CHAPTER ONE

1.0 Introduction

This work is an environmental archaeological study of human occupation of the rainforest environment in coastal area of south-western Nigeria during the late Holocene period. It is an attempt to ascertain how humans related with the rainforest environment through their culture, subsistence economy and coping strategies during this period. The study of humans from an environmental perspective is of fundamental importance because humans are, themselves, living components of the environment, and they derive all their needed materials (food, shelter, water, clothing, air) from it. Butzer (1982:4) observed that "the environment has perhaps been taken for granted" in the sense that some scientists, unconsciously or deliberately, overlook and neglect its relevance, and do not include it in their studies. Since humans had been, and still are, actively involved in sourcing all their raw materials from the environment, the environment is a very important factor which plays significant roles in shaping a people's culture, subsistence economy, food production capacities and technological development and advancement. Thus, any study of humans without a critical look at the environment under which they lived and subsisted is subjective and incomplete. Therefore, a proper understanding of the environment, and possibly its history through a specific period is a *sine-qua-non* in human-environment studies. The results of such research will undoubtedly provide a better understanding of human history. In order to understand clearly the relationships between humans and the environment, it is necessary to have a brief look at the environment.

1.1 The Environment

Simply put, the environment is the immediate physical surrounding in which an organism or a group of organisms lives on a particular part of the earth. It consists of both living and non-living components. Although, the above definition states that the environment contains both living and non-living components, there is no mention of humans in it. Williams *et al.*, (1998) recognized the need to clearly include humans in the definition of the environment. This was because of the recognition of the fact that the continous human interactions with the environment indicated that they are an important part of the environment in which they live. In line with the above, Sowunmi (1999:199) stated that the environment should involve that which “refers to both the human and non-human components as one integral entity”.

Therefore, an all-encompassing definition of an environment is the sum total of the immediate physical surrounding of humans, other living and non-living things, including all elements, factors, conditions and relationships that have some impact on their growth and development. The living things (plants and animals) are generally referred to as biotic factors while the non-living components are called abiotic factors. The latter include sunlight, temperature, water, soil and atmospheric gases.

The environment influences practically everything within it. Most influenced are the living components especially humans, their resources and culture. The way the environment influences humans is briefly described in the following scenario: A significant increase in the temperature of the earth that occurs over a long period of time, possibly due to an unusually high amount of insolation can lead to environmental changes. With increase in temperature, glaciers in both the northern and southern poles will melt. As a result, huge volume of water will be fed into the oceans and other water bodies. Consequently, there will be a significant rise in sea level. Thus, cities and towns located along the coast will experience severe floods while others might become submerged. This will lead to loss of lives and properties, destruction of farmlands and businesses and in most cases render people homeless and jobless. All these could cause people to relocate to other areas leading to significant increase in human population in those areas. If such a scenerio happens in already congested cities, for instance Lagos Nigeria, there will be serious competition and struggle for the available natural and food resources. Such pressure on the available resources, such as forest resources for instance, will culminate in the rapid depletion of the plant and animal components. With the destruction of such an environment, plants and animals whose natural habitats are the forest will diminish and some may eventually go into extinction or at least become extirpated from that area.

From the foregoing, it is evident that there is a strong relationship between humans and their environment. Furthermore, a good knowledge of the environment, more than ever before, is required for the continued existence of the human race. This is very true particularly because it is now very clear that man needs to manage his resources and energy for the sustenance of present and future generations. The physical environment consists of the atmosphere, hydrosphere and lithosphere while the biological components include humans, animals and plants. Presented below is a brief discussion of these components.

1.1.1 Physical components of the Environment

Atmosphere

This comprises a mixture of various gases surrounding the earth. The gases are nitrogen (78%), oxygen (21%), carbon (IV) oxide, CO_2, (0.03%), water vapour (1%), argon (0.9%) and the remaining rare gases (0.06%). Nitrogen is needed by plants for nutrients. Certain bacteria which live in the roots of plants fix nitrogen which plants subsequently utilize. Furthermore, plants absorb compounds which contain nitrogen, when the plants eventually die, the nitrogen is then contributed to the nutrients in the soil. Carbon dioxide is of great importance due to its ability to absorb heat and make the lower atmosphere warm by heat radiation from the sun. Green plants also utilize CO_2 in photosynthesis in the production of food, and in the process oxygen is released. Humans take in oxygen and give out CO_2 which is used by plants and the cycle continues. The amount of CO_2 gas in the atmosphere has been on an unprecedented increase after AD 1750 and particularly since the last century (Wanner *et al.*, 2008). This increase has been attributed mainly to bush burning and the burning of large quantities of hydrocarbon fuels by humans. The increase in CO_2 gas is one of the major causes of global warming. Ironically, the plants (large forest vegetations) needed to utilize and therefore remove most of the CO_2 from the atmosphere, through the process of photosynthesis, are being indiscriminately cut down and destroyed daily.

