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Shifting Fish Consumption and Climate Change On the Swahili Coast (A.D. 800-1500)

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ABSTRACT: This study investigates fish exploitation throughout the development of two Swahili settlements on the East African coast, A.D. 800-1500. The aim is to identify and explain changes in subsistence strategies in this region against a backdrop of cultural and climatic changes. The changing contribution of fish to the Swahili diet is studied by comparing the chronological distributions of four principal animal food sources: fish, chicken, goat/sheep, and cattle. A mean trophic level study is applied to the archaeological fish data to identify differences in the composition of exploited fish species through time. Paleoclimate data from East African lakes provide a history of dry and wet periods in the region. Preliminary results show an increasing reliance on domesticated animals, with a decline in the ratio of fish to domesticated animals in the 12^{th} to 13^{th} centuries that may be related to abrupt shifts between dry and wet environmental conditions in the region. Studying this shift in diet within its climatic context contributes to our understanding of how people react to a changing environment and how these actions helped shape Swahili history.

KEYWORDS: FISH CONSUMPTION, FISHING STRATEGIES, PALEOCLIMATE, SWAHILI COAST, SHIFTING DIET

RESUMEN: Se investiga la explotación pesquera a lo largo del desarrollo de dos ciudades Swahili en la costa este de África, de 800 a 1500 d.C. El objetivo es identificar y explicar los cambios en las estrategias de subsistencia en esta región en relación a cambios culturales y climáticos. Se compara la distribución cronológica de cuatro principales fuentes de alimentos de origen animal: pescado, pollo, cabra/oveja y ganado vacuno. Un estudio del nivel trófico medio se aplica a datos arqueológicos de pescados para identificar diferencias en la composición de especies de pescados explotados a través del tiempo. Datos paleoclimáticos de lagos en ésta región ofrecen un historial de periodos secos y húmedos. Los resultados preliminares muestran una disminución en la proporción de peces en relación a animales domésticos en los siglos 12 a 13, que puede estar relacionada con cambios ambientales abruptos entre condiciones secas y húmedas. Este estudio contribuye a nuestro conocimiento de cómo la gente reacciona a los cambios ambientales y cómo estas acciones ayudaron a formar la historia de la costa Swahili.

PALABRAS CLAVE: CONSUMO DE PESCADO, ESTRATEGIAS DE PESCA, PALEOCLIMA, COSTA SWAHILI, CAMBIOS DE DIETA

INTRODUCTION

The East African coastline from Somalia to Mozambique is dotted with remains of «stone towns» known for the coral-based architecture that formed the homes, palaces, and mosques of the Swahili people. These cultural centers flourished mainly between the 8th and 15th centuries A.D. and were key nodes in the trade network between the interior of Africa and across the Indian Ocean as far as Persia, India, and China. The sea played an important role in the development of Swahili culture not only because of the cyclical monsoon currents that allowed traders to travel around the Indian Ocean, but also because the sea was the source of an important daily subsistence food: fish.

Historical accounts of travellers that reached the Swahili coast describe fishing and diet in this region as early as the first century A.D. (Casson, 1989: 59-60). These historical descriptions are complemented by zooarchaeological research that shows evidence for the consumption of fish, domesticated animals, and hunted animals (Wright *et al*., 1984; Wright, 1992; Horton, 1996; Radimilahy, 1998; Van Neer, 2001; Fleisher, 2003; Juma, 2004; Badenhorst *et al*., 2011). Shanga and Chwaka are two settlements along the Swahili coast with overlapping periods of occupation showing evidence of an increase in the consumption of domesticated animals compared to fish in the 12th to 13th centuries (locations in Figure 1). A simultaneous trend of changes in local fishing strategies is observed through more detailed analyses of the published fish remains data. Here, I examine the influence of regional climate change on shifting fish consumption trends in the Swahili coast by comparing zooarchaeological data from two island communities.

