



Middle Holocene Environmental Change at Mtwapa Creek, Kenya: Distinguishing Human Activity from Regional Ecological Processes

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Abstract. Very little is known about human occupation of the East African Coast prior to the Swahili period. Only a handful of pre-Swahili archaeological sites from this region have been investigated in any detail. The Holocene archaeology of the coastal region requires research attention if the role of indigenous African populations in later ethnic mosaics is to be understood. Pollen, fungal spores, and charcoal remains from a sediment core derived from Mtwapa Creek are presented with the goal of better understanding mid-to-late Holocene (c. 7500–4000 cal yr BP) occupations of the coast. Evidence for increased local burning, herbivore activity, and overall landscape disturbance possibly derived from cultivation activities characterizes the period between c. 6200–4000 cal yr BP. Intensive exploitation of riverine habitats was practiced in the neighboring hinterland during this period, and it is proposed that similar adaptations may have been at play in coastal drainages at Mtwapa Creek and elsewhere contemporaneously. A variety of investigative methods are proposed that may yield additional information on human activities during this time period.

Keywords: Anthropogenic impact · Coastal ecosystems · Fungi
Intertidal core · Holocene · Paleoecology · Palynology · Swahili

Introduction

In contrast to the well known Swahili cultural phenomenon of the past two millennia, the archaeology of the pre-Swahili East African coast has been largely ignored. Indeed, the scope of human activities in this region prior to the Late Holocene is almost completely unstudied. Exceptions to this trend are few and far between (Omi 1982, 1984, 1986, 1991; Helm 2000; Helm et al. 2012; Shipton et al. 2018), yet this evidence suggests that the East African Coast was rife with human activity through, and perhaps previous to, the Holocene. As little archaeological detail dating to the Early and Middle Holocene is yet available for this region, a landscape-scale approach is employed here to render any significant changes to ancient coastal ecologies due to human activities visible. In an effort to clarify the nature of pre-Swahili human environmental impacts, I offer a paleoecological reconstruction of Mtwapa Creek Estuary and the surrounding environs during the Middle Holocene (c. 7500–4000 cal yr BP), using pollen, microscopic

charcoal, and fungal spore data from a sediment core spanning this period. This data is then integrated with known archaeological knowledge of Holocene human occupation of the East African coast. First, a brief overview of integrated palynological and fungal research in East Africa is presented, followed by a review of pertinent archaeological data from the East African coast. Next, nested microbotanical data from a 5 m sediment core collected at Mtwapa Creek are discussed and interpreted. I use these interpretations to hypothesize the nature of human occupation of this area during the Middle Holocene, and advocate for the usefulness of interpreting multi-proxy environmental records in light of local archaeological evidence as a potential means of dealing with equifinal data sets. Finally, suggestions for additional topical research are put forth.

Multi-proxy paleoecological data sets have aided in defining environmental and cultural chronologies in numerous regions in East Africa (e.g. Cohen et al. 2005; Gelorini et al. 2011, 2012a, b; Lejju et al. 2005; Palacios-Fest et al. 2005a, b; Rucina et al. 2009; van Geel et al. 2011; Wooller et al. 2003; and many others). Lejju et al. (2005) have reconciled several lines of paleoecological evidence, including pollen, phytoliths, and fungal spores, with archaeological and historical evidence at Munsa, Uganda to better understand site use and occupation. Further South, past ecological change at Lake Tanganyika has been documented in a set of very detailed environmental records derived from numerous proxies by Cohen et al. (2005) in a special issue of the *Journal of Paleolimnology* (Palacios-Fest et al. 2005b). Data from fungal spores is emphasized more specifically by Gelorini et al. (2011, 2012a, b) and van Geel et al. (2011). Van Geel et al. (2011) analyzed an assemblage of fungal “non-pollen palynomorphs” (NPP’s) from Lake Challa in southeastern Kenya, and found that more than two thirds of typed NPP specimens could be identified, or “linked,” to known taxa of fungi. As study of microscopic African fungal bodies is still in its relative infancy, many specimens which could not be reliably assigned to taxonomic groups were “typed” according to shared morphological affinities. Nevertheless, the authors found that diagnostic spores could often be assigned to known genera or species, yielding (in these cases) a level of taxonomic resolution similar to that possible with pollen grains. Of these diagnostic types, a variety are substrate-or-environment-specific indicators. *Sporormiella*, for example, has been documented as an obligate coprophile, growing exclusively on dung substrates (Davis 1987; Davis and Shafer 2006; Raper and Bush 2009; Parker and Williams 2011; Baker et al. 2013).

Local Environment and Sedimentary Context

The surrounding landscape of Mtwapa Creek today is agrarian to semi-urban in nature. Agricultural activities in the vicinity are largely coconut, mango, and maize farming. Small-scale husbandry of cattle, goats, and sheep is also practiced. The coring location is situated approximately 4 km West of the town center of Mtwapa on a tidal mudflat off the northern shore of the Mtwapa Creek estuary. A band of small agricultural homesteads shields the coring site from the small commercial area surrounding the B8 highway, the major (and only) North-South highway serving the coastal region. Moisture availability in the near-coastal plain is greater than in the more arid hinterland. Rainfall in the region varies between 800–1400 mm per annum (Oosterum 1988).

Recent coastal sediment deposits in this region, dating to the post-Pleistocene, have been described by Thompson (1956), Williams (1962), and later by Oosterum (1988), who synthesized descriptions from these and other earlier studies, and whose designations I employ here. The intertidal mudflats from which core material was extracted belong to the aptly named *recent tidal-flat deposits* identified by these authors, being derived primarily from fluvial sedimentation processes. Sedimentary material comprising these deposits originates primarily from surrounding land terraces eroded via rainfall and mechanical disturbance, as well as suspended particulate matter of small size transported into mudflats at high tide. These mudflat deposits occur frequently in mangrove environments throughout the East African littoral, and have been characterized as Thionic Fluvisols (Michieka et al. 1978; Boxem et al. 1987). These sediments are comprised of dark grey-to-olive green clays and clays with varying proportions of sand in their matrix. These deposits have been identified as Holocene and Late Pleistocene in age, with only very gentle gradation in sediment characteristics being detectable over this timespan.