Part of the atmosphere is the wind system. In West Africa for example, climate is determined by two wind systems: The North-east trade wind and the Southwest monsoon winds. These two wind systems affect the position of the Inter Tropical

Divergence (ITD). This ITD is the meeting point of the two trade winds. When the moisture-laden southwest monsoon wind dominates, the ITD is pushed further north, and moisture is deposited as rain in the hinterland. This ushers in the raining season which lasts for about nine to ten months in the southern parts of the region. The reverse occurs when the dusty Northeast trade wind dominates. The atmosphere is also responsible for the distribution of heat and moisture over the globe. Without this activity, some places will be extremely cold or hot and will be very unconducive for human, animal or plant life.

Hydrosphere

This consists of all the water bodies on earth including oceans, seas, rivers, lakes and streams; over 70 % of the earth is covered by water. The hydrosphere is important because it is home to several aquatic fauna and flora. It also plays a very significant role in determining the climate of an area. For example, the south west monsoon wind which blows over the Atlantic Ocean causes rainfall along the coast and hinterland of the African continent. Furthermore, it, along with the atmosphere, serves as transport of heat across the latitudes. This ensures the balance and circulation of heat transfer from low latitude regions to high latitude and Polar Regions. Without this transport, surface temperature will be much higher in the equatorial zones and much lower in the polar zones. Such a situation will be unfavourable for terrestrial and aquatic life on the earth. The presence of the liquid form of water is one of the factors that make life possible on Earth, and is unique to our planet. Water is so important to life in that it is used for domestic activities such as cooking and drinking, and for industrial purposes. Water is equally a very crucial part of human and animal life. It is said to contain about 70% of the human body mass; it plays an active role in transport of food, blood and heat within the human body.

Lithosphere

The lithosphere is the earth's crust and mantle; the latter is the outermost rigid layer of the earth. The lithosphere provides solid support for all living things on the planet. Aside the fact that it provides this support for human and animal movement and buildings, the soil, in and on which plants grow, is derived from it. Rocks, which are components of the earth's crust, are broken down through a process called weathering of rocks. This is the process by which soils are formed. Therefore, without the lithosphere, there will be no terrestrial plants or any form of vegetation cover on the earth. Furthermore, soils are a home to many small animals such as earthworms, termites and rodents. Their burrowing activities help to aerate and loosen the soils for the penetration of plant roots. Without their activities, perhaps, the growth of plants will be slowed down considerably.

1.1.2 Biological components of the Environment

These components comprise all living things i.e. plants and animals including humans. The area where living organisms interact with one another and the rest of the environment is called the biosphere. The biosphere is evidently a complex aspect of the environment. Through the process of transpiration, water is given off from the stomatal cells of plants to the atmosphere as vapour to form clouds. When the clouds are saturated, the water subsequently falls back as rain to water the earth, and also goes into various bodies of water. Therefore, an area with a large vegetation cover and abundant sunlight experiences abundant rainfall. This accounts for the tropical areas having rainfall almost all the year round. The natural vegetation of an area is often a distinctive feature of the climate. In other words, it is the climate of an area that determines the kinds of vegetation there. In addition, plants are the sources of food to humans as well as other animals. As a result, certain animals are only found in specific vegetation types because of their dependence on the plant resources in that vegetation. In other words, plant communities usually have characteristic animal species associated with them. For example, the African giant snail (*Achachatina achatina*) and Elephant are found in forest vegetation, and wildebeests, duikers, large cats (lions, leopards and cheetahs) and warthogs are found in savanna regions of Africa. Chimpanzees and gorillas are only found in the forest regions of Africa; elk, reindeer and bison are found in temperate and coniferous forest in America, Asia and Europe, while bobcats, raccoons, skunks, black bears, caribous, wolves, deer are found in the temperate forests of North America. It is this direct or indirect dependence of animals on plants that explains why, from a reconstruction of the vegetation of an area, inferences can be made on the associated animal species.

Aquatic plants fix abundant carbon in the oceans, thus creating a balance in the amount of carbon in the atmosphere. This is achieved through phototsynthesis. During photosynthesis, green plants absorb sunlight energy as well as CO_2 and then convert it to carbohydrate (food). In this process, abundant CO_2 is removed from the atmosphere and fixed within plants. The removal of excess CO_2 gas—one of the most devastating greenhouse gases—from the atmosphere is a sure way of reducing global warming as well as in mitigating the effects of human-induced climate change. Due to their large size and complex diversity, plants in the tropical lowland rainforests are able to do this fixing more than plants in other vegetation zones. This is one of the main reasons several environmentalists have been speaking against rainforest destruction and for their conservation particularly in places where they are abundant—Amazon Basin in South America, Central (Congo Basin) and West Africa.

At this point, it is important to state that the physical and biological components of the environment interact with one another. This important interaction brings about natural state of equilibrium known as homoestatis. Consequently, what affects one component literally affects the other. However, the environment changes periodically, which is to say that the earth is not always static because of changes in some of the components of the earth system particularly climate.

Having given a brief outline of the environment, attention will now be focused on the tropical rainforest environment followed by specific cases of human-environment inter-relationships beginning with the earliest ancestors of humans.

1.2 The Tropical rainforests

These are low altitude or lowland forest vegetation characterized by diverse plant species and closed canopies with trees ranging between 5m and more than 30m in height. There is very little undergrowth including few grasses. Trees are characterized by broad leaves which are larger than those of trees of typical savanna species.