MATERIALS AND METHODS

I compared two sets of published zooarchaeological data to explore regional fish consumption trends throughout the development of Swahili settlements. The current chronological study was limited to the faunal assemblages from Shanga and Chwaka, which were published separately but have comparable quality and range of data. Each faunal assemblage was recovered from a single domestic midden deposit using 5 mm mesh screens and quantified by number of identified specimens (NISP) (Horton & Mudida, 1993: 675; Fleisher, 2003: 365, 321). The Chwaka assemblage was smaller (1938 NISP) compared to the Shanga assemblage (6690 NISP), but it was also retrieved from a smaller unit (2x2 m) than the Shanga assem-

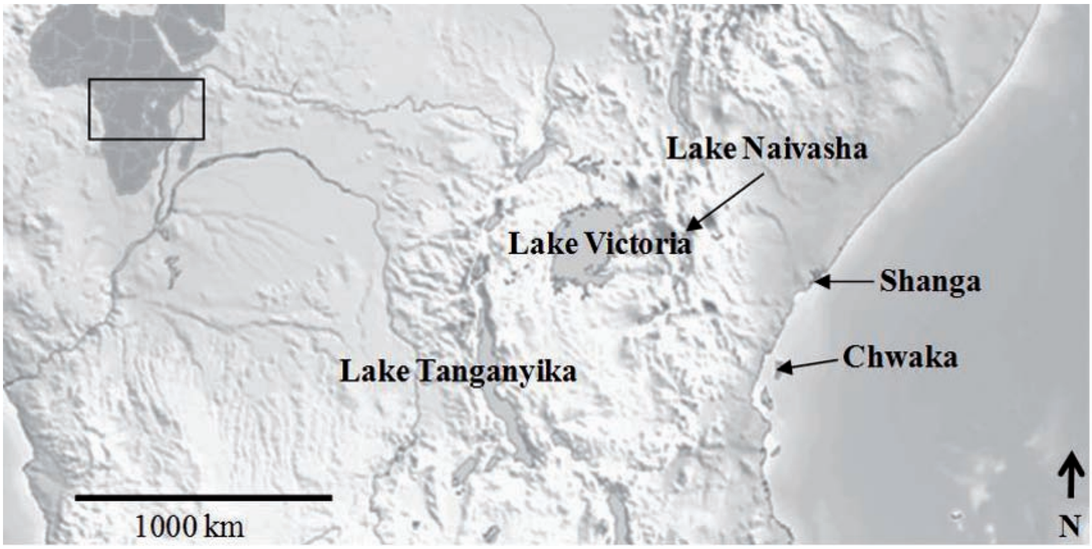

FIGURE 1
Location of two Swahili archaeological settlements mentioned in the text. Paleoclimate data come from three regional lakes.

blage (5x5 m) (Horton & Mudida, 1993: 675; LaViolette, 2000: 57; Fleisher, 2003: 380). The actual density of faunal remains cannot be compared because the total number of remains is not available for the Shanga assemblage, only the number of identified specimens. Thus, I used only the identified specimens to compare both sites. Both assemblages were representative of subsistence patterns at their respective sites because they were recovered from large long-term domestic middens. A chronological comparison was possible because the faunal data sets from both settlements were divided into excavation layers associated with chronological sequences. In addition to an overlapping period of occupation, both settlements reached similar sizes of around 12 to 15 ha (Horton *et al*., 1996: 33; Fleisher, 2003: 152).

Shanga lies on Pate Island in the Lamu Archipelago of what is now northern Kenya. Pate is one of three main islands at the mouth of three rivers in a wide bay that is characterized by fringing mangroves and offshore coral reefs (Horton, 1996: 17-18). Chwaka, on the other hand, lies farther south on Pemba Island off the coast of northern Tanzania. Pemba is an offshore island that includes a variety of environments such as deep coastal inlets, mangroves, and reefs (Fleisher, 2003; LaViolette & Fleisher, 2009: 437).

Horton & Mudida (1993: 676) provided data for 6009 fish bones and 681 other animal remains identified from Trench 2 at Shanga, which were associated with a chronological series of 12 phases from the 8th through 14th centuries. Unit 7 at Chwaka represented four archaeological layers of occupation from the 11th through 15th centuries. Fleisher (2003: 380) presented data for 568 identified fish remains and a total of 1370 other identified animal remains. I focused on four main food groups —fish, chicken, goat/sheep, and cattle— that constituted over 95% of the total number of identified fauna at each site. I plotted the chronological distributions of the four main food groups using total NISP per phase to compare changes in the proportion of each food source throughout the occupation at each settlement.