Mangrove communities are by far the predominant vegetation along the estuary margins and undeveloped parts of the coast. Eight of the nine recognized species of East African mangroves are native to Kenya, including *Rhizophora mucronata* (Lam.), *Ceriops tagal* (C. B. Rob.), *Bruguiera gymnorrhiza* (L.), *Avicennia marina* (Forsk.), *Sonneratia alba* (Sm.), *Heritiera littoralis* (Aiton.), *Xylocarpus granatum* (Koenig.), and *Lumnitzera racemosa* (Willd.). The ninth species, *Avicennia officinalis*, is today found only in coastal Madagascar. Local coastal communities frequently rely on mangrove forests for building timber, craftworking (e.g. construction of fish traps), and as a fuel source (Taylor et al. 2003). According to Taylor et al. (2003) mangroves are a lynchpin of estuarine ecologies, with leaf litter from mangrove forests responsible for a large portion of organic inputs into these environments. Mangrove pollen is well represented throughout the sediments examined here.

Pre-Swahili Archaeological Research

Available data on Holocene human habitation of the East African coast is very scanty in comparison with what is known of the later Swahili occupations of the region. Linguistic and ecological evidence has been cited in argument that southwest Asian colonizers definitely encountered significant populations of indigenous African peoples occupying the coast (Schoenbrun 1993; Ehret 1998). However, only a few studies containing primary data relating to ‘stone age’ coastal occupants have been published, spanning from present day Mozambique (Morais 1988; Adamowicz 1990) north through Kenya and Tanzania (Soper 1966; Chami and Kessy 1995; Kessy 1997; Chami 1998; Omi 1982, 1984, 1986, 1991; Shipton et al. 2018), and into Somalia (Coltorti and Mussi 1984). A succinct overview of these studies is provided by Helm (2000), but the findings of Omi (1982, 1984, 1986, 1988, 1991) will be the primary sources discussed further here, as lithics pre-dating the Early Iron Age are detailed there. The very recent findings of Shipton and colleagues (2018) are not discussed here.

Omi (1982, 1984, 1986, 1991), and contributors to these reports, describe multiple coastal archaeological sites in varying degrees of detail (See Fig. 1), focusing primarily on the geomorphic and stone tool content of each. The main site of focus in these

studies however, is the large, multi-component hillside site from where these volumes get their name, Mtongwe. This site, southwest of Mombasa City, across the large creek channel, is dominated by three separate hills: Sassoon Hill, Omar Hill, and the more southerly Ali Abubakar Hill. Excavations were performed at each of these hill site areas of Mtongwe. The authors provide detailed maps of the sedimentary strata encountered in various excavations at Mtongwe, but the only artifactual evidence presented is recovered lithic material.

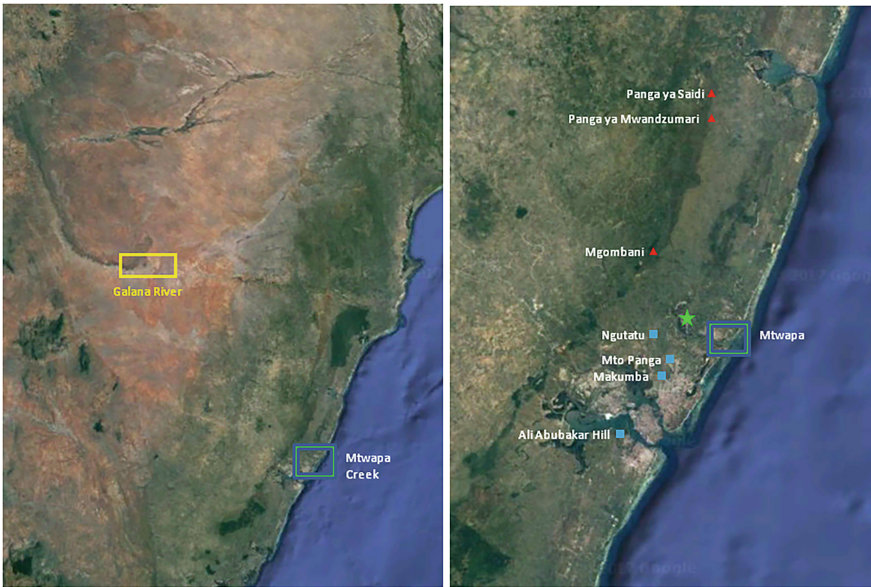


Fig. 1. Location map of the study area.

Considerable variation exists between the lithic assemblages recovered at each hill excavation. Following this, Omi (1984) argues that these assemblages reflect human activity spanning the “... *Earlier Stone Age to the Later Stone Age* (Omi 1984, p. 22; authors emphasis).” Unfortunately, Omi and colleagues do not employ lithic typologies specific to East African stone tool industries, assigning given finds to “Acheulean,” “Mousterian,” or “Fauresmith” industries. Nevertheless, detailed drawings and measurements, and even photographic plates in later volumes of this series, are provided of recovered lithic implements, allowing independent analysis of these assemblages. The exact identities of lithic assemblages analyzed and recovered during these excavations are beyond the scope of this chapter. It suffices to say that variation in lithic assemblages recovered from Mtongwe and other coastal sites such as Panga ya Saidi (Shipton et al. 2018) suggests that human occupation of the Kenyan coast prior to the advent of the Swahili period persisted for some time.