It is well known that the climate of an area greatly influences the type of vegetation present in that area. So it is with the rainforest. The rainforest region of southern Nigeria receives between 2,500 and 3,000 mm of rain per annum; rainfall occurs all year round and temperatures are stable and range between 25°C and 27°C (Vansina, 1990). In other words, in tropical rainforests, temperature and moisture are high while seasonality is low. In contrast, the Sahel savanna barely receives between 500 and 750 mm per annum.

Basically, there are two types of tropical lowland rainforests: (1) the evergreen tropical rainforest with closed canopies and no particular marked dry season. This is referred to as the wetter type of the rainforest and (2) the semi-deciduous tropical rainforest. This second type is the drier forest type and has a brief dry season lasting up to two months. This is not as dense as the former. Generally, rainforest vegetation has very diverse flora as well as fauna. Globally, rainforests are located along both sides of the equator i.e. between latitudes 15°N and 15°S. They are found in parts of North, South and Central America, West, Central, East and South Africa, South-east Asia and Australia. Within the forest, there are edaphic varieties as well as ecotones.

In Nigeria, for example, the edaphic varieties of the rainforest are:

1. The freshwater swamp forest (FWSF) and
2. The mangrove swamp forest (MSF); the ecotones earlier mentioned are the savanna-forest mosaics.

1.2.1 Importance of the rainforests

Rainforests constitute the richest assemblage of diverse plant and animal species in the world i.e. they have high biodiversity. Such high biodiversities are essential for the sustenance of life on Earth. Below are some of the benefits of the rainforest:

Ecological Role

Rainforests are a gene bank of rare species of plants and animals. This bank is a natural source of these rare life forms which can be drawn from for future use. Since forests contain a very large number of plants, they are a sink for carbon dioxide (CO_2). By acting as a sink for CO_2, global temperatures are reduced. Photosynthesis by green plants also reduces the amount of CO_2 in the atmosphere. Rainforest plants (all green plants) release abundant oxygen through photosynthesis into the atmosphere. Humans and animals in turn take in the oxygen, which is necessary for respiration. Without this seemingly simple process–photosynthesis–there will probably be no life on earth. Some cryptogams (lichens, algae and mosses) found in forest vegetation are known to absorb pollutants dangerous to human and animal lives. This is because they readily accumulate airborne pollutants, and are sensitive to significant changes in pollution levels (Oniawa, 2000). Thus, any significant changes in, or destruction of the cryptogams' habitat or ecosystem, can pose serious threat to life as pollution levels may be increased beyond those for human tolerance. Mangroves act as filter systems in estuaries and swamps controlling pollutants such as nitrogen, phosphorus, petroleum products and halogenated compounds (Khor, 2005). The lenticels in the roots of the mangroves which ensure that the roots are aerobic create conducive environments for microbes to further break down these pollutants (Hayes–Conroy, 2000). Without this process, the pollution of mangrove and fresh water swamps will pose serious dangers to aquatic life.

Economic Role

Fishes, reptiles, crustaceans including shrimps and other edible aquatic animals find breeding ground around fresh water and mangrove swamp forest vegetation. These are known to form delicacies in most parts of southern Nigeria. The rainforest is a rich source of herbal drugs, vegetables and fuel. Hunting of animals commonly called *bush meat* (cane rat, antelopes, hare, buffalo, warthog, porcupine, baboons and monkeys) is a common occupation and source of revenue or income in forest regions. The West African honey bees, *Apis melifera adansonii,* also visit flowers of forest plants for their pollen and nectar. The nectar is the main component of honey. For example 111 tonnes of honey is produced annually from mangrove trees in Sundarbans in India. It is claimed that this Sundarbans honey is potent for healing “strange” illnesses. Honey is also known for its nutritive, medicinal and cosmetics values (Crane, 1980).

Leafy vegetables obtained from rainforest serve as sources of food, vitamins, carbohydrates, protein and oils needed by man for body healths. Certain important oil-producing plants are found in the forest. The oil palm, *Elaeis guineensis*, is one such plant. At least two oils are obtained from the oil palm tree namely the red oil which is obtained from the pericarp and the highly medicinal dark-coloured oil obtained from the kernels. In addition, virtually all parts of the oil palm tree have been found to be very useful (Sowunmi, 1999). Some of the products obtained from the tree are brooms, baskets, palm kernel and fuel. Another oil-producing forest plant is *Canarium schweinfurthii*. Many forest trees are usually felled and used as timber. These trees include *Milisia excelsa* (Iroko), *Nauclea dedierichii* (Opepe), *Khaya ivoriensis* (Mahogany), and *Rhizophora* spp. (Mangle wood). Timber is used in building, road construction, furniture and as fuel.