High chronological resolution and a large fish remains assemblage lend Shanga to more detailed studies of changing fishing strategies over time. Mean trophic level (MTL) traced changes in the composition of fish remains by representing whether the average fish catch was from higher or lower levels in the food chain. Research on contemporary fisheries has demonstrated a link between a declining MTL and overfishing, resulting in the underrepresentation of high trophic level species (Pauly *et al.*, 1998). In archaeological samples, MTL is not a measure of fishing intensity but may be used with other forms of evidence –e.g., decreasing size, habitat use– to indicate changes in the composition of fish that may be related to intensified fishing (Reitz, 2004). Analysis of variation in MTL provided information in potential changes in the strategies and tools used to exploit particular types of fish or changes in the availability of certain fish types in the exploited marine ecosystem. I calculated the MTL of fish identified to species and genus level for each phase of occupation at Shanga using published trophic levels for each species (*FishBase*, 2011; for methods see Wing, 2001). In cases where the fish remains were identified to only genus, which occurred in 5 out of 51 cases, I averaged the trophic level of all species of this genus present in the region (e.g., *Lethrinus* sp. in Figure 2).

I explored trends in the representation of commonly identified fish species at Shanga to identify changes in fishing strategies, such as an increase in the number of shark remains. The presence of sharks indicated the use of a different set of fishing tools and strategies suitable for pelagic fishes of greater size. I plotted the number of shark remains as a percentage of the total number of fish bones to indicate the relative importance of offshore fishing at Shanga.

Finally, I examined the relationship between fish consumption patterns and their climatic context by comparing the zooarchaeological data to published paleoclimate data for this region. Lake-core data reconstruct past climatic conditions by analyzing ancient sediments of inland freshwater bodies. The composition of pollen, diatoms (a type of phytoplankton), and other chemical and biological traces served as proxies for water temperature and levels at three East African lakes: Naivasha, Victoria, and Tanganyika.

RESULTS

I analyzed the importance of fish in Swahili diet over time by comparing the temporal distributions of fish, chicken, goat/sheep, and cattle remains —four principal animal food sources. Overall,

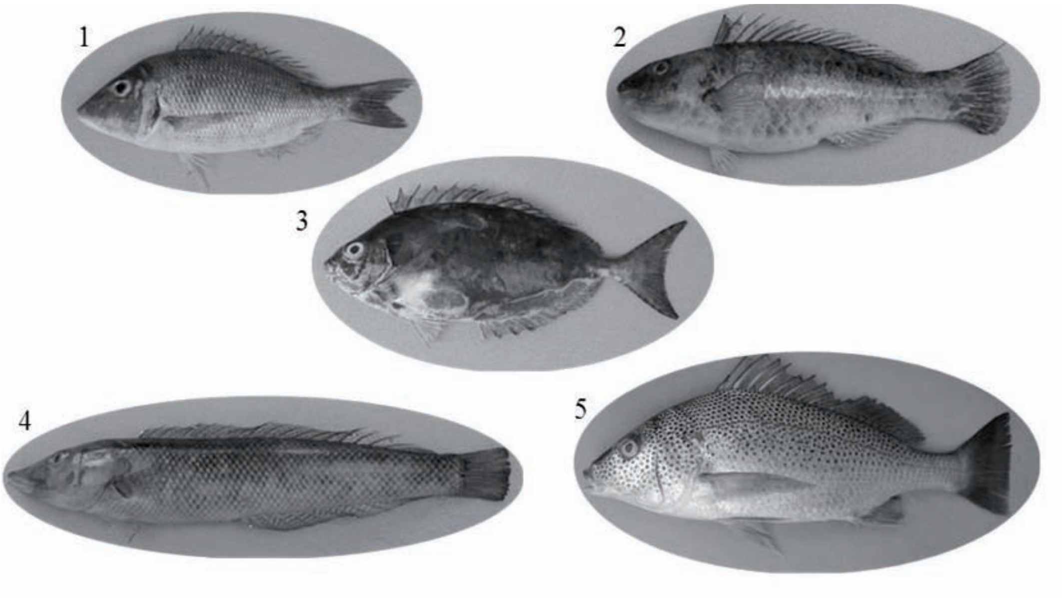

FIGURE 2

Five examples of commonly identified fish taxa from Shanga Trench 2: Fish are in the following format: Taxa (trophic level, NISP) 1. *Lethrinus* sp. (3.61, 2017); 2. *Leptoscarus vaigiensis* (2.27, 894); 3. *Siganus sutor* (2.00, 395); 4. *Cheilio inermis* (4.04, 172); 5. *Pomadasys multimaculatum* (3.99, 139) (Fish data from Horton & Mudida, 1993; trophic levels from FishBase, 2011).