The few published radiocarbon dates from this project (Omi 1991), derived from materials excavated at Ali Abubakar Hill, support the notion of human coastal occupation from at least the Late Pleistocene into, and likely through, the Holocene and proto-Swahili period, slightly predating the second millennium BP. Four radiocarbon assays were made on charcoal recovered from a bed of reddish orange sand with

calcareous particles in the matrix. The resultant dates varied in age considerably, ranging from $17,680 \pm 270$ BP [$21,325 \pm 367$ cal BP] to $1,090 \pm 90$ BP [953 ± 186 cal BP]. Calibrated dates reported here were obtained via Calib 7.1, using the SHcal13 calibration curve (Stuiver et al. 2017). Alternate calibrations using the mixed Marine & NH Atmosphere curve in this program (Stuiver et al. 2017), with hypothetical marine carbon percentages of 1–5% resulted in only small departures from calibration with the SHcal13 curve. Furthermore, the youngest dates were derived from materials in deeper sedimentary levels than older dates. Excavation depth measurements recorded in Omi's 1991 volume are reported in *meters above sea level*, rather than the more traditional *centimeters below surface/datum*. Thus, higher measurement values indicate shallower sedimentary contexts from the excavation reported therein. Sediment admixture and/or the nature of recovery techniques may be responsible for this juxtaposition. A large discrete charcoal block with provenience at 41.70 masl (meters above sea level; original measurement value) yielded a date of $9,050 \pm 150$ BP [10103 ± 214 cal BP] (again, see Omi 1991, p. 33 for clarification of depth measurements). The authors note that the remaining three dating assays were performed on collections of small charcoal fragments collected from throughout each additional sedimentary level. Contamination by modern plant roots and insect bioturbation, they argue, resulted in influx of young carbon into lower stratigraphic levels. Therefore, the date derived from 41.70 masl likely represents the most secure date from this site. Regardless of overall stratigraphic integrity at this site, the dates indicate a long history of occupation, well preceding the last several thousand years. While Omi and colleagues posit an age for the lithic assemblages at Ali Abubakar Hill much older than these radiocarbon dates suggest, this conclusion is based upon now outdated lithic temporal associations. In fact, the lithic assemblages from numerous coastal sites documented by Omi and co-workers closely resemble Eburran lithics from the Central Rift Valley, detailed by Ambrose (1984, 1998) and others (Wilshaw 2012). Hypothesizing a cultural or evolutionary connection between coastal and Rift Valley lithics would obviously be impossible at this point, however, as lithic technologies are known to display high inter-site and inter-regional variability. Despite this, general trends in dimensional reduction over the last 10,000–15,000 years, documented by Ambrose (1984), suggest that coastal lithics from sites such as Ngutatu and Mto Panga may potentially be of Late Pleistocene or Holocene origin. Thus, coastal occupations and activity sites detailed in the works of Omi (1982, 1982, 1984, 1986, 1991) may actually be considerably younger than argued to be in these volumes. Comparison of these finds with lithic data recently available from the site of Panga ya Saidi (Shipton et al. 2018) will undoubtedly aid in contextualizing these materials.

Methods

A five meter sediment core was extracted from the intertidal zone of Mtwapa Creek using a modified piston corer. Sediments were extruded and sampled every 5 cm along the entire length of the core. Approximately 15–20 ml of sediment were excised for each sample. Sampled sediments were sealed in whirl-paks[®] and returned to the Department of Anthropology at Washington State University for processing and analysis in the Palynology and Paleoenvironments Laboratory (now the Archaeobotany Laboratory)

housed there. Nineteen sediment samples were selected for analysis. Sediment processing was performed using the following procedure: quantification of 2 ml of sediment for each sample, addition of two commercially produced *Lycopodium* tablets to allow calculation of pollen and spore concentrations, carbonate removal with 10% Hydrochloric Acid, screening through 150 μm wire mesh, overnight immersion in 65% Hydrofluoric Acid to remove silicates, 20" treatment with 1% Potassium Hydroxide to dissolve humates, dehydration in 99% Glacial Acetic Acid, acetolysis treatment as outlined by Erdtman (1960), heavy density separation with Sodium Polytungstate at 2.34 specific gravity, curation with glycerin in glass vials. Each chemical treatment step was followed by repeated rinsing in deionized water and centrifugation at $>2,000$ rpm.

Samples material was mounted on glass microscope slides to undergo microscopy. Counting of pollen, spores, and charcoal was performed under a light microscope at 100–400x magnification, with higher magnifications of up to 1000x being used when necessary. Vertical traverses of each slide were made until at least 400 pollen grains were counted for each sample. This procedure was repeated for counting of fungal spores and of charcoal fragments. Identifications were made using published micrographs and available regional pollen (Caratini and Guinet 1974; Bonnefille and Riollet 1980) and spore (Jarzen and Elsik 1986; Gelorini et al. 2011; van Geel et al. 2003, 2011) keys, as well as online resources such as the African Pollen Database. Charcoal was categorized into size ranges [small-sized 3–25 μm , medium-sized 26–75 μm , large-sized 76–150 μm], and counted following the procedure outlined by Rucina et al. (2009), with identifications proceeding according to the recommendations of Waddington (1969) and other authors (Patterson et al. 1987; Pitkanen and Huttunen 1999; Clark 1988). Graphical rendering was performed on Tilia 2.0 (Grimm 1991). Pollen, spore types, and charcoal size classes are rendered as percentages of the overall assemblage in each sample.

Results

Radiocarbon Dates

Six bulk carbon dates were obtained via Direct AMS, which indicate that this sediment core captures the majority of the Middle Holocene (See Table 1). All dates were calibrated using CALIB 7.1 (Stuiver et al. 2017) under the MARINE13 calibration curve to account for marine reservoir effects. Results confirmed that the period between c. 7500–4000 cal yr BP is reflected in these sediments, comprising the majority of the Middle Holocene (8200–4200 cal yr BP), and likely verging into the earliest part of the Late Holocene (4200 cal yr BP-forward) as defined by Walker et al. (2012).

Table 1. Radiocarbon dates and associated depths from Mtwapa Creek.

Depth (cm)	uncal yr BP (BP)	cal yr BP (BP)	Age range (1 sigma) (BP)	Laboratory code
20	4247 \pm 30	4355	4307–4406	D-AMS 010033
60	5191 \pm 29	5555	5516–5590	D-AMS 007685
155	5785 \pm 31	6215	6183–6253	D-AMS 007686
265	5901 \pm 50	6319	6271–6372	D-AMS 017968
380	6875 \pm 34	7391	7351–7427	D-AMS 017969
492	6940 \pm 34	7448	7414–7477	D-AMS 005585

After graphical rendering of results, sum of squares analysis suggested the existence of two major analytical zones: a younger zone defined by sediments above 175 cm below ground level, and an older zone comprised of all deeper sediments. The older zone is from here on called Zone 1, and the younger zone, Zone 2. This phenomenon was captured independently in pollen, fungi, and charcoal datasets. Association between dates suggests rapid sediment accumulation during the mid-8th millennium BP and during the mid-to-late 7th millennium BP. During each of these periods, over 100 cm of sediment accumulated over very short timeframes. During the earlier of these two periods, diversity of pollen and fungal spores is relatively high (See Figs. 2 and 3). High rates of sediment accumulation such as witnessed at these times are likely the result of precipitation and/or erosion rates. As will be discussed later, climate models indicate that wetter conditions than present predominated during and through these timeframes. Especially wet periods during this extended humid phase may be responsible for these brief periods of extreme sediment deposition. Erosion due to landscape disturbance is another possibility which may account for high sedimentation, but charcoal frequencies and other palynological indicators of disturbance present conflicting signals with regard to forces affecting landscape alteration, leaving this interpretation dubious, but not able to be ruled out.

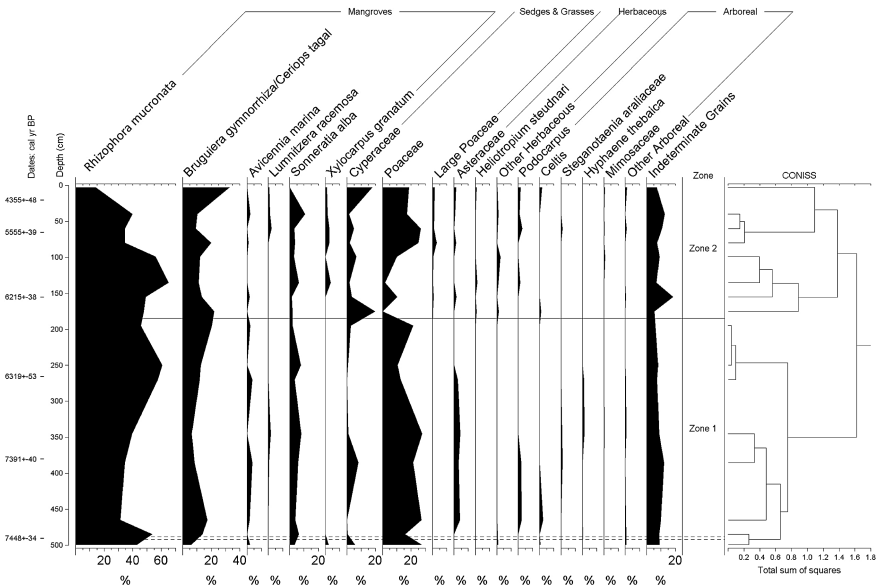


Fig. 2. Pollen representation at Mtwapa Creek.

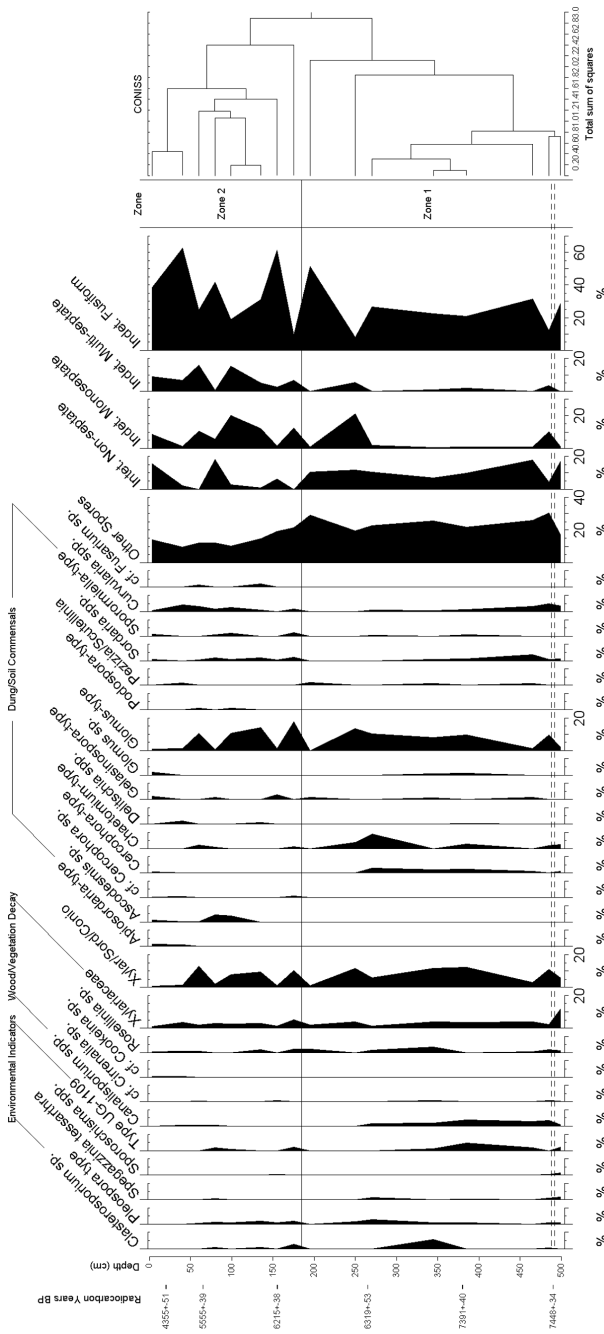


Fig. 3. Fungal representation at Mtwapa Creek.

Pollen

The pollen assemblage from Mtwapa Creek was found to be of relatively low diversity, being overwhelmingly composed of the pollen of various mangrove types (See Fig. 2). The majority of grains identified capture an antagonistic relationship between *Rhizophora mucronata* (always dominant) and the less diagnostic grains of both *Bruguiera gymnorrhiza* and *Ceriops tagal*, which cannot be reliably distinguished at the relatively low levels of magnification used in this study. Other mangroves, including *Sonneratia alba*, *Avicennia marina*, *Lumnitzera racemosa*, and *Xylocarpus granatum* are present in lower concentrations. This likely reflects fluctuation in tidal heights and/or salinity conditions within the local mudflat over time, and corresponding movement of groves of high, medium, and low tide adapted mangroves. Research related to the dynamics of mangrove ecology has been recently reviewed by Punwong et al. (2013a, b), and is not rehashed here (see also, Gastaldo 2012).

Sedge and grass pollen also are present in considerable concentrations. In the oldest sediments, Cyperaceae and Poaceae percentages seem to mirror each other. Yet in the youngest sediments, an inverse relationship between these types develops. Closer examination of Cyperaceae species composition in this assemblage may yield pertinent information on the ecologies of present sedge types, shedding light on the nature of the relationship between grasses and sedges in this environment. Overall grass pollen concentrations remain relatively high and constant through the core stratigraphy, with fluctuations and low percentages characteristic of depths between 100–200 cm. Low concentrations of large-sized Poaceae pollen (“large-sized” being defined as $>37\ \mu\text{m}$ in maximum diameter) appear in the youngest sediments, along with trace percentages of *Heliotropium steudneri* and other assorted herbaceous taxa, present in very low amounts. Asteraceae percentages generally parallel those of grass pollen.

Patterns in arboreal pollen representation are variable. *Podocarpus* and *Celtis* pollen (presumably not of local origin) are a constant, low-level presence in the oldest sediments, but then vanish and reappear intermittently through the youngest sediments. Low levels of *Hyphaene thebaica* and *Steganotaenia arialiaceae* are present in older sediments in very low numbers, while pollen of Mimosaceae presents in trace amounts in the youngest sediments.

Fungi

Fungal diversity was found to be considerably higher than pollen diversity (See Fig. 3). Encountered spores were grouped based on environmental and substrate-mediated conditions which each fungal type has been found to be associated (see Fig. 3; fungal representation), with unidentified and indeterminate types being grouped according to spore morphology. Type UG 1109, as-yet unnamed, has been posited to be associated with xeric conditions by Gelorini et al. (2011). Concentrations of these spores closely follow Poaceae pollen percentages. Wood and vegetation decay commensals were found in moderate diversity through all sediments. Concentrations of individual types vary over time, but remain relatively constant as a percentage of overall spore content throughout core stratigraphy.

Spores commensal with dung and soil isolates were very diverse in all levels. The strongest presence is that of *Glomus*-type spores, a soil erosion indicator with concentrations which vary through time (especially in the youngest sediments), yet remain a relative constant. Many saphrotrophic and coprophilous fungal types present in low concentrations throughout the core, while others, including *Apiosordaria*, *Ascodesmis*, and *Podospora* appear only in the top 1–2 m of sediment.

Spores which are often found in association with particular plants or types of vegetation were also recovered. *Curvularia* spp. have been found to grow on grasses, maize, wheats, and rice (Ellis 1971). Various species of *Fusarium* have also been reported on grasses, but more frequently on stored sorghum and millet (Onyike and Nelson 1992; Penugonda et al. 2011). Overall spore diversity, to include unidentified and non-diagnostic spores, increased in sediments shallower than 200 cm below ground level.

Discussion

The often equifinal nature of anthropogenic and climatic environmental signatures poses obvious problems in the investigation of ancient ecologies. This is particularly true for archaeologists interested in human landscape impacts. As discussed earlier, multiple lines of proxy evidence have been used to approach this issue with great affect in East Africa and elsewhere. Paleoenvironmental records from East Africa suggest that persistent humid conditions progressively gave way to a more xeric climate between the Early Holocene and c. 5700 cal yr BP, after which dry conditions seem to have persisted until well after 4000 cal yr BP. A warming trend seems to have ensued after c. 4500 cal yr BP, although conditions remained dry (Richardson 1972; Nicholson 1996; Bergner et al. 2003).

Zone 1: c. 7500–6300 cal yr BP

If human impacts indeed shaped the Middle Holocene ecology of the Mtwapa Creek catchment, data patterns should differ from what would be predicted by climate models for the region. Of particular importance is the period after c. 6200 cal yr BP, which seems to capture much environmental fluctuation. If ecological changes captured in this core are solely climatologically mediated, proxy data should point toward a relatively humid, yet drying, period between c. 7000–5700 BP, and a dry period between c. 5700–4000 BP, when core chronology terminates.

Climate models predict a relatively humid phase prior to 5700 cal yr BP in this region (van Zinderen Bakker 1966; Thompson et al. 2002; Kiage and Liu 2006). Mangrove pollen ratios remain relatively stable during this timeframe, while grass pollen percentages are relatively high, as are Asteraceae and *Podocarpus* percentages. While these patterns would not necessarily be expected under conditions of relative humidity, moisture availability may not have been great enough to favor the development of forest cover that could outcompete grassland environments. Based on floristic analysis of numerous grid squares surrounding a mangrove coring site, Punwong et al. (2013a) contend that Poaceae representation in sediment cores from

mangrove environments may not accurately reflect the actual presence of these environments in the immediate landscape. However, based on the presence of considerable amounts of grass-dominated landscape near the Mtwapa Creek coring site, there does not seem to be sufficient reason to discount the importance of grasses in this analysis. *Podocarpus* presence is likely a relic of regional pollen rain, which may have been preferentially introduced during precipitation events. Sedges, many of which favor less saline environments, also experience an extended period of stasis during this early period. Based on these pollen data, there does not seem to be much justification for discounting climatic patterns as a primary mediator of environmental conditions during the first approximately 1000 years captured in sediments from Mtwapa Creek.

Fungal data from the oldest sediments unfortunately do not much aid in further clarifying the source(s) of ecological mediation during this period. Spores of both *Glomus* sp. and *Glomus*-type, which are taken as indicators of soil erosion, display elevated concentrations in sediments dating between c. 7500–6200 cal yr BP. The means by which erosion may have been affected, however, are still unclear. Precipitation and/or disturbance potentially related to desiccation, mechanical disturbance by human activity or animal traffic, or grazing by herbivores may all result in similar erosional signals. *Cercophora* sp. and *Cercophora*-type spores also show slightly elevated concentrations in these sediments. While often found on dung, *Cercophora* also occurs on decayed wood and/or plant material (Bell 1983). *Canalisporium* spp. is commensal with decaying and inundated wood, and is found in elevated percentages in the oldest sediments. Wood decay likely would be favored by moist conditions, as predicted by climate data. Gelorini et al. (2011) identified Type UG-1109 as a possible indicator of locally dry conditions based on the similarity of this type to a European spore type which indicated such conditions. Elevated percentages of Type UG-1109 during the likely relatively wet period between 7500–6000 BP cast this relationship into doubt. The existence of human-created dry microhabitats in this vicinity which might have played host to xeric-commensal fungi should not be ruled out, however. Thusfar though, the most likely scenario favors the prevailing climatic regime as the primary shaper of the Mtwapa Creek ecology prior to c. 6200 BP.

Zone 2: c. 6200–4000 BP

In sediments shallower than approximately 175 cm below ground level, relatively rapid fluctuations in pollen and fungal representation occur. Climate models predict the existence of very dry conditions during this period, with a notable warming trend beginning slightly prior to 4500 BP. Punwong et al. (2013a) appear to capture the predicted cool and dry period in the Rufiji Delta of Tanzania between c. 5600 and 4600 cal yr BP as a seaward movement of mangroves during this period, indicating a sea level regression. After this time, sea levels appear to rise again, enabling a coincident mangrove resurgence. If this phenomenon occurred at Mtwapa Creek, it does not appear readily apparent in the pollen data. Indeed, both *Rhizophora mucronata* and *Sonneratia alba* present with relatively high values during this period. This would not be expected if sea levels were subsiding. It may be that sea levels dropped in this vicinity, yet that tidal levels did not drop sufficiently to render the immediate mudflat environment unsuitable for *Rhizophora mucronata*. Tidal levels may have dropped

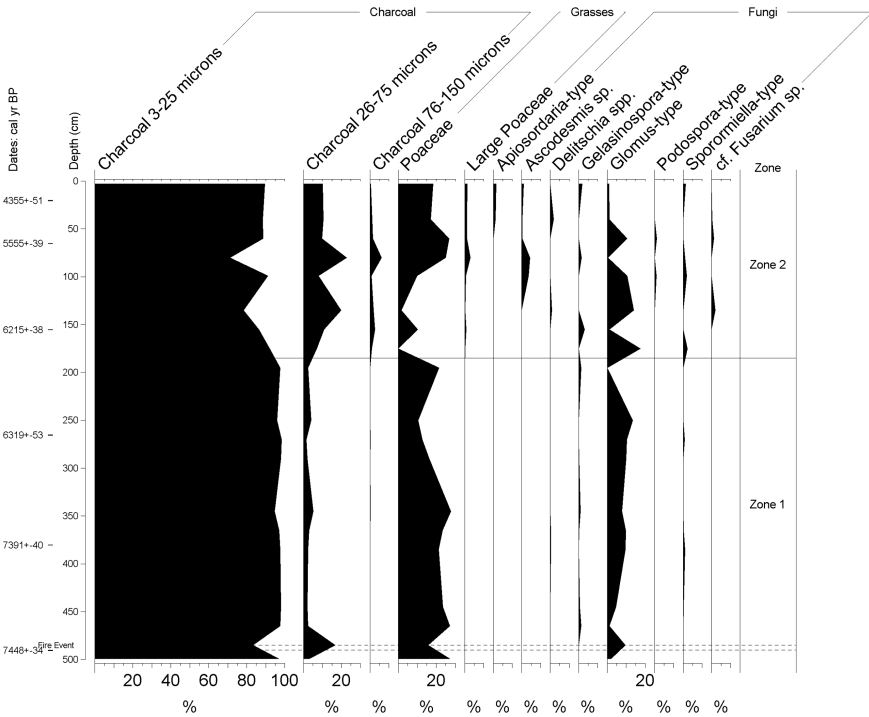


Fig. 4. Integrated charcoal and palynomorph indicator representation at Mtwapa Creek.

enough, however, to create favorable nearby conditions for *Xylocarpus granatum*, which prefers much less frequent inundation.

In the terminal sediments of Zone 2, *Rhizophora* percentages drop, while percentages of *Ceriops tagal* and *Bruguiera gymnorrhiza* increase. This may reflect selective mangrove harvesting for building materials and other uses, as has been documented in later Swahili communities (Kusimba 1999). This could indicate sea level subsidence during the period shortly preceding 4000 cal yr BP. Sedge percentages also increase during this latest period. These patterns, as well as the fact that no further significant sediment accumulation apparently took place, may be due to the absence of sufficient suspended sediment in tidal events to affect a depositional environment. Fluvial transport inputs from landward freshwater runoff likely were not powerful enough to reach mid-mudflat contexts, leading to the effective termination of sedimentation at the coring location.

The near disappearance (and subsequent reappearance) of grass pollen during the earliest part of Zone 2 is anomalous. *Rhizophora* pollen may have simply been too numerous for many grass pollen grains to be captured during microscopy. Cool and dry conditions are not a likely culprit responsible for very low grass pollen values, as sedge percentages are elevated at this point in the Mtwapa Creek chronology. A potential scenario which could account for both low Poaceae and high mangrove percentages would be burning of grasslands. Large-sized (>75 μ m) charcoal fragment

concentrations peak during this time, indicating increased local burning of vegetation (see Fig. 4). This would also explain the elevated sedge percentages seen at this time, as a waterlogged environment would provide a measure of protection against land fires. *Heliotropium steudneri* and other herbaceous taxa appear in low numbers coincident with the lowest observed grass pollen values. Asteraceae percentages, at all times, seem to parallel grass pollen percentages, albeit in much lower numbers. It may be that select herbaceous taxa were able to colonize (if only temporarily) recently disturbed or burned areas prior to the resurgence of grasslands after fire events.

Through the majority of Zone 2, paralleling both grass and Asteraceae values, large-sized Poaceae pollen (>37 μ in diameter) appear in low numbers. All large-sized Poaceae in this core fall into a size range between 37–42 μ in diameter. This closely matches the size range of the pollen of domesticated sorghum (*Sorghum bicolor*, (L.) Moench), an important traditional East African cultigen (Schmidt and Bothman 2005). While this is reason for pause, numerous uncultivated wild grasses have been found to share overlapping (and larger) size ranges with large-sized Poaceae pollen from Mtwapa Creek (Mercuri et al. 1999; Mercuri and Trevisan Grandi 2001; Mercuri 2008). Though it cannot thus be proven that the sudden appearance of relatively large-sized Poaceae pollen in the Mtwapa Creek record represents cultivation activity, the possibility merits further exploration.

Alongside large-sized Poaceae pollen and later peaks in Asteraceae percentages, a fungal type identified as cf. (*conferatur*) *Fusarium* sp. appears. Numerous species within the genus *Fusarium* have been found strongly associated with stored grains (Onyike and Nelson 1992; Chala et al. 2014). While filamentous grass-commensal fungi are often found in association with grassland environments, *Fusarium* has been found to predominate in stored-grain contexts. While, again, this does not represent an evidentiary “smoking gun” for grain storage or domesticated grains, *cultivation* and *collection* of wild grains by foraging populations may be responsible for this particular fungal signature. Also a possibility is that a particular type(s) of wild grass (as yet unidentified specifically) producing relatively large pollen grains found an amenable habitat niche during the increasingly arid phase captured in Zone 2. Concurrently, fungal types including species of *Fusarium* may have found the same.

Also of particular note, unique increases in the representation of coprophilous fungi occur within Zone 2. *Ascodesmis* sp. and *Delitschia* spp. fungal spores appear only during Zone 2, concurrent with, or slightly later than evidence for large-sized Poaceae, *Fusarium*, and increased percentages of large-sized charcoal, indicating more localized burning. *Ascodesmis* spores have been reported on various types of dung, while *Delitschia* spp. have been identified as distinct indicators of large herbivore activity by Gelorini et al. (2012b). *Sporormiella*-type spores, while present in very low concentrations in Zone 1, experience peak percentages in Zone 2. Non-obligate coprophiles including *Apiosordaria*-type and *Podospora*-type also only appear in Zone 2.

The representation of *Gelasinospora*-type spores also deserves attention. The presence of *Gelasinospora* in sediments has been shown to be strongly associated with burning. Indeed, the initial appearance of *Gelasinospora*-type in Mtwapa Creek sediments occurs immediately after a posited fire event captured in the oldest sediments of Zone 1, evidenced by increased occurrence of charcoal in the size range of 26–75 μ . While a long period of relative stasis characterizes both larger sized charcoal and

Gelasinospora-type concentrations, in Zone 2 sediments percentages of both are elevated. Furthermore, concentration increases in both of these (and other) proxies are episodic and irregular, rather than progressively increasing. An already dry environment experiencing progressive warming after c. 4500 cal yr BP, as predicted by climate models (Karlen et al. 1999; Kiage and Liu 2006), might be expected to likewise undergo progressively more (and more frequent) burning events. This is apparently not the case, as large-sized charcoal concentrations level off during the period of the expected heatwave. Overall charcoal data patterns support the idea that episodic burning was characteristic of the period between c. 6200–4000 BP. With the exception of the previously mentioned small spike in larger-sized charcoal fragment concentrations after a putative burning event early in Zone 1 sediments, charcoal in the largest two size classes only appears in any number during the period represented by Zone 2.

Middle Holocene Landscape Use in the Coastal Hinter

Multi-proxy research is an important analytical strategy for investigating Middle Holocene coastal occupations in East Africa, as archaeological information dating to this period is chronically underrepresented, not only in the coastal region, but in hinterland regions as well (Kusimba et al. 2005; Wright 2007; Wright et al. 2007). Kusimba et al. (2005) surveyed and excavated numerous sites from the Tsavo region, with a minority of sites from the Bungule complex containing occupations dating to the mid-and-earliest Holocene. Wright (2005), and later, Wright et al. (2007) provided optically stimulated luminescence (OSL) dates from several sites along the Galana River in Tsavo which placed early floodplain occupations in the region at c. 6000 BP. Wright (2007) and Wright et al. (2007) argue that the Galana River floodplain provided an attractive living environment to hunter-gatherers exploiting mostly local resources for over 5000 years, from roughly 6000–900 BP. This more intensive exploitation of riverine environments would have been a potential means of dealing with increasingly xeric conditions. Wright et al. (2007) also contend that hunter-gatherers living along the Galana River adopted intensive local resource exploitation strategies after c. 6000 BP, relying on locally available game and lithic materials, mainly quartz. A similar lithic material procurement strategy seems to be characteristic of coastal occupations described by Omi. Local slate was utilized primarily, with quartzite being of secondary importance.

Evidence for human activity on the East African Coast during this period also appears at inland sites in the form of marine shell (Leakey 1966; Nelson 1993; Wright 2005), indicating the existence of geographically extensive resource exchange networks better evidenced by lithic source materials (Kusimba 2003). Unfortunately, these occupations are located hundreds of kilometers away from Mtwapa Creek, and thus cannot be considered part of the “local” coastal archaeological record. Lithic evidence described by Omi (1982, 1984, 1986, 1988, 1991), attributed to Early-to-Late Stone Age peoples, provides the only described record of potential Middle Holocene human occupation of actual coastal environments in present-day Kenya.

Of the sites and materials described by Omi, the most proximal to the coring site is the site if Ngutatu, roughly seven kilometers southwest of the mudflat coring location at Mtwapa Creek. According to Omi (1982):

At Ngutatu A, seven crescent-type stone tools, four micro-blades, seven cores, fifty-three flakes and one small chopper were collected. All implements are made of shale, except for one chopper and one flake made of quartzite. At Ngutatu B, four side-scrapers, one end-scraper, one micro-blade, thirty-one cores and seventy-one flakes and chips were collected, all implements being made of shale. (Omi 1982, p. 145).

Ambrose (1984) identifies progressive reduction in microlith sizes as a useful means of inferring the age of lithic assemblages from the Central Rift Valley. While exact numerical metrics for lithics from Ngutatu are not given, microlith dimensions reconstructed from scaled illustrations of Ngutatu microliths indicate mean length and width measurements that fall within the range of Ambrose's Eburran 4 and 5, corresponding to a time range between c. 8500 BP and c. 2000 BP. A thorough overview of Eburran chronology is provided by Wilshaw (2012). As this estimate uses comparison with a non-local lithic typology, this is obviously a very unsatisfactory means of inferring the age of the Ngutatu occupation. However, considering metric and technological similarities between the Ngutatu lithic assemblage and lithic types from the Holocene of central Kenya (including Eburran assemblages), as well as marine shell remains found in these contexts, it is not outside the realm of possibility that microlith size reduction trends identified by Ambrose (1984) might be in evidence during the Middle Holocene in the coastal region of Kenya as well. Although the existence of a relationship between coastal and Rift Valley lithic technologies remains pure speculation at this point, I argue that it is worthwhile to consider the possibility that similar lithic technologies and manufacturing trends were practiced during the Holocene in these two very different regions.

Conclusion

Even taken together, microbotanical, settlement, and lithic evidence presented here in support of human modification of East African coastal landscapes during the Middle Holocene is hardly irrefutable, and based at times on little more than speculation. Having said this, the list of coincident data patterns with uncertain origins presented here should not be ignored. Fungal and palynological data suggesting that large herbivore activity may have increased between c. 6200–4000 BP co-occur with increased evidence for intermittent localized vegetation burning at Mtwapa Creek. Novel pollen types including large-sized Poaceae, and fungal types found associated with grain storage (e.g. cf. *Fusarium* sp.) also appear and persist during this period, suggesting that cultivation of plant foods may have occurred at an early date. Macro-botanical evidence will obviously be needed to confirm this. Even if these patterns can potentially be interpreted as merely the result of fluctuations in the local climatic and/or precipitation regimes and floral and faunal adaptations to them, human adaptations in the bordering Tsavo region after c. 6000 BP reflect settlement and resource use strategies designed to exploit virtually the same conditions that environmental models

predict existed at Mtwapa Creek during this period. Less extensive and more intensive occupation and use of more circumscribed environments would presumably lead to less ephemeral exploitation of such landscapes, leading to more distinctive environmental signatures of land and resource use. Even if human occupation of the East African Coast was of relatively low intensity prior to the last few millennia comprising the Swahili and proto-Swahili periods, these ancient human populations merit the archaeological attention that has historically been denied them. It is rarely demonstrated directly or indirectly (Morris et al. 2015) that colonizing populations from southwest Asia and elsewhere around the Indian Ocean littoral encountered indigenous African populations upon arrival. These populations are often given little more than lip-service acknowledgement as undoubtedly an “important” part of the multi-ethnic mosaic that came to comprise later East African coastal populations. Cultural traditions documented to have been introduced from afar are often emphasized in the archaeological literature, while it is implicitly assumed that indigenous cultural adaptations must have filled the “vacuum” left unexplained in the creation of the Swahili mosaic. I argue that these indigenous populations deserve our renewed future attention.

Several researchers, in addition to Omi and colleagues, have attempted to address these pre-Swahili contexts in recent years (Crowther 2012; Helm et al. 2012; Shipton et al. 2018). Building on this work, several lines of inquiry may be useful in future investigation of the history of coastal occupation in East Africa. More finely resolved records of sea levels through the Holocene will shed light on the significance of mangrove pollen fluctuations over time. Marine terrace records detailed by Oosterum (1988) and others are effectively geologic in time scale resolution. Century, or at least millennial scale knowledge of ancient sea levels would be more appropriate for making inferences concerning past environments. Some research has already been performed in this area (Woodroffe et al. 2015). Mangrove pollen data will undoubtedly be part of this investigation.

Metric data on pollen of coastal grasses will shed light on the nature of relatively large-sized Poaceae pollen recovered in Zone 2. Ecological information on endemic grasses producing pollen of this size will render a clearer picture of grassland dynamics through the Holocene. Sampling of fungal communities commensal with specific grassland contexts will further enlighten this investigation, allowing for comparison of modern and ancient grassland fungal communities. Additionally, modern fungal samples gathered from coastal livestock grazing plots will elucidate the potential value of coprophilous fungi as indicators of herbivore density. In sum, the constellation of proxy signals presented here is sufficient to suggest that human occupation of the East African coast during the Middle Holocene was sufficient to impact coastal ecologies considerably.

Finally, renewed archaeological investigation of known archaeological sites pre-dating the Swahili period will undoubtedly provide new insight into the nature of Holocene coastal occupations. Focus on other aspects of human behavior, aside from lithic technology, that may be preserved at these sites will be a valuable source of information. Additional survey of coastal riparian and hinterland environments for evidence of pre-Swahili sites should provide a clearer picture of the task ahead.

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