Environmental Role

Rainforest vegetations are a sink for carbon. It has been reported that more than half of carbon emitted into the atmosphere is stored in forests, grasslands and oceans. Less than half of the emitted carbondioxide in the world goes into the atmosphere where it inturn contributes to global warming (Schulze, 2009). The world's forests remove 2.4 billion tonnes of atmospheric carbon/year (Pan *et al.*, 2011) while tropical forests alone remove 1.6 billion tonnes of this carbon from the atmosphere (Gullison *et al.*, 2007). Pan *et al.,* (2009) suggested that when tropical forests are left to grow and expand they have large capacity to remove atmospheric carbon dioxide. In corroboration of the above, Schulze *et al.*, (2009) opined that maintaining forests is very crucial to stabilizing greenhouse gases in the atmosphere. Unfortunately deforestation and burning of tropical forest release 1.5 billion tonnes of carbon/year while global deforestation releases 2.9 billion tonnes of carbon/year into the atmosphere. These activities cancel more than half of the sinks by tropical forest and all of world forest with a deficit of 0.5billion tones of atmospheric carbon/year (Gullison *et al*., 2007). This is one of the reasons why, more than ever before, protection of the world's forest particularly the tropical forest is crucial to mitigating climate change and can not be over-emphasized.

Rainforest trees act as windbreakers, limiting the force of winds or floods on adjacent lands. Mangroves are known to prevent erosion by trapping silt and protecting inlands or islands against storms, tsunamis and hurricanes (Bandaranayake, 2000). With increase in greenhouse gases and global warming, sea levels are expected to rise. This may result in the submergence of coastal lands or islands. However, areas with dense mangrove vegetation may be protected from any such anticipated natural disaster. For example, in the past, mangrove swamp forests were abundant along the shores of the Indian Ocean and they protected the hinterland from tsunamis and floods. Recent destruction of mangroves has made these areas highly susceptible to floods.

Mangroves facilitate sediment traps thus promoting aggradation and maintaining the quality of coastal waters; they act as natural breakwaters protecting coastlines from erosion during storms. Mangroves are a natural resource base for silviculture and a large range of economic products; they are also habitats for rare fauna, and nurseries for commercially valuable fish and crustaceans. Mangrove swamp forests can also serve educational and tourism uses.

1.3 Environmental Archaeology

Environmental archaeology, otherwise known as human ecology, a sub-discipline of archaeology, is one of the ways by which human-environment relationships are studied. Environmental archaeology makes use of disciplines in the natural sciences such as chemistry, physics, biology and geology.

Environmental archaeology is broadly divided into three branches namely:

1. Archaeobotany: study of plant remains from an archaeological context
2. Geoarchaeology: study of geological sediments from an archaeological context
3. Zooarchaeology: study of animal remains from an archaeological context

A combination of results obtained from studies involving these three branches of environmenal archaeology provides a fuller and better picture of human-environment relationships. Because humans cannot do without food, especially plant food resources, they actively interact with plants (and animals) more than other components of the environment. Furthermore, apart from obtaining food resources from plants, they also derive other raw materials from plants which they use e.g. for medicine and drugs, transportation, building, rituals and for their sustenance. Humans, in their search for plant or other resources, sometimes alter the vegetation of an area. Such changes in the vegetation can be traced in the fossil records. Iversen (1956) was the first to demonstrate this using pollen evidence. During the Neolithic period forests became widespread in Denmark and humans found their way into the forest and engaged in agriculture. Iversen

(1956) identified three distinct stages of human colonization in this area. The first was occasioned by rapid decline in pollen of tree species with sharp rise in the pollen of herbaceous plants, as well as appearance of cereals and weeds associated with forest clearance. Iversen (1956) interpreted this to mean that humans cleared the forest and planted food crops. The second stage was characterised by the increase in the pollen of tree species "which typically follow forest clearance—willow, aspen, birch..." (Iversen, 1956:36). The pollen record indicated that these early people may not have cut down the entire forest trees but engaged in systematic forest clearance. The occurrence of tree species such as willow, aspen and birch which naturally colonise recently cleared forests indicated that while an area within the forest was cleared and cultivated, the other was left to grow/fallow. The appearance of birch was interpreted as an indication that the people used fire as a means of clearing the forest. Furthermore, during this same period, pollen of clover, sheep's bit, pasture plants and other grasses appeared and increased. This reflected possible occurrence of grazing animals within the now open forest vegetation. The third stage was characterized by the decrease in grasses, birch and hazel with phenomenal rise in oak pollen. This last and final stage was interpreted as a period when the site was abandoned, which then allowed for regeneration of the forest. Thus, Iversen (1956) demonstrated that during Neolithic times, humans had already started clearing the forest in Denmark. Palaeoecological studies from the Near East and China (Denham and White, 2007) have shown that human impact on the vegetation became more pronounced beginning from the early Holocene ca. 10,000 yrs ago. This was the period of agricultural beginnings or food production. This was because, preparatory to farming, large areas with vegetation were usually cleared and burned. Such human activities altered the original vegetation of the area. Hence, human impact on the environment can be ascertained by studying vegetation changes.

Non-anthropogenic environmental changes can also be ascertained from environmental archaeological studies. Plants are among the best natural archives of environmental changes. This is because, since whole plants unlike animals are not mobile, they will manifest the effect of any unfavourable environmental conditions. The species and population of plants that characterise a particular environment during a given period can thus give an idea of the environmental conditions that prevailed at the time. Fossilized remains of plants are used in ascertaining past vegetations and thus in reconstructing past environments. One of the ways by which past vegetation and environmental changes are studied is palynology.

Palynology is the microscopic study of fossil and extant organic microfossils such as pollen and spores, acritarchs, dinoflagellates and fungal spores. These microfossils are collectively called palynomorphs. The word Palynology was coined by Hyde and Williams in 1944 in a privately circulated Newsletter which dealt with the subject (Faegri and Iversen, 1989). Palynology is derived from the Greek word *Palynein* which means to 'spread or strew around". This is because Hyde and Williams (1994) (In: Faegri and Iversen, 1989) observed that pollen of European plants, most of which are anemophilous, being dispersed by the wind often appear as dust in the atmosphere. It is the application of palynology in archaeology that makes it a powerful tool in environmental archaeological or human ecological studies.

Lennart von Post in 1916 presented the first paper on the application of palynology (pollen analysis) to a Quaternary site at an International Geological Congress held at Kristiana (now Oslo) Norway (Bryant and Holloway 1996). In 1925, Post himself examined fossil pollen from an archaeological site. This was the first time such an attempt was made. According to Faegri and Iversen (1988:1-2), pollen analysis (palynology) is by "far the most important method for the reconstruction of past flora, vegetation and environment." Although palynology now encompasses other microfossils, pollen grains and spores, on account of their ubiquitous nature, remain the most commonly studied fossils in the world of palynology. The sizes of pollen and spores range from 5 µm to 200µm, and usually these palynomorphs can be identified based on their distinct morphological features. These features which include type, number and character of the apertures, exine structure and/ or sculpture, and pollen shape and size, are the basis for identifying both fossil forms and extant types. Pollen and spores are usually excellently preserved and are thus well represented in sediment deposits except in oxidized or aerated soils. The assemblage of pollen and spores in palaeoecological context provides a relatively broad picture of the environment and the surrounding vegetation that produced the pollen and spores (Elenga *et al*., 2000; Singh *et al.*, 2010).

1.4 Palynology and environmental changes

Changes in the environment have significant impact on the vegetation of an area. This is because the vegetation, being part of the environment, will respond to the environmental dynamics in that area. It is the ways in which the vegetation responds to environmental changes that are used as indices of environmental changes, whether they are natural or human-driven. Therefore, if changes in vegetation provide indications of environmental changes, it becomes necessary to study the vegetation history of an area in order to understand human-environment inter-relationships in that area. In palynological studies, two main approaches are used in identifying human impact. The first is to understand the changes in forest composition and the second is to study species associated with or indicative of human activities. These approaches seek to demonstrate that certain vegetational changes can be attributed to human activities such as forest clearance and/or agricultural practices.

Although palynology primarily provides information on vegetation, other secondary inferences such as faunal components, climate, past sea levels, and human disturbances can be made from its study. The success or failure of such attempts however depends on the "closeness or the relations between the vegetation and the features studied" (Faegri and Iversen, 1988:2). The correct identification of pollen and spores especially to the lowest possible taxonomic level is one of the most important aspects of palynology. Furthermore, fossil pollen are assigned to extant parent plants otherwise known as their botanical affinities based on the close similarities between the fossil form and extant pollen. It is assumed that the parent plants that produced the fossil pollen and spores are the same as the present/extant ones, and that their morphology, habit and natural habitats have remained virtually the same through time. The correct identification of pollen and spores therefore aids in logical, and often times objective palaeoenvironmental and vegetational reconstructions.

Apart from palynomorphs, microscopic charcoal has now been included in routine pollen analysis especially if one of the aims of the research is to obtain evidence of human impact on the environment and human use of fire. Charcoal is valuable in providing direct evidence of fire. It is generally believed to be a product of biomass burning. Kangur (2002:289) stated that "charcoal analyses of sediments…are the primary evidence from which reconstructions of past fires are made". But their greatest limitation is the inability to identify the microscopic charcoal to the parent plants. This limitation not withstanding, Faegri and Iversen (1988:201) stated that "large charcoal peaks suggest fairly regular intense fires which probably resulted from stress imposed on vegetation by changing climate". Furthermore, Athens and Ward (1999:298) stated that "charcoal particles are generally regarded as a key indicator of anthropogenic activities in tropical palaeonvironmental studies". In addition, Kangur (2002:289) opined that microscopic charcoal "is a sensitive indicator of palaeoenvironmental change whether caused naturally or by humans".

The combination of palaeoenvironmental methods such as archaeological, palynological and anthracological is therefore crucial in environmental archaeological research. Denham (2007:12) puts it succinctly: "the combined use of phytoliths and pollen analyses, together with macro- and microcharcoal frequency distributions, provides a complementary and more robust interpretation of vegetation history than the application of these techniques in isolation". However, new techniques such as parenchyma, starch grain and molecular analyses (DNA) have been developed and are being used in understanding how humans interact with the environment especially in relation to the emergence of agriculture (Dehman and White, 2007). The combination of data generated from these methods i.e. palynology, anthracology and archaeology, thus provides a better picture of palaeoenvironment and past human interactions with the environment than when a method is used alone. This is the basis for this present study.

1.5 Human occupation of the rainforest

There are controversies over whether humans actually lived or not in the forest environment, as well as the nature of their impact, if any, on the forest during the Late Pleistocene. There is the opinion that human occupation of the rainforest was not possible for most part of the Late Pleistocene or is, at best, only a very recent phenomenon (Bailey *et al.*, 1989). This is because it was assumed that the rainforest was a jungle and hostile environment on account of its diverse plant species, and is an insect-infested environment with weather that is humid and hot for most part of the year as well as acidic and infertile soils. It was argued that since the rainforest was uninhabitable, food production/agriculture would have been impossible in such an environment. As a result, man would have ignored it and preferred a more open and agriculturally-friendly environment such as the savanna. A second view is that humans actually occupied the rainforest vegetation as far back as late Pleistocene times from ca. 40,000 to 13,500 yrs B.P. In Papua New Guinea, for example, during the late Pleistocene period, human occupation of these areas is at least 40,000yrs old (Groube *et al*., 1986; Stevenson 2004; Hunt and Rushworth, 2007).

Closely related to the above issues are the concepts on the causes of environmental change. Two main schools of thought exist. The first states that environmental changes are primarily a nature-driven phenomenon particularly during late Holocene times. This extreme view excludes the possibility of a human factor for environmental changes during those times (Maley, 1996, Salzmann and Hoelzmann, 2005). The second is that, though climate might be the primary force behind environmental change, humans have become a significant and contributory factor in this respect during the late Holocene especially from between 3,000 yrs and 2,000 yrs B.P. (Kirch, 1996; Sowunmi, 2004; Stevenson, 2004; Athens and Ward, 2004).

If the view of the first school of thought is accepted, it would then appear that humans were not, partly or wholly, responsible for, or did not contribute to environmental changes in the late Holocene except of course in the last 200 years. The acceptance of this view implies that human interactions with the environment were insignificant during the late Holocene times. In other words, their interactions with the environment did not lead to any significant changes in the environment in the late Holocene. But that, in itself, will be controversial, because humans (anatomically modern humans), since their evolution some 150,000 yrs ago, have been interacting with the environment. Their interactions would have significantly affected the environment particularly during the period of agricultural beginnings from early to mid Holocene. On the other hand, if the second school of thought is considered more valid, we would then need to ascertain the history of human interactions with the environment during the late Holocene period.

1.6 Early Hominins/Humans and their environments

Since the evolution of hominins or human ancestors in Eastern Sub-Saharan Africa about four million years ago, they have been relating with their environment for their basic necessities, i.e. food, water and shelter. These human ancestors first occupied the savanna regions of Africa before moving to other areas. This is based on marine, geomorphological, botanical and palaeontological evidence. Lake basins of the rift valley provided favourable habitats for the first hominids and their associated faunas (Phillipson, 1985). The discovery of the so called 'ape-man' *Australopithecus africanus* was made by Raymond Dart in South Africa. This discovery prompted many archaeologists, anthropologists and palaeoenvironmental scientists to focus their research on these parts of Africa in the last century (Leakey *et al.,* 1964 and Brown *et al.,* 1985). Other fossils which have shed more light on human origins include *Australopithecus afaraensis, Homo habilis* and *H. erectus.* The latter species is regarded as the closest relative of modern humans, *Homo sapiens.*

Since many fossils of hominins and early humans were recovered from savanna-like environments, early studies of hominin/human evolution and their interactions with the environment were focused on savanna regions. On the contrary, such studies on forest environments are few due, in part, to the focus of earlier studies on human-savanna environments; and partly to the erroneous belief that the rainforest was a single, monotonous, impenetrable environment through time (Vansina, 1990). Furthermore, the forest environments in other areas in Africa, especially West Africa, are not conducive for bone preservation due to the acidic nature of the soils. This is in contrast to the East and South African soils. Soils in East and South Africa are alkaline in nature and bones are excellently preserved in such a medium. These areas had experienced several volcanic eruptions in the Cretaceous and late Tertiary period. The volcanic materials exuded from the eruptions and deposited on the area are rich in phosphorus and potassium. These elements are alkaline in nature, and explain the several excellently preserved fossilised remains of earliest humans and animals recovered from Eastern and Southern parts of Africa.

Due to the young age of the Quaternary, the records of environmental changes that occurred during this time are more complete than those of the pre-Quaternary period. The records from the former therefore present better opportunities for understanding the history of the Earth's palaeoenvironment than those of the latter. Aside the natural changes that have been noticed in the forest, there is evidence of some human interactions with the forest environment. Human occupation of tropical rainforests dating back to ca. 8,000 yrs B.P. in South America (Piperno *et al.*, 1990; Hastorf, 2007) and 40,000 yrs B.P. in South East Asia. (Groube *et al*, 1986; Flenley and Newsome, 1998; Pasveer, 2002; Hunt *et al*., 2007) have been well documented and research is still in progress. These human interactions have been prominent particularly in the late Holocene period (Dull, 2004; Mercader *et al.*, 2001). The results of a few of such studies are presented

The Klasies River mouth cave in South Africa is one of the most important and well-studied sites of the earliest occurrence of anatomically modern humans (AMH). The stratigraphic sequence of one of the excavated profiles of the Klasies River mouth cave shows at least four human occupational periods. These are (1) shortly after ca. 125, 000yrs B.P., (2) around 110,000 yrs B.P., (3) before ca. 90,000 yrs B.P., and (4) before 60,000 yrs B.P. It has been suggested that the gaps in between "reflect the absence of human populations in the region due to the difficulties of coping with arid periods" (Rightmire and Deacon 2001:144). Rightmire and Deacon (2001) reported the recovery of human remains, charcoal, hearth, ash and stone tools such as bifacially flaked leaf-shaped points from the site. The recovered faunal remains include those of small terrestrial vertebrates, ranging from reptiles, large herbivoures, and a variety of marine species such as fish and (rare) amphibians. Other aquatic animals include seals and shellfish. These archaeological remains are indications of the kinds of food that formed part of the people's diet at that time. This pointed to the fact that the early occupants of the site relied on their immediate environment for survival. On account of the recovered floral and faunal materials, the inferred environment was "a rich, diversified mosaic of forest and bushveld…eland, buffalo and antelopes" (Sowunmi, 1998: 217). The vegetation was thought to be more of a savanna rather than typical rainforest. Although, the recovered stone tools were hardly retouched, it has been suggested that hunting was practised. This was based on the recovery of a weapon tip embedded in a vertebra of a giant buffalo.

Recent anthracological and palynological analyses of samples from an excavated rock shelter in Abric Romaní located near Capellades, about 45 km northwest of Barcelona, Spain, have revealed the existence of Neardethals between 57,000 yrs and 47,000 yrs B.P. in that area. The palaeoecology of the site, based on palynology and anthracology, particularly the abundance of *Pinus sylvestris*-type pollen and macro-charcoal, showed that the site was “a patchy landscape, with different vegetation assemblages in the territory including forests, riverside forests, prairies, and steppes with more or less humid connotations” (Burjachs *et al*., 2012:34). In addition, based on the abundance of pollen of conifers, it was inferred that the palaeoclimate was characterised by lower temperatures and higher precipitation than today because these are the present-day ecological requirements of *Pinus sylvestris*. Anthracological analyses of the many macro charcoal particles showed that the Neanderthals used fire, and the firewood used by them was pine.

Based on pollen and geomorphological evidence, Kirch (1996) established that the reduction in a hitherto heavily forested area between 2500yrs B.P. and 1800yrs B.P. in the Mangaia Island was human-induced. The major changes noted in the pollen record included drastic reduction in forest trees and marked increase in charcoal particles. The results of the geomorphological studies carried out there showed that there was an increased rate of erosion. This was attributed to the heavy loss of vegetation cover. Reduction was also noted in the populations of native birds and fruit bats, and the introduction of many economic plants: coconut [*Cocos nucifera*], taro [*Colocasia esculenta*], banana [*Musa* sp.], breadfruit [*Artocarpus altilis*], sugar cane [*Saccharum officinarum*] and sweet potato [*Ipomoea batatas*]), and domestic animals such as pacific rat [*Rattus exulans*], chicken [*Gallus gallus*] and pig [*Sus scrofa*]). Thus the pollen evidence was corroborated by archaeological evidence. Available archaeological evidence indicated that Polynesians arrived in the Mangaia Island between 2,500 yrs B.P. and 1,600 yrs B.P. Similarly, the disappearance of forest and mangrove and their eventual replacement by coastal vegetation in NE Caledonia was attributed partly to late Holocene drier climate and partly to human impact on the vegetation (Stevenson, 2004). This was because the decline in the pollen of forest trees and increase in charcoal coincided with the arrival of humans in the area ca. 3,000 yrs

B.P. Furthermore, archaeological evidence indicated that humans arrived in the area between 3,100 yrs and 3,150 yrs B.P. The results of the few palynological studies discussed above, therefore, revealed human-environment interactions during the late Holocene. More robust results were obtained when the palynological studies were combined with other proxy data such as geomorphology, anthracology (microscopic charcoal) and archaeology. The results of palynology in combination with other related disciplines offer a holistic approach as well as promising results for the understanding of human interactions with the environment.

Anthropogenic impact on the rainforest has reduced it drastically, resulting in marked depletion of its diversity. This reduction in forest has also contributed to climate change (Okali, 2011; Oyelaran, 2011). The use of felled trees as fuel contributes CO_2 into the atmosphere contributing to global warming. Because of the importance of the rainforest, there is need for its conservation for both the present and future generations. However details about the vegetation history of the rainforest in Nigeria are not yet well known. For example, it is important to know, from an environmental archaeological perspective, how far back humans have been destroying the rainforest environment and when their impact became pronounced. Such information is useful in addressing human-induced environmental changes.

A reconstruction of the rainforests in southern Nigeria, and ascertaining the antiquity of human occupation of these forests, especially the mangrove swamp variety in the Holocene period are required. Such data would provide much information on human-environment interactions in the forest environment of Southern Nigeria during the Holocene period. With the increasing population of humans in the world today, human demands for food and other vital resources from the environment have been on the increase. The current population of the people on earth stands at approximately 7 billion, consequently human pressure on the environment has increased tremendously. For example, 45% of the earth's original forests have been cleared for industrialisation purposes in the last 100 years. Burning of fossil fuels such as crude oil and coal has led to a significant increase in the atmospheric concentrations of greenhouse gases, all within the last 250 years. According to the 2007 report of the International Panel on Climate Change (IPCC), human activities are some of the most significant factors contributing to climate change and global warming. Of these human activities, deforestation, bush burning, industrialisation and burning of fossil fuels contribute most to climate change. It was suggested by Crutzen and Soermer (in: Steffen and Tyson, 2001) that this period when human activities have produced globally disturbing effects should be called the "Anthropogenic era". In fact, several other scientists including Oyelaran (2011) and Okali (2011) seem to support the "Anthropogenic era" proposal. The latter two scientists recently opined that in Africa, where there are comparatively fewer highly sophisticated and technologically-advanced industries, the two leading factors responsible for climate change are bush burning and deforestation. These are human activities. If human activities are the main drivers of the *current* climate change, when did they (humans) become the main drivers of this climate change? What factors have led to the increase of these human activities? It will also be instructive to ascertain what the environment was during the pre-anthropogenic era i.e. a period under which human-environment interactions were almost always at equilibrium, and human-induced climate change was non-existent. This is particularly important as lessons learned from human-environment interactions during the pre-anthropogenic era can be applied to solve, or at least address, the current environmental challenges facing humans. Before the advent of agriculture there was an equilibrium maintained between humans and the environment due largely to the low human population. Thus, the environment was not over-exploited or drastically affected.

1.7 Humans in the rainforest of Africa with reference to Nigeria

Archaeological and palynological evidences have shown that early humans who inhabited the forest regions did not adversely affect the ecosystem. Sowunmi (1998:82) stated that "several evidence showed that man's exploitation of the biological resources did not have an appreciable or notable impact on the environment until between 3,500 yrs and 3,000 yrs in Ghana, Cameroon and Nigeria". At present there is not much information on the history of human occupation of, and adaptation to, the rainforest in southern Nigeria except for the works of few authors, notably Sowunmi (1981a& b), Umeji *et al.,* (2012), Shaw and Daniels (1984), Oyelaran (1991) and Alabi (1998). In the southern parts of Nigeria, Sowunmi (1981a) submitted that at 2800yrs B.P., human impact on the forest became noticeable. This was based on the marked decrease in the pollen of forest taxa accompanied with a concomitant and phenomenal increase in the pollen of *Elaeis guineensis*, as well as those of plants associated with human habitation. In the forest zone of Eastern Nigeria (Udi-Okigwe plateau), based on archaeological and palynological evidences, human occupation of the area is put at 3000 yrs B.C. (Umeji *et al.*, 2012). Similar results but of younger dates were recovered from Congo. Elenga *et al.*, (1994) noted an unprecedented and abundant increase in the pollen of *Elaeis guineensis* ca. 2,850-2,700 yrs B.P. in the Congo. This almost coincided with the time when forest taxa declined. The authors, based on the pollen evidence, concluded that human presence in the area may be at least 2,800 yrs old. Thus, it has been established from an environmental archaeological approach that human occupation of eastern and southern parts of Nigeria is at least 5,000-2,800 yrs B.P. old.

In Western Nigeria, the earliest date for the existence of humans in the rainforest zone has come from the Iwo-Eleru rock shelter. Iwo-Eleru is about 24 km from Akure, Ondo State, and is situated in the present-day northern limit of the rainforest. The rock shelter was excavated by Shaw in 1964 (Shaw and Daniels, 1984). Archaeological finds at the site include human skeletal remains, microlithic tools (arrow tips and barbs), heavy-duty scrapers and chisels. The human remains were a skull dated to ca. 11,000 yrs B.P., and some other parts. This archaeological evidence thus shows that the rock shelter was occupied at least 11,000 yrs ago. Changes in the tools utilized by the occupants of the rock shelter were interpreted as indications of a changing environment. Microlithic tools were predominant at lower levels of the rock shelter representing the period between 12,000 and 9,500 yrs B.P. Here the subsistence of the people was presumed to have been mainly hunting as the recovered microlithic tools were probably used mainly for hunting purposes. However, as from 9,150 yrs B.P., a new tool type—heavy-duty scrapers and chisels—became increasingly abundant with a remarkable decrease in microliths. This change in tool type is believed to reflect a change in the vegetation of the area as well as change to a vegetable diet or plant-based subsistence. Unfortunately, the pollen analysis of soil samples recovered from the excavation did not yield any pollen. As a result the palaeoenvironment of Iwo-Eleru was based on palaeobotanical records obtained from other sites with similar ages in West Africa.

These records indicated that prior to 11,200 yrs B.P. the forest vegetation was fragmented and possibly restricted to small refugia while savanna vegetation predominated. During the early to mid-Holocene, there was a re-establishment of forest vegetation from 9,150 yrs B.P., and this remained so until about 3,500 yrs B.P. However, as relevant as these results are to the Iwo-Eleru palaeoenvironment, there might be certain local differences not represented in these data. This is because similar vegetations in a region respond differently to environmental changes.

Oyelaran (1991) carried out excavations at Itaakpa rockshelter located in the present-day Kogi State, North Central Nigeria. Although this rockshelter is located in a mosaic of lowland rainforest and secondary grassