence by 700 BCE in China, although whether it included cowries from the Maldives is unknown. In any event, there is reason to think that occupation of the Maldives began more than two thousand years ago. There are slight hints of a Southeast Asian influence in the sequence, but very little to pin it down temporally or by source.

There is a 500 km gap from the Maldives to the Chagos islands (5–7 degrees south), discovered by Portuguese seafarers between 1500 and 1550. The Chagos group has the highest rainfall of remote islands in the Indian Ocean and it supported dense forest, huge colonies of nesting seabirds, and abundant sea and lagoon fisheries. Diego Garcia was used as a leper colony in the 1780s and colonized permanently from 1793 by Mauritian-French plantation owners and an African–South Asian Creole population that came to be known as Ilois. The island is 25 km long and an almost continuous atoll in which the land is 0.5–2.2 km wide and readily habitable by oceanic colonists. Archaeological research on historical ceramics, abundantly distributed around former plantation sites on Diego Garcia, shows that they are mostly of British manufacture (the French having ceded control in 1810), but also of Chinese manufacture in the mid-nineteenth century. Nothing of possible premodern source has been reported. Our archaeological coring and test pits throughout the island located no evidence of premodern remains, such as worked shell or bone, stone, or metal artifacts. Charcoal and marine shell are extremely scarce below the modern soil. What we found was collected and radiocarbon-dated: of thirteen dates, all eight on charcoal samples plus one on marine shell were effectively modern. Two calibrated dates on shell from East Point test pits gave age ranges at two sigma of 900–1100 CE, and two others, 350–1200 BCE. There was no stratigraphy in the excavated coral sand and nothing to suggest that any of the shell was culturally deposited.

A core through wetland near the modern military base disclosed a 1,300-year-long sequence of pollen, charcoal, and isotopic data. This shows that the first occurrence of fire, coincident with greater abundance of herbaceous plants and ferns and an opening up of the forest, is evident by 1210–80 CE. Local disturbance continues until 1400–45 CE,
when forest again becomes dominant and undisturbed until 1650–1810 CE. Given that high rainfall effectively precluded natural fires on Diego Garcia, the most likely explanation for the premodern period of fire and vegetation change is that there was either a colonization lasting a century or so, which is unlikely given the general absence of premodern archaeological remains, or multiple visits to the island. Until there has been further research on the area around the wetland, it is not possible to say anything more, except that as paleoecological coring did not disclose any other such record on Diego Garcia, a serially used campsite seems more likely than continuous occupation.

The Seychelles Islands include granitic high islands and numerous coral islands, both atolls and raised coral islands, such as Aldabra. The Seychelles may have been the “Zarin” islands noted in Arabic records dating 1460–1530, but they were probably uninhabited when Vasco da Gama sailed by in 1502, and certainly so when settlement began in 1770. Common speculation about pre-European discovery has not yielded anything except tantalizing remarks about remains of a stone construction on Frigate Island and, on Curieuse Island, possible “forts and supposed…boat channels.” Some interest has centered on graves at Anse Lascar on Silhouette Island, which are reputedly ancient Arab burials, but the grave sites, marked out on the ground surface with stone and originally with vases set up as well, were probably from the late nineteenth century when Indian workers (“Lascars”) were brought to Silhouette to work in the coconut plantations. A sample of human bone from one grave was radiocarbon-dated to 1650–1950 CE (OxA-3885). Rock markings on Therese Island, which have also encouraged ideas of Arabic or pirate occupation, are of natural formation.

Our archaeological and paleoecological coring, plus test pits in caves and rockshelters, extended across three of the four main granite islands in the inner Seychelles: Mahé, Praslin, and La Digue. We found and excavated one coastal shell midden on La Digue. It contained some glass, European pottery, and pig bone with shell and charcoal down to 60 centimeters (cm) depth. A radiocarbon sample from the base of the midden assayed at 1520–1800 CE. No material remains indicative of premodern occupation were found in any cave or rockshelter sites, with one possible exception. Test excavations in the largest coastal rockshelter on Praslin found several small pieces of charcoal in a compact brown grit, possibly a former soil horizon, at 40–65 cm depth. These dated to
85–235 CE, but without any cultural remains in association they are just as likely to have been charcoal blown into the shelter from natural forest fires, as the Seychelles are located in a relatively dry region of the Indian Ocean. That conclusion is supported in the pollen diagrams from our wetland coring. At Petit Police, on the southern tip of Mahé Island, there is a continuous charcoal trace from the base of the core, dated from five thousand years ago up to the present (the current ground surface at the time of core extraction). However, charcoal abundance begins to rise strongly only at about 1500 CE, with grass and coconut pollen indicating more open coastal vegetation after about 1635 CE. These various data suggest that there was no human habitation in the high islands of the Seychelles until the modern era. More fieldwork is needed to test that conclusion, and whether it is relevant to distant coral islands in the Seychelles, such as Aldabra.

The initial colonization period in the Comores Islands, the Dembeni phase, began in the period 750–850 CE, as indicated by imported glazed ceramics from the Persian Gulf and East Asia.46 These probably came via East Africa where they also occur. Locally made ceramics have incised ladder motifs, typical of East Africa, in the westerly islands, but shell-dentate impressions in the easterly islands. The latter might suggest a connection with Madagascar47 and possibly with Southeast Asian traditions, although not necessarily directly. The greater frequency of shell-impressed pottery in the islands than on mainland East Africa, which has been held to imply initial migration to the former,48 might reflect only greater access to alternative ceramic choices in the latter. The Dembeni phase people cultivated rice in particular, and also millet, legumes, coconut, and bamboo. They husbanded goats and had some cattle and pigs.49 The relative frequency of exotic goods in Dembeni sites indicates fairly frequent access to coastal East Africa or Madagascar.

_Madagascar_

Investigations in Madagascan archaeology and historical linguistics40 indicate that human occupation extended back to about the mid-first millennium CE. Rockshelter sites of local foraging and open sites with evidence of swiddening date to the sixth to eighth centuries CE on the northeast coast and have evidence of iron working, shell-impressed pottery, and the manufacture of vessels from chlorite schist. Some radiocarbon date ranges in these sites extend back to the third century CE.
but there are uncertainties in their interpretation. By the tenth century, substantial settlements existed on the northeast coast, including the town of Mahilaka. It had locally made and imported ceramics that are very similar to those in the Comores, metal working, rice, goats, cattle, and imported glass beads. It probably exported rock crystal, chlorite schist vessels, natural products, and possibly slaves. In southern Madagascar, the earliest ceramics are of locally made Andaro style dating to about 900 CE and Triangular Incised Ware (TIW), common on the southern Swahili Coast 600–1000 CE.

The consensus formed on these data, that Madagascan archaeological remains extended back to the mid- or late first millennium CE, was challenged recently by evidence purporting to show that a rockshelter in northernmost Madagascar, which had been thought to date to the fourth to sixth century CE and was regarded as the oldest habitation site in Madagascar, had actually been occupied by at least 2000 BCE. This site, Lakaton’i Anja, and another in the north, Ambohiposa, are the first in Madagascar to disclose an industry of small flaked chert tools. In Lakaton’i Anja, flakes of coarse chert are found in all levels, but some of fine chert occur only near the base of the site. Ceramics in the upper layers date to the eleventh to fourteenth centuries CE and the lower layers were radiocarbon-dated on charcoal to the tenth to thirteenth centuries CE. However, optically simulated luminescence (OSL) dating of sediment deposition showed that the lowest layers were deposited 4,400 years ago, the middle layers 2,700 years ago, and the upper layers about 900 years ago. These dates were adopted as the site chronology.

The preference accorded OSL over radiocarbon dating in this case is, we think, mistaken. OSL uses samples from manifestly intact stratigraphy to date the natural sequence of sedimentation. It only dates cultural material within layers if those have not been disturbed. At Lakaton’i Anja, they had been disturbed by bioturbation, the result of large-diameter termite burrows extending from the upper to the lower layers. Movement of material through the burrows has inverted some radiocarbon dates on charcoal relative to their expected order of greater age with depth, and very likely it also allowed chert flakes from upper and middle layers to be redeposited in lower layers. It is much more probable, then, that the age of cultural material throughout Lakaton’i Anja is in the range of the seventh to thirteenth centuries CE, as it is in the cognate site at Ambohiposa. On that assumption, the earliest
archaeology in Madagascar does not date earlier than the mid-first millennium CE. Furthermore, given that almost none of the charcoal samples used in radiocarbon dating in Madagascar have been identified to taxa, the extent of the “old wood” problem is unknown and the dates overall are quite probably one hundred to three hundred years too old. This has not mattered as much as it might because other data have been interpreted as evidence that human occupation and anthropogenic biological change in Madagascar had begun much earlier than suggested by the archaeological chronologies. From evidence of forest firing and vegetation change, and from radiocarbon-dated bones of extinct animals bearing damage interpreted as cutmarks from butchery, the presence of people in Madagascar has been proposed as beginning 1,500–2,000 years ago, 2,000–2,500 years ago, or more than 4,000 years ago. The substantial literature on this matter cannot be considered adequately here, and in any case there is an undeniable possibility that a landmass the size of Madagascar might have been the setting for unconnected colonizations at different times and from unrelated sources. The scope of research is still too narrow to rule that out. Nevertheless, the region from which most of the data and the main hypotheses arguing for human habitation much earlier than the mid–first millennium CE come is southwest Madagascar, and our research there is coming to a more conservative conclusion about the age of initial colonization.

We cored lakes and swamps to obtain paleoenvironmental sequences and excavated in three sites—Ambolisatra, Itampolo, and Taolambiby—containing remains that have been central to hypotheses about initial human contact with Madagascan megafauna (these being giant species of lemur and tortoise, the huge elephant birds, large species of tenrec and the carnivorous Fossa, dwarf hippopotamus, and the Nile crocodile). Although sometimes described as archaeological sites, it is only at Taolambiby that there is relatively slight evidence of human occupation in the upper level of the site. Rather, these are primarily subfossil sites (i.e., places where the bones of animals that died naturally have been accumulated comparatively recently, in these instances in former lakes or ponds). All three sites, however, have produced megafaunal bones radiocarbon-dated to two thousand years ago or older that show purported butchery damage. We reexamined collections of Madagascan megafaunal bone in the University of Madagascar’s Museum of Art.
and Archaeology (Antananarivo), the Oxford University Museum of Natural History, and the National Museum of Natural History (Paris), in order to determine the nature and rates of potential cultural damage on megafaunal bone.

Some specimens collected more than one hundred years ago from the three sites exhibit scratches, scores, or puncture marks that have been interpreted as butchery damage. Our reexamination, including by electron microscopy, indicates that all of the scratches and scores are more plausibly attributed to taphonomic conditions, notably trampling of bones in gritty sediments. This was the case at Taolambiby in particular: bones in lacustrine sediments replete with coarse-grained quartzite rock and sand eroding from lake-edge scarps were trampled prehistorically by the dominant species, hippopotamus, and have been trampled since by cattle crossing the site to an adjacent waterhole. Crocodiles and other carnivores produced puncture marks and breakage, and some breakage and other damage has clearly occurred since the bones were collected.

The argument that megafaunal processing occurred at all rests more plausibly on perilously few cases of megafaunal bones that have undoubted cutmarks: slices, gashes, and chop marks that appear to have been made by metal tools. We agree with this assessment of the cause, but not with the implications of age that have been drawn from it. Our new data provide significant evidence. Excavations in the three sites produced a total of 2,756 bones or bone pieces, of both extant and extinct taxa, the largest such collection from Madagascar (the main extinct taxa in order are hippopotamus, crocodile, giant tortoise, giant lemurs; the former two probably overrepresented by their habitual attachment to water). We found no cutmarks on newly recovered bones from Itampolo or Ambolisatra, and at the latter our excavations showed that the bones were in association (i.e., in the position of a natural death assemblage). There is thus a question about whether the megafaunal bone damage was perimortem, as has been assumed. Examination of bone from Taolambiby showed that on the extant taxa, mostly of the sifaka lemur, *Propithecus verreauxi*, undoubted cutmarks occurred at a rate of 16.5 percent of the estimated minimum number of individuals (MNI). For the extinct megafauna, the cutmark rate for the total MNI is only 0.06 percent, or one specimen. During our excavations at Taolambiby we noticed that occasional inadvertent damage by field-workers
using the sharp, crescentic-edged Madagascan spades to clean trench faces produced planar cuts on subfossil bone shafts and clean slices across epiphyses if the bone was still bedded tightly in damp, dense silt. This damage is identical to that on examples of cut-marked megafaunal bones in museum collections, suggesting that perhaps it also occurred during the collection process.

Consequently, while we agree that there is evidence of cultural modification on a very small number of bones from extinct megafauna in museum collections, it is impossible to show that it was perimortem or to rule out modern damage. The radiocarbon age of bones alone is, thus, an unreliable guide to the age of the cultural damage they might have sustained. Reliable dates are restricted to bones recovered in controlled excavations, where the existence or absence of prior damage can be verified. At Taolambiby, there is only one clear cutmark of apparent ancient origin on a megafaunal bone from a newly excavated sedimentary context. It is a hippopotamus bone radiocarbon-dated to 690–880 CE. By our criteria, this is the oldest acceptable cutmarked megafaunal bone from Madagascar.

Irrespective of conclusions about the age of the damaged bones, it is important to understand that there is remarkably little material evidence of killing, butchery, or consumption of Madagascan megafauna. Substantial bone breakage, bone burning, and association of bone with butchery tools, charcoal, middens, and other signs of human occupation, which are the common attributes of megafaunal processing in Eurasia, the Americas, and New Zealand, have not been found in Madagascar. Flaked stone tools are scarce, probably because iron tools were available by the first millennium BCE in Southeast Asia and East Africa, potential source regions of Madagascan colonists, but the absence of butchery sites and the scarcity of other cultural evidence of interaction with megafauna is odd considering the abundance of megafaunal bone and elephant bird eggshell preserved in the sediments of southwest Madagascar. This raises questions about extinction, when and how in particular.

In regard to the chronology of extinction, the most detailed data set is from our research at Taolambiby, where a curve of charcoal abundance can be matched against radiocarbon dates on bone. The charcoal shows several spikes between 500 BCE and 950 CE and a rapid and continuing increase in abundance from 1100 CE onward. The 950 CE
charcoal spike corresponds with eighteen of nineteen radiocarbon dates from our excavations, including the youngest ages for all the megafauna that produced radiocarbon dates: hippopotamus, crocodile, and two giant lemurs (*Pachylemur, Archaeolemur*). We interpret these data as indicating that Taolambiby ceased to accumulate megafauna at about 1000 CE as the human population became more abundant, and probably permanently resident, in the vicinity. Among the last megafauna were the bones of small, extant fauna showing clear cutmarks. At Itampolo and Ambolisatra, our radiocarbon dates on megafaunal bone also terminate at 800–1000 CE, indicating that this was approximately the extinction period in southwest Madagascar for the megafaunal mammals.

Recent palynological evidence of vegetation change also suggests that undoubted anthropogenic impacts may have been later than argued previously. Forest burning up to two thousand years ago is largely confined to the arid southwest region, where natural firing would be expected in any case, with wetter regions showing later rises in charcoal abundance around 1000–1200 CE. A recent summary of the current Madagascan data points to substantial vegetation transitions and forest burning as occurring 800–1200 CE. Initial analyses of our sedimentary cores are showing similar results.

Whether megafaunal disappearance at about this time was the product of “imperceptible overkill” reflecting the vulnerability of generally conservative life histories among megafaunal taxa during a period of rapid human population growth, or due to the relentlessly deleterious effects of pronounced climatic dessication in Madagascar generally from 750 to 1200 CE, or to some other cause or combination of causes, there is little doubt but that the period around the end of the first millennium CE was the most critical. Some taxa continued in existence for several hundred years later in some places, probably including elephant birds in southwest Madagascar (radiocarbon dates on their eggshell extend up to about 1400 CE, even later), and crocodiles could always migrate naturally from the Comores or East Africa.

Our current view is that Madagascan colonization probably began around the eighth century CE, as in the Comores and very probably through them, and that it involved rapid dispersal of coastal settlement at low population density, especially along the west coast, which resulted in, or coincided with, the circumstances that caused substantial megafaunal loss by around the end of the millennium.
Hypotheses about initial colonization of the remote East African islands have proposed either migration from mainland East Africa in the first or second millennium BCE, especially to southwest Madagascar, or late first millennium BCE transoceanic voyaging from Southeast Asia. As we have argued, migrations so early are not supported as strongly in the archaeozoological and paleoecological data of Madagascar as once seemed to be the case. Additional considerations in this matter are the implications of paleobiological data, and of what is known about seafaring capabilities.

**Paleoecological and Archaeozoological Data**

Food plants transferred around or across the Indian Ocean from Southeast Asia to East Africa suggest that hybrid bananas were introduced to Africa by about 500 BCE, but as hybridization could have occurred in Southeast Asia or South Asia where there were wild bananas from at least the early Holocene, the question of source remains open. Evidence of genetic similarity between Southeast Asian and African banana cultivars still leaves the “mode of dispersal from Asia to Africa... uncertain; terrestrial and maritime routes have been proposed.” Yams and taro, probably cultivated in Madagascar from early in the second millennium CE at least, are of Southeast Asian origin, but when and how they arrived is unknown archaeologically. Rice and coconut were present by the late first millennium CE in coastal East Africa, the Comores, and Madagascar.

Archaeozoological data suggest, although questionably, that the domestic pig, a possible Southeast Asian import, occurred in the sixth to tenth centuries CE in Zanzibar and the Comores, but not until the thirteenth century in Madagascar. Madagascan dogs have genetic ancestry which is almost entirely African, with minor and probably later Southeast Asian infusion. The domestic chicken, found in the Comores and Madagascar by the ninth century CE, is descended from Southeast Asian junglefowls, but by 3,500 years ago it was widely spread from the west Pacific across Asia to North Africa. Haplogroups A and D occur in Madagascar, the former being the most widespread of all haplogroups globally and the latter having a South Asian origin but occurring prehistorically through Southeast Asia and the Pacific islands.
In Madagascar, chickens arrived as part of a group of African or South Asian domestic species, including cattle and goats, which had existed already for several centuries in coastal East Africa. The black rat reached northeast Africa from South Asia more than 2,000 years ago, and seems to have spread, possibly along with chickens, into East Africa by about the eighth century CE and to Madagascar soon afterward. Genetic data suggest that Madagascan black rats have origins in South Asia and came specifically from Arabian Peninsula populations. Independent colonization seems to have occurred at about the same time in Madagascar and the Comores, with some back migration from the former to the latter. Mice also seem to have arrived from the Arabian Peninsula. Recent evidence indicates that black rats reached Mauritius and Christmas Island a century or two before European discovery. Neither Southeast Asian rats with immense oceanic dispersal ranges in prehistory, such as *Rattus exulans* and *R. tanezumi*, nor the west Pacific *R. praetor*, seem to have reached African coasts or islands.

**Paleobiological Data**

Human genetic data for Madagascar show approximately equal origins in African and Southeast Asian populations, but also some South Asian ancestry, while Comorian genetics disclose a predominantly African origin, with 17 percent and 11 percent of Middle Eastern and Southeast Asian contributions respectively. The strongly mixed African–Southeast Asian genetic signature among both males and females throughout Madagascar indicates either that the initial immigrant population was already heterogeneous in origin, or that substantial heterogeneity arose very soon after the beginning of initial colonization. The first proposition rules out initial colonization by direct voyaging from Southeast Asia and the second implies either contemporaneous African colonization of Madagascar or that an African population was already in residence. The issue is accentuated by evidence that Malagasy mtDNA has a “Malagasy motif” that is not recorded in Indonesia, despite it being a variant of the Polynesian motif. If its absence there is confirmed in further research, then it must have originated early in the formation of the Malagasy population or within a group outside Southeast Asia prior to its colonization of Madagascar. Genetic modeling found that the mtDNA component arose from a small cohort of female colonists, perhaps thirty in all, with a very high proportion of Southeast
Asian ancestry. Evidence from Y-chromosome and autosomal single nucleotide polymorphisms (SNPs) show, however, that Malagasy have a dominant African origin in both coastal and highland populations. It is possible that there were groups of Southeast Asians settled along the main trading routes of the northern Indian Ocean, as suggested in Sri Lanka, but probably not in the Maldives, where evidence of more direct transoceanic movement could be expected. There, genetic analysis shows a strong correlation with South Asian populations and almost none with Southeast Asia, indicating that “the proposed Indian Ocean seafaring route through the Maldives did not include migration to these islands.”

Overall, these paleobiological data, which by no means exhaust the range now available, do record a significant contribution of Southeast and South Asian taxa to East Africa during the approximate period from 2,500 to 1,000 years ago, plus some evidence of African material and taxa being transferred to South and Southeast Asia. However, the evidence seldom points clearly to particular routes or modes of transfer. There is nothing in these data, for example, that requires transfer by sea, except across the Mozambique Channel (and of black rats to Mauritius and Christmas Island), even if it is very likely that much of the material was, in fact, carried by sea. Most particularly, there is nothing in these data to require direct oceanic passages between Southeast Asia and Africa.

**Seafaring Technology and Capability**

Systematic offshore seafaring in the Indian Ocean began about 2000 BCE with passages from the Red Sea and Persian Gulf to and from South Asia, and it expanded from about 1500 BCE to include sailing across the Bay of Bengal to and from Southeast Asia. Extended mobility between Southeast Asia, South Asia, and East Africa seems to have included the first remote islands, the Maldives, in the late first millennium BCE. From then on, ships of western Indian Ocean types sailing under squaresail frequented the East African coast until squaresail was widely replaced by the lateen sail, probably between the tenth and fifteenth centuries CE in this region. Whether there were direct transoceanic passages between East Africa and Southeast Asia by the late first millennium CE is open to question. Ned Alpers, in this volume, suggests that both littoral and transoceanic voyaging might have occurred between them at various
moments in time. On current data that is undeniable, but as the issue is important for the history of the remote islands, it is one worth pursuing further here, if only to suggest which propositions seem more plausible in the light of current evidence.

Southeast Asian shipbuilding was relatively advanced by the first millennium CE, as shown by archaeological remains of ships up to 20 meters (m) in length, and by contemporary Chinese references to larger ships from Southeast Asia. Those had been made by a distinctive Southeast Asian combination of edge-joined (by sewing initially and later by ties with an increasing use of treenails) and lashed-lug planks over inserted frames. The hulls may have been fitted with leeboards or outriggers, as in the famous engraving from Borobudur (although that seems to depict a raft). The ships were probably rigged with the canted squaresails known in Indonesia from at least the ninth century CE. But whether these early Southeast Asian vessels were ever sailed directly to East Africa is unknown. There are no East African shipwrecks of the period from which their presence or otherwise might be ascertained, and “ship graffiti” on the Swahili Coast are too late to be useful in this particular matter. It is worth emphasizing, however, that if transoceanic shipping occurred, it cannot have done so often, given the absence of premodern cultural remains on central Indian Ocean islands such as Diego Garcia.

The alternative is that transoceanic mobility involved the outrigger canoe, the characteristic vessel of local communities on each side of the ocean. It may not have operated far offshore on the African side, considering that Swahili maritime competence flourished only in the late first millennium CE, and also because the double outrigger, which seems to have been used in East Africa before a recent transition to single outriggers, implies inshore sailing, as open-sea conditions strongly favor the single outrigger. Southeast Asians, however, had much longer canoe-voyaging experience. This certainly included the use of outrigger technology, but it is not clear that this was an early Austronesian innovation, as it is so often described. In Austronesian linguistics, it is uncertain that *katiR = outrigger canoe belongs to Proto-Malayo-Polynesian (PMP), especially as specific terms for outrigger technology are later Proto-Oceanic (POc) innovations from the west Pacific rather than Southeast Asia. Island Southeast Asian rock-art includes pictures of boats that, in the main, probably belong to an “Austronesian painting
tradition.” None of the rock-art boats has been radiocarbon-dated directly and some are probably recent. Others, though, are stylistically similar to boats shown on Dong Son drums, dating 1000–0 BCE. Against the expectation that at least some of these boats would depict outrigger canoes, none does so. Conjecture about early Holocene outriggers in China is unconvincing, and the earliest, indirect, archaeological evidence of outriggers is from Sri Lanka, about 300 BCE, much earlier than the first depiction of outriggers in ninth century CE Java.

There is similar uncertainty over sailing rigs. PMP *layaR = sail is early, but terms that refer to spars or rigging are later (e.g., POc *jila = spar, boom, or yard, while Proto–Eastern Oceanic *pana = mast or boom, probably dates to the first millennium CE).

These data suggest that Austronesian sailing technology may have developed rather slowly and perhaps differently between the Indian and Pacific oceans despite common origins. It is then problematic to envisage Pacific innovations such as the Oceanic spritsail as the rig that enabled long-distance sailing by Southeast Asians to Madagascar and East Africa. Historical evidence shows no Oceanic spritsail in the western Indian Ocean, but rather outrigger canoes propelled by the double spritsail (a rectangular sail held up by angled spits, or spars, to each of its upper corners in such a way that the rig could be shaped fore-and-aft).

The early Indo-Pacific history of the double-sprit rig is, like so much else, also obscure. It might have come from the common spritsail that existed in the Mediterranean from the late first millennium BCE, and was possibly carried into the Indian Ocean more than two thousand years ago along with the Mediterranean squaresail. But there was a more rudimentary form of double spritsail found historically from the Bay of Bengal to the Pacific Ocean as far east as New Zealand. It consisted of a high, narrow, quadrangular sail attached along its length either side to spits that were each held erect by a forestay and brace or sheet and running forecast. This form of double spritsail may have originated in China and been carried into Southeast Asia by Austronesian dispersal. Its existence begs the question of whether East African double spritsails were early adaptations of Mediterranean spritsails or convergent designs that derived from the Austronesian form.

The significance of this necessarily technical discussion is that while the East African historical type had some windward ability, the Austronesian form did not. It would have been extremely difficult for
outrigger canoes under Austronesian double spritsails to make successful transoceanic passages from Southeast Asia to East Africa. Computer simulation shows that the passage is effectively impossible by downwind sailing in either direction. Even sailing with a modest windward ability, such as that conferred by the western Indian Ocean spritsail, the simulations show that few routes were feasible, the best being from northern Sumatra to Madagascar in January through February with passage times of ten to thirteen weeks, which are very long periods for delivering a colonization group of sufficient size to have a reasonable chance of population longevity. These simulations, moreover, were conducted using modern marine meteorological data. Recent work in the South Pacific shows that those data can be very misleading for understanding sailing conditions a millennium or more ago. Until sailing conditions around the late first to early second millennium CE have been established similarly for the Indian Ocean, the possibilities for transoceanic voyaging to East Africa will remain almost entirely conjectural, while the existence of littoral routes is a matter of historical consensus.

SEAFARING AND COLONIZATION IN A DIVIDED OCEAN

The Indian Ocean enigma considered here is that, despite a longer and richer history of premodern maritime mobility than in the other oceans, relatively fewer of its remote islands were inhabited before 1500 CE. This seemed especially odd in light of the frequently advanced proposition that Southeast Asian seafarers made direct transoceanic passages between Indonesia and East Africa, in some versions beginning in the last millennium BCE. It is purported that people, cultigens, commensals, and artifacts were carried in each direction between Indonesia and Madagascar, independently of movement along established trade routes, terrestrial and coastal, around the northern perimeter of the Indian Ocean. Our fieldwork on the central oceanic islands, together with earlier conclusions, uncovered little material evidence of a premodern human presence that might support this hypothesis. In addition, to the extent that the hypothesis has relied upon arguments of early colonization in Madagascar for its assertion of early transoceanic seafaring, we also find it unconvincing. The proposition that there is clear evidence of butchery marks on bones of extinct megafauna radiocarbon-dated up to 2000 BCE in Madagascar is eminently debatable. Focusing on
megafaunal subfossil sites of the southwest region, we examined both the historical bone collections from which propositions of early butchering had been advanced and our own newly excavated material. We concluded that there is no reliable evidence of megafaunal butchery prior to the mid-first millennium CE and that most of the extinct species survived up to about 800–1000 CE, some later than that. Recent paleoenvironmental studies, including ours, also date initial anthropogenic changes in vegetation to about the same period.

Whether evidence of connections between Madagascar and Indonesia implies direct transoceanic voyaging also remains open to debate. Madagascan and Comores human populations certainly have Southeast Asian genetic origins to a significant extent, and these are supported by linguistic and customary attributes, as well as some elements of material culture, but nothing about these features compels the conclusion that migrants sailed directly across the ocean. Some introduced plants and animals in the remote East African islands likewise have Southeast Asian origins, but they may have come through South Asia or continental East Africa before transfer to the remote islands. Our research on remote islands in the central Indian Ocean that are often suggested as waypoints in transoceanic voyaging found little evidence of premodern contact. Furthermore, the rather sparse evidence of seafaring does not suggest transoceanic passages to East Africa in Southeast Asian ships or in outrigger canoes. The latter may have been simply a domestic boat-building tradition carried by Southeast Asian migrants who had traveled in existing perioceanic shipping, and the double spritsail used on western Indian Ocean outrigger canoes has potential origins in both Southeast Asia and East Africa. The limited evidence of premodern contact in the Chagos, Mauritius, and Christmas Island is also relatively late, fourteenth and fifteenth century—too late to be relevant to transoceanic colonizing movements by Austronesians. Nevertheless, it is the earliest manifestation of voyaging into the heart of the Indian Ocean, and as such, it might represent explorations, possibly by Arabic shipping, under a newly arrived lateen sail.109

We agree with a recent assessment that “pre-first millennium AD Austronesian migrations to eastern Africa and Madagascar remain entirely hypothetical and are not currently supported by solid evidence,”110 but we also think that propositions of frequent trading or raiding directly from Southeast Asia to East Africa, or of a “dispersal corridor”
directly from Southeast Asia to the remote East African islands remain rather far from demonstration. As one scholar points out, neither the Barito Dayaks who formed the nucleus of the Malagasy Southeast Asian population nor the Malagasy ever had the seafaring technology required to cross the Indian Ocean. However, the Malays did: they provided most of the Malagasy seafaring terminology and were active participants in late first millennium CE trading networks that extended around the northern coasts of the Indian Ocean to East Africa.

In the current state of knowledge, at least half of the genetic composition of Malagasy people is African, and pigs, dogs, chickens, rats, and mice had mainland African or far western Indian Ocean residence prior to movement to Madagascar. These data suggest that, the significant contribution of Southeast Asian genetic and cultural elements notwithstanding, the formation of the Madagascan colonizing population, both human and commensal, took place in East Africa and departed from there. The alternative is that migration from mainland Africa was temporally coincident with transoceanic voyaging from Southeast Asia, but on the ground of parsimony we prefer the former hypothesis. We envisage mid- to late first millennium CE Southeast Asian migration to mainland East Africa along well-established voyaging routes around the northern perimeter of the ocean, probably in Southeast or South Asian commercial vessels that brought functioning groups of Malay and Indonesian migrants to East Africa, and thereby into the nascent Swahili population. Subsequent movement to Madagascar and the Comores was perhaps by Swahili groups in which Southeast Asians held socially dominant positions.

Migration, we have suggested, followed trade in the Indian Ocean, and up until the sixteenth century, the trade that connected the Indian Ocean also divided it, a point made since antiquity. By the second century CE, geographers such as Ptolemy saw the Indian Ocean (Indikon pelagos) as two seas. A largely northern region in which sea travel and trade were well established was the Erythraean Sea (probably meaning red or glittering), sometimes the Mare Indicum, which stretched from the Red Sea eastward to India, Sri Lanka, and the Gulf of Bengal. In the first century CE guide *Periplus Maris Erythraei*, it also extended southward along coastal East Africa to the Tanzanian islands. The remaining ocean, unknown to classical geography, was a largely southern vastness called the Mare Prasodum, a name often glossed as “Green Sea” after...
Latin prasinus, meaning “green,” but which more correctly referred to prason (weed or kelp). Perhaps the inference of a “Seaweedy Sea” was that sailing was impeded there and the Mare Prasodum was thus to be avoided.\textsuperscript{114} The ancient perception of a divided ocean had a continuing historical validity,\textsuperscript{115} which is also evident in the premodern history of island colonization.

Throughout the Indian Ocean north of the equator, and extending to seven degrees south down the coasts of East Africa and Indonesia, all the islands were colonized more than 2,500 years ago, in some cases much earlier than that. South of the equator, most islands were uncolonized until the modern era, and the few exceptions, we argue, not until within the last 1,300 years: Comores and Madagascar. Some of the reasons for this are readily apparent. Early seafaring developed from Red Sea and Persian Gulf beginnings in the northern Indian Ocean where monsoonal conditions, understood in a maritime context by at least 2,000 years ago, allowed predictably seasonal return voyaging before the wind, in boisterous summer westerlies and steadier, winter easterlies across the Arabian Sea and Bay of Bengal. Further south, the monsoon winds were mainly from southwest and northeast and they were largely confined to within about 500 km of the East African coast as far south as the Mozambique Channel. Consequently, while the Comores and northern Madagascar were within the monsoon region, all the other habitable islands south of the equator remained largely within the southeastern tradewind zone.\textsuperscript{116} Virtually the entire premodern colonization of Indian Ocean islands can be perceived, then, as a phenomenon of the monsoons and of the peculiarities of seafaring networks and boat technology that developed within them. Equally, it might be said that the modern colonization of the other remote islands was a phenomenon of the tradewinds and the voyaging technology developed in them, initially in the Atlantic.\textsuperscript{117}

Turning back to our original hypotheses to account for the remote islands enigma in the Indian Ocean, it is apparent that the first can be discarded, at least provisionally. In Crossing the Green Seas, we tested the previously established colonization record and found that it was robust. A premodern landfall was recorded in Diego Garcia and similar contact can be inferred in Mauritius and Christmas Island but remains of colonization, or of any habitation at all, are lacking. The second hypothesis has some substance. Which remote islands were inhabited
before the sixteenth century depended essentially, we propose, upon whether they were located within the monsoon wind system. As that was distributed to the north tropics and the western side of the ocean, at least according to modern observations, it included only remote islands that were relatively close to continental shores. The monsoonal wind directions switched into the northwest about 500 km off the East African coast, a direction dangerous for seafarers who did not want to sail far into the unknown with little prospect of working back against the wind. The third hypothesis is particularly important. The northern perimeter of the Indian Ocean had been a major routeway for migration and, presumably, down-the-line exchange between small-scale communities since the Pleistocene migrations of *Homo sapiens*. By at least the third millennium BCE, marine mercantilism featuring extended offshore seafaring had arisen with the advent of the sail and in the context of developing complex polities, notably in the Persian Gulf and the Indus Valley. Imperatives of trade and regular seasonal variation of sailing conditions, acting in mutual coercion, had probably produced a system of monsoonal cabotage several millennia before the time of Hippalus, the legendary first-century-BCE Greek navigator to whom some classical writers attributed the discovery of the southwest monsoon. 118 The quite precise constraints of maritime technology and commercial practice that made this system successful from mid-Holocene antiquity up to modern times precluded much exploratory voyaging, and any island colonization, beyond its limits. It is in the light of a long-term requisition of seafaring for trade, with its deployment shaped by the agency of the monsoonal winds, that we can understand the premodern remoteness of so many islands in the Indian Ocean.

**ACKNOWLEDGMENTS**

We thank the following for facilitating research on Diego Garcia: The British Indian Ocean Territory Commission, Professor Charles Sheppard, Nigel Wenban-Smith, Commander Richard Stephens Royal Navy, Major Peter Carr Royal Marines, Adrian Cresse, Chris Hillman, Nigel Prickett, and Amy Prendergast. For research assistance in the Seychelles we thank the Seychelles Bureau of Standards, the National Heritage Division, the National Monuments Board, and the National Museums of Seychelles, especially Marcel Rosalie, Elvis Nicette, Cecille Kalebi,
Thérèse Barbé, Christian Reepmeyer, and Rosanne Anderson. For assistance with the Madagascan project we thank Mike Parker Pearson, Chantal Radimilahy, Ramilisonina, Lucien Rakotozafy, Harimbolamanana Rasamoelina, Rodin Andrianjafisoa, Victor Rasanatovo, Retshitse, Amy Prendergast, Jean-Luc Schwenninger, and the Université d’Antananarivo. Anthony Cheke and Julian Hume kindly provided information on the Mascarenes, and Ken Aplin advised the black rat radiocarbon results from Christmas Island. We thank Krish Seetah for his assistance to the ANU Indian Ocean project and for his hospitality during the Stanford University workshop on the Indian Ocean in March 2014. Valuable comments on our paper were received from others at the meeting and subsequently. We thank Emily Kent for help with our bibliography.

NOTES


3. 1500 CE is taken here as the beginning of the modern era in the Indian Ocean.

4. By “habitable ocean,” we mean the tropical and temperate regions. The number of habitable islands in each ocean depends on the criteria used and the scale of resolution at which islands are counted. The data used here are from a conservative file on the UN system-wide earthwatch site, http://islands.unep.ch.

5. We define “remote islands” as those that required a single passage distance of at least 250 km. It is not an entirely arbitrary distance. Coasting vessels in the Indian Ocean two thousand years ago were making about 50–60 nautical miles (roughly 100 km) per 24 hours, partly because they often lay ahull during darkness, so 250 km represented at least two nights at sea and generally sailing out of sight of land; thus, probably a planned voyage well offshore. The geological distinction between “continental” and “oceanic” islands is useful but from a seafaring perspective it is distance and sailing conditions relative to technological capability, rather than geological origin, that determine the degree of remoteness.

7. W. Foster, ed., The Journal of John Jourdain, 1608–1617, Describing His Experiences in Arabia, India, and the Malay Archipelago (Cambridge: The Hakluyt Society, 1905), 50. The Mauritian dodo is the best-known case from which such deductions were made, but others carry the same implication (e.g., the source of the startlingly feminine coco de mer, collected on beaches in the Maldives and highly valued in medieval Europe, was unknown until its sensational discovery growing abundantly on Praslin Island by the Marion DuFresne expedition in 1768).


11. Vink, “‘New Thalassology.’”


14. Vink, “‘New Thalassology.’”


18. Vink, “‘New Thalassology,’” 59, paraphrasing a remark about the Atlantic by John Elliot.


The IPWP is the large expanse of unusually warm water that extends from the equatorial eastern Indian Ocean through island Southeast Asia to the west Pacific. Changes in it are reflected in irregular fluctuations of the ENSO in the Pacific and in the similar IOD system.


40. In the absence of any other evidence, we hoped that radiocarbon dates on shell and charcoal, although lacking any cultural context, might suggest a period of premodern human habitation. They did not.

41. G. R. Tibbetts, Arab Navigation in the Indian Ocean before the Coming of the Portuguese (London: Luzac and Royal Asiatic Society, 1971). Tibbetts disagrees with the frequent assertion—for example, G. F. Hourani,
Arab Seafaring in the Indian Ocean in Ancient and Early Medieval Times (Princeton, NJ: Princeton University Press, 1951), 83—that da Gama was guided by the famous Arab navigator Ahmad Ibn Majid, who had been one of the authors of the geographical texts published in the late fifteenth century that mentioned the Zarin Islands.

42. Da Gama did not land, nor did he write that on one island a fire and some people, possibly castaways, were seen on a beach, as reported by a Flemish sailor in da Gama’s fleet. W. McAteer, Rivals in Eden, Being the First Part of the History of the Seychelles, 1742–1827 (Mahé, Seychelles: Pristine Books, 2001), 17, 264.

43. For example, volume 20 of the Encyclopaedia Brittanica (Chicago: University of Chicago, 1968), 30, says this: “The Seychelles are believed to have been visited in the twelfth century by ships from the Arabian Sea and Persian Gulf.” According to L. Mair and L. Beckley, Seychelles: The Bradt Travel Guide (Chalfont St. Peter, UK: Bradt Travel Guides, 2008), 11, “islands in roughly the same position as the Seychelles appeared in Arab documents dated AD 851. A cluster of mouldering graves, believed to be those of Arab sailors, has also been found on the island of Silhouette.” However, A. C. McKenzie, “Fragments of Early Seychelles History,” Journal of the Seychelles Society 1 (1961): 7–21, writes that Arab texts from 851 CE and 915 CE refer to the Maldives and, vaguely, to high islands beyond.


47. Wright, “Early Seafarers,” 35.


55. Disagreement between charcoal and OSL dates is not uncommon, and for very similar reasons as here. For example: rat bones in New Zealand were dated two thousand years old by association with OSL, but subsequent reexcavation showed heavy bioturbation, and radiocarbon dates directly on the rat bones then showed that none were older than 1200 CE. J. M. Wilmshurst et al., “Dating the Late Prehistoric Dispersal of Polynesians to New Zealand Using the Commensal Pacific Rat,” Proceedings of the National Academy of Sciences USA 105 (2008): 7676–80. Ekblom, Anneli, Paul Lane, Chantal Radimilahy, Jean-Aime Rakotoarisoa, Paul Sinclair, and Malika Virah-Sawmy. “Migration and interaction between Madagascar and eastern Africa, 500 BC–1000 AD: An archaeological perspective.” In Early Exchange between Africa and the Wider Indian Ocean World. edited by G. Campbell, 195–230. New York: Palgrave MacMillan 2006, refer
surreptitiously to our spoken remarks about Lakaton’i Anja and misrepresent our view on OSL dating and Madagascan chronology.

56. Radiocarbon dating measures the age at which an organism died. As trees are often long-lived, and their inner wood is already long dead, many charcoal dates are too old. The old wood problem bedeviled Polynesian radiocarbon dating for many years until routine identification of charcoal to find material from short-lived shrubs or grasses became a routine requirement. That is not yet the case in Indian Ocean island research, largely because there is no readily available expertise to do the identification, so our charcoal dates, along with most others, should be regarded as approximate.


63. Whether it occurred around the time of death, either as a cause of that or in subsequent processing of the carcass.

64. This is especially so in the National Museum of Natural History (Paris), where heavy chopping on megafaunal bones appears modern and was seemingly intended to create pegs or similar articles out of subfossil bone.

65. We assume that the cutmark is contemporary with the radiocarbon date but, strictly speaking, all we really know is that it was preexisting (before excavation). It is possible that it was made at some substantial time after the death of the animal. It is important to note as well that radiocarbon dating of bone has improved markedly since most of the earlier determinations on Madagascan megafauna were made in the twentieth century. One consequence is a high rate of dating failure today: of fifty-five bone samples that we submitted for accelerator mass spectrometry (AMS) dating at Oxford University, twenty-seven were rejected during processing. It is probable that many of the bones dated some decades ago would have failed today, and that their results are unreliable.

66. Radiocarbon samples on giant tortoise, elephant birds, and some giant lemurs from our excavations failed to produce results.


69. Virah-Sawmy, Willis, and Gillson, “Evidence for Drought.” Severe aridification may have played a significant part in extinction of giant lemurs as these often used nonriparian habitats that were already very dry. B. E. Crowley, L. R. Godfrey, and M. T. Irwin, “A Glance at the Past: Subfossils,

70. It is possible that early Madagascan colonists, having some domestic animals of their own, did not bother to hunt adult megafauna for food. If they preferred juveniles, especially very young animals, taking them individually as needed and processing them in domestic sites, then not much could be expected to survive. Juvenile bone decays much more rapidly on the ground surface than adult bone, and is often consumed by dogs and other scavengers. Until we have much more evidence from early middens, the rate of predation upon the Madagascan megafauna cannot be estimated. It was, though, potentially significant to “imperceptible overkill” through slaughter of juveniles (Brook and Johnson, “Selective Hunting of Juveniles”). In that case, the scarcity of megafaunal bone in cultural sites, and the still greater scarcity of undoubted butchery damage on collected megafaunal bones that are almost entirely from adult individuals, do not provide useful guides to human-megafaunal interaction in Madagascar or its role in megafaunal extinction.


75. Boivin et al., “East Africa and Madagascar”; and Fuller et al., “Archaeobiology of Indian Ocean Translocations.”


88. Square sails were the early sail form in the Indian Ocean and China up to the second millennium CE and square or quadrilateral sails were


91. Speculation that ships such as that depicted at Borobudur did sail to Madagascar was indulged by J. Hornell, “Outrigger Devices: Distribution and Origin,” *Journal of the Polynesian Society* 52 (1943): 91–100, but without adduction of evidence.

92. C. Breen and P. J. Lane, “Archaeological Approaches to East Africa’s Changing Seascapes,” *World Archaeology* 35 (2004): 469–89, say the graffiti are thirteenth to sixteenth century CE. R. J. Whitewright, “Maritime Technological Change in the Ancient Mediterranean: The Invention of the Lateen Sail” (PhD diss., University of Southampton, 2008), has fifteenth century for square-sailed ships resembling *mtepe* at Zanzibar and sixteenth century for the earliest depiction of a lateen rig.


97. Pawley and Pawley, “Canoes and Seafaring”; and A. Pawley, “Austronesian Dispersal.” These terms are: *patoto = outrigger connecting sticks; *katae = canoe side without outrigger, and *kiajo = outrigger boom. Some of them may refer not to outriggers in the modern sense, but to their precursors, such as bamboo floats attached to hulls. Proto-Oceanic is associated with Lapita culture, dating about 1200–600 BCE.


99. Depicting outriggers might have been difficult in the side-on perspective adopted. Lape, O’Connor, and Burningham, “Rock Art.”


105. A. Anderson, “Catching the Wind: The First Great Phase of Oceanic Colonization” (lecture, New Zealand Aronui Lecture Series, Royal
A. Schottenhammer, “The ‘China Seas’ in World History: A General Outline of the Role of Chinese and East Asian Maritime Space from Its Origins to c. 1800,” *Journal of Marine and Island Cultures* 1 (2012): 63–86, thinks that functional sails may not have been in use in China until about 500 BCE, but agrees that they were probably invented by people such as the Yue, who were, as it happens, part of the Southeastern non-Han population from which sprang the Austronesian speakers.

106. Captain Cook and Joseph Banks commented on the absence of a windward capacity in the Maori sailing rig, the Austronesian form of the double spritsail. Modern examples of the spritsail in Madagascar have a useful windward capacity but we note that in these, one sprit is stepped and stayed as a mast so the rig is now effectively a common spritsail, not a double spritsail.


109. The existence of the lateen sail in the Indian Ocean before the arrival of the Portugese is uncertain. Iconographic depictions date to no earlier than the fifteenth century, but slight archaeological data suggest it may have been used by the thirteenth or fourteenth centuries and perhaps earlier. Whitewright, “Maritime Technological Change,” 166.


111. As proposed variously by Beaujard, “First Migrants to Madagascar,” Figure 1; and R. Blench, “Two Vanished African Maritime Traditions and a Parallel from South America,” *African Archaeological Review* 29 (2012): 281. Other scholars suggest a midoceanic staging point such as the Maldives or Sri Lanka; for example, Fuller et al., “Archaeobiology of Indian Ocean Translocation,” 15.


Investigating Premodern Colonization of the Indian Ocean

Factor,” in East Africa and the Indian Ocean, ed. E. A. Alpers (Princeton, NJ: Marcus Wiener, 2009), 39–51, envisages a lengthy island-hopping movement down the coast of East Africa, and its creolizing impact on Indonesian immigrants, before migration to Madagascar. The hypothesis of Southeast Asian migration along established trade routes to East Africa and thence to the remote islands is almost precisely opposite to that preferred by Allibert, “Austronesian Migration.”


115. As observed by Toussaint, History of the Indian Ocean, 6–7.

116. More than 500 km or so offshore, the northeast monsoon winds turned northwesterly and flowed intermittently over the Seychelles and Chagos. The northwesterlies blowing offshore into an apparently empty ocean were probably a danger known to early navigators that reinforced their persistence with coastal routes.

117. Tradewind-adapted seafaring was the primary agency of interoceanic globalization in the sixteenth to eighteenth centuries.

118. The story is legendary. “Hippalus” is more probably a misspelling of bipalum, meaning “the wind from below or under the sea” (i.e., from the unknown regions to the south), according to McGrail, Boats of the World, 256.