both Shanga and Chwaka showed a pattern of increasing faunal remains with a decrease at the end of the 14th century that reflect the intensity of human occupation during the development and subsequent abandonment of each settlement (Horton, 1996: 394-406; LaViolette & Fleisher, 2009: 445). Against that backdrop, both settlements showed evidence of a relative decline in the importance of fish compared to domesticated animals beginning around the end of the 12th century. At Shanga, where the data were more detailed, the decreasing representation of fish compared to domesticated animal remains was more evident; between the 12th and 13th centuries the relative amount of fish declined as the numbers of domesticated animals increased (Figure 3). At Chwaka, in contrast, all four animal groups increased and then declined during that time period. The rate of increase in fish remains, however, was not as steep as for the other groups and was surpassed by that of cattle and chicken remains around the turn of the 12th century (Figure 4). The group of goat/sheep at Chwaka was represented by only 15 remains that could not be considered as evidence of any clear pattern. Fleisher (2003: 383) noted that between A.D. 1000-1200, fish remains constituted around 65% of the faunal assemblage, and, in the periods that followed, fish made up less than 30% of the assemblage; after A.D. 1200, the majority of bones was instead composed of domesticated animals.

Analysis of the composition of fish taxa throughout the occupation at Shanga showed a declining trend in MTL, a possible indication of pressure on the local marine ecosystem from fishing intensification (Figure 5). The fluctuating pattern around the trend line was a reflection of the total number of fish remains. Horton & Mudida (1993: 680) noted that samples with larger numbers yielded a wider range of species. Samples with a wider range of species, in turn, had higher numbers of low trophic level species. I examined the composition of species throughout the declining MTL.

Most of the fish represented in the Shanga assemblage were associated with inshore fishing; Lethrinidae and Scaridae, two families of reef-associated fish, constituted 56% of the total identified fish at Shanga (see data in Horton & Mudida, 1993: 676). Species from the family Lethrinidae, which on average have a moderate trophic level of

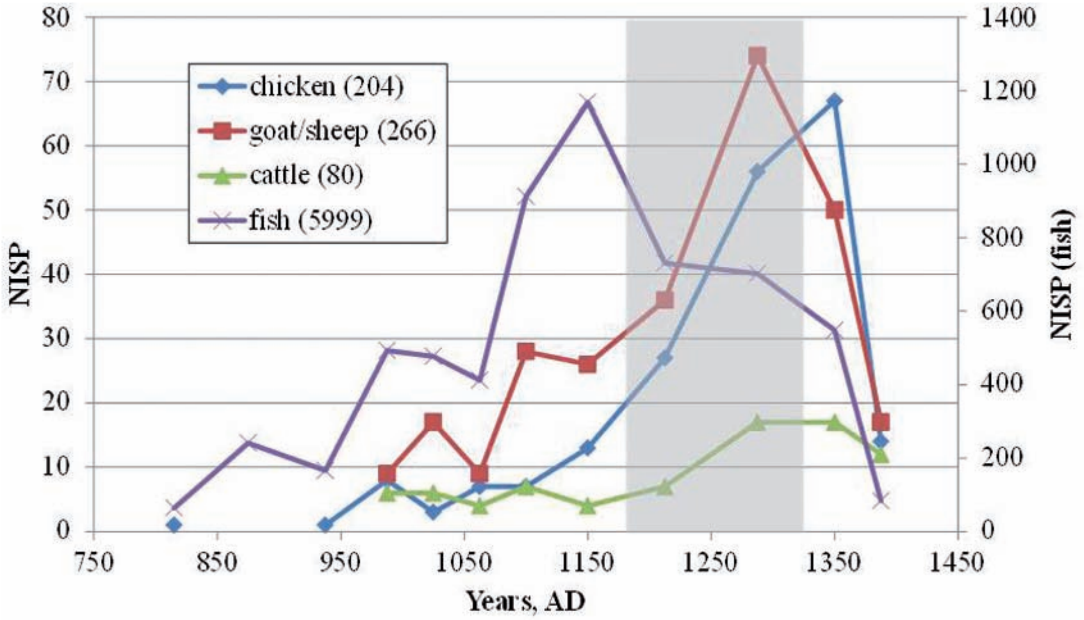

FIGURE 3

Chronological distribution of four main food sources at Shanga.Numbers of fish remains decrease as numbers of domesticated animal remains increase in the 12th to 13th centuries, a period of shifting climate (marked in gray). Fish are on secondary axis to compare overall trends among all food items. The total number of identified specimens (NISP) for each food type is indicated in parentheses. (Data set from Horton and Mudida 1993).

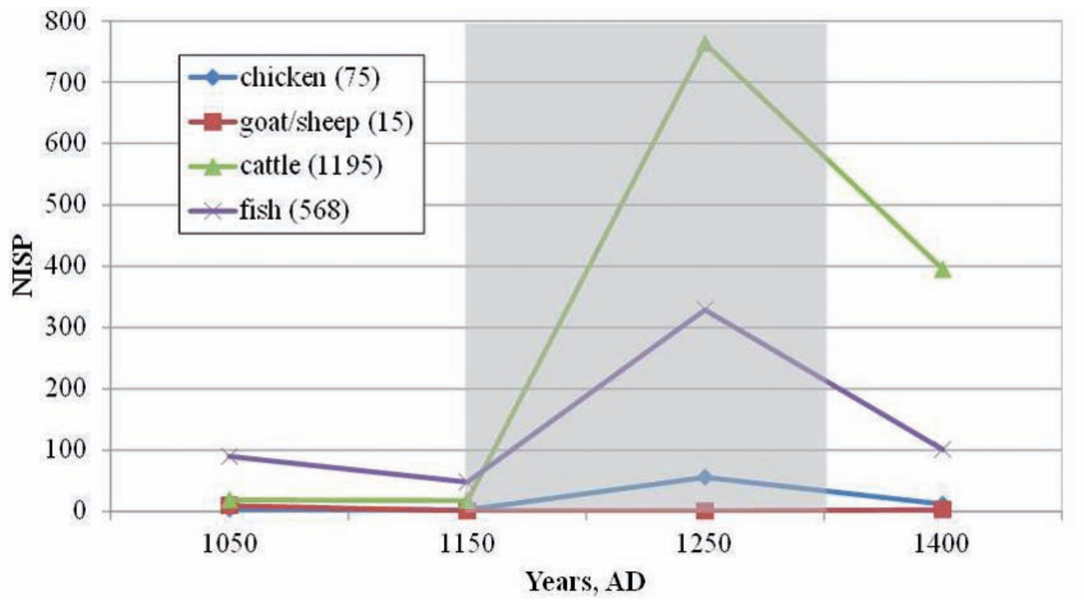

FIGURE 4

Chronological distribution of four main food sources at Chwaka. Numbers of cattle remains increase at higher rates compared to fish remains during the 12th to 13th centuries, a period of climate change (marked in gray). The total number of identified specimens (NISP) for each food type is indicated in parentheses. (Data set from Fleisher 2003).

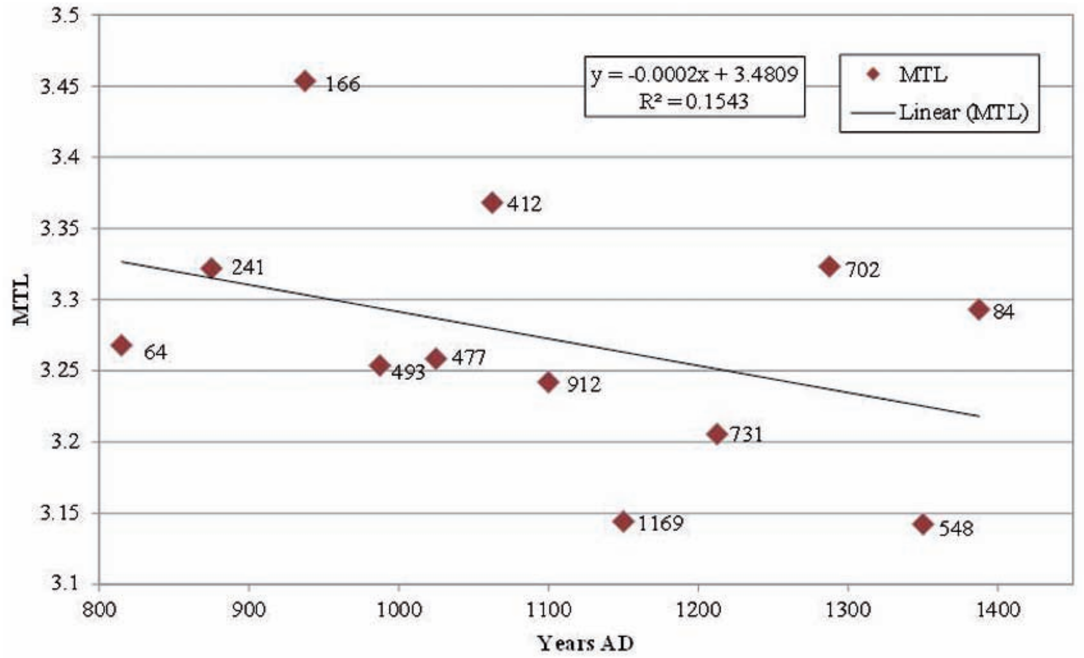

FIGURE 5

Shanga mean trophic level (MTL) over time with linear trend line. Samples sizes (NISP) indicated next to each MTL value. (Data set from Horton and Mudida 1993).

3.61, increased after A.D. 1000. In the family Scaridae, numbers of *Leptoscarus vaigiensis* decreased over time while *Scarus ghobban* increased at the end of the 13th century (Horton & Mudida, 1993: 678). This pattern could indicate a change in habitat exploitation since *L. vaigiensis* —with a slightly higher trophic level than other species in its family— is more commonly found in seagrass areas while *S. ghobban* is found near reefs. In the Haemulidae family, *Plectorhinchus flavomaculatus* decreased over time while *Pomadasys multimaculatus* increased in the 14th century (Horton & Mudida, 1993: 678). The increase in *P. multimaculatus* —which has a lower trophic level— could also indicate a change in habitat because this species is found more often in estuaries than *P. flavomaculatus*. Horton & Mudida (1993: 679) reported that shark remains, mostly of the genus *Carcharhinus*, appeared in the record after the 12th century. Interestingly, as the MTL declined, the percentage of shark remains to total fish remains was rising, although shark species have high trophic levels (Figure 6).

The main period of subsistence change, in the 12th and 13th centuries, was also a period of shifting climate. Shifts in lake levels have been recorded by paleoclimate studies of East African lake sediments (Verschuren *et al*., 2000; Johnson *et al*., 2002; Stager *et al*., 2005, 2009; Russell & Johnson, 2007)[1]. Overall, the East African lakes appear to have been affected by a decrease in lake levels before the end of the 12th century followed by an increase in the middle to late 13th century (Figure 7). Verschuren *et al*. (2000) estimated that the depth of Lake Naivasha changed from around 20 m to <5 m during a saline lowstand between A.D. 1000-1270, with a wet interval that increased the lake levels to around 15 m and back to <5 m between A.D. 1200-1250 (Verschuren *et al*., 2000: 411). Lake Naivasha has a surface area of approximately 140 km^2 —more than 200 times smaller than that of Lake Victoria and Lake Tanganyika. Thus, while all three lakes showed evidence of

[1] Paleolimnology data associated with these publications are available in the National Oceanic and Atmospheric Administration (NOAA) website: ftp://ftp.ncdc.noaa.gov/pub/data/paleo/paleolimnology/eastafrica/

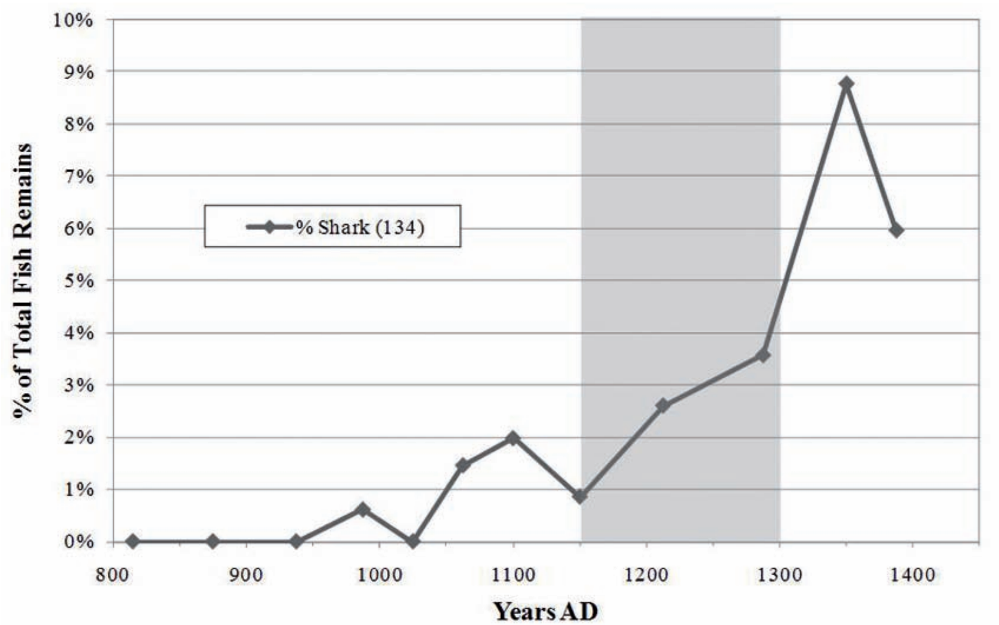

FIGURE 6

Shanga shark remains as a percentage of the total number of fish remains over time. The period of interest is marked in gray. (Data set from Horton & Mudida, 1993).

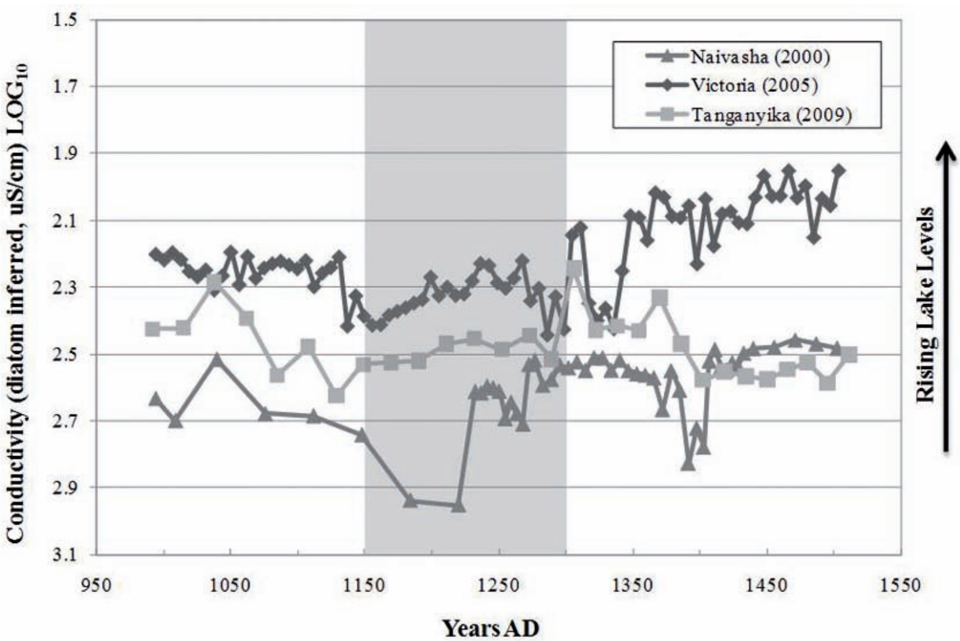

FIGURE 7

Comparison of East African lake level proxies (AD 1000-1500).Conductivity levels through time, inferred from the diatom record. Lake levels are lower when conductivity is higher (as shown by the arrow on the right). The period of interest is marked in gray. (Data sets from Verschuren et al. 2000; Stager et al. 2005; 2009).

drier conditions around the 12th century, the Lake Naivasha record showed higher sensitivity to changing regional rainfall patterns.

DISCUSSION

Faunal remains revealed an important dietary shift around the end of the 12th century at Shanga and Chwaka, two Swahili settlements with comparable chronological data. Both site assemblages showed a downward trend in the ratio of fish to domesticated animals. The decreasing importance of fish was interpreted relative to the increasing consumption of domesticated animals during this period, which was also characterized by having some of the highest numbers of fish remains. Horton & Mudida (1993: 681) recognized a pattern in the faunal remains from Shanga indicating that «on in the final phases does meat significantly replace fish as a protein supply». In his overview of consumption trends at Chwaka, Fleisher (2003: 382-383) noted that the increase in domesticated animals was similar to the trend at Shanga, where fish «drop off dramatically» after the 12th century. More faunal assemblages with long and precise chronologies are needed to determine if the dietary shift visible at Shanga and Chwaka was a regional trend.

The decreasing importance of fish in the diet at Shanga was accompanied by evidence of changing fishing strategies. A closer look at the chronological distributions of fish species revealed that the pattern of declining MTL was related to changes in the exploited habitats. For example, within the family Haemulidae, *P. flavomaculatus* —a higher trophic level species found near reefs— decreases as *P. multimaculatus* —a moderate trophic level species inhabiting estuaries— increased. McClanahan and Omukoto (2011) note that earlier phases in the Shanga assemblage are composed of more near shore species with longer lifespans, and later phases are composed of species that inhabit deeper waters and tend to have larger bodies. They associate these changes with the increasing use of offshore technologies.

Additionally, off-shore fishing strategies that resulted in higher numbers of shark remains became especially widespread during the period of shifting diet around the 12th century. Mudida (in Horton *et al*., 1996: 380) deduced that offshore fishing developed in the later part of Shanga's history since «substantial exploitation of sharks and barracudas began around 1100».

Paleoclimate data from three regional lakes provide evidence of a dry climate, interrupted by an abrupt wet period, during the 12th and 13th centuries. Although the link between regional and coastal climate trends is not well understood, a sudden shift between dry and wet conditions may have had an effect on coastal environments by increasing the amount of sedimentation in the water through the combined effects of erosion and runoff into the sea, thus decreasing the amount of light available to sustain a viable coral reef. The environment around Shanga, which lies at the mouth of three rivers, would be susceptible to this type of runoff. Such an event could lead inshore fishers to resort to alternative strategies such as going farther out to sea or create a heavier reliance on other food sources such as domesticated animals. Additionally, an onset of wet conditions during a drought period could create more favorable conditions for domesticated land animals that graze on green pasture, such as cattle, sheep, and goat.

Lake-core data and fish remains analysis provide evidence that an unstable climatic backdrop could have influenced the patterns of shifting diet and fishing strategies on the Swahili coast. However, it is only one aspect that can be seen as a contributing factor to a complex phenomenon. Another aspect that requires further consideration is the developing urbanism of the settlements. The period of shifting diet occurred as both Chwaka and Shanga reached a peak in their development as coastal trading cities with increasing prestige and growing populations to feed. The relationship between the social dynamics of food consumption and the environment requires further exploration as much as the climatic hypotheses proposed above.

CONCLUSIONS

Analysis of consumption trends at two Swahili settlements with overlapping chronologies showed evidence for a shifting diet of declining consumption of fish compared to domesticated animals, which may be linked to an unstable period of climate change visible in lake-core studies. At Shanga, this period was also characterized by a declining mean trophic level and a rise in shark consumption that indicate changing fishing strategies. These observations suggest that climate could have played a role in the changing subsistence patterns on the Swahili coast in the 12th to 13th century.

This preliminary meta-analysis of published faunal records requires additional investigation. Further faunal studies of long and detailed sequences of occupation are needed to determine if the trend in declining importance of fish consumption is a widespread regional phenomenon. A better understanding of the role of fishing across a community through the intra-site analysis of Swahili settlements can also help us understand the implications of changes in fish consumption and fishing strategies on a local scale.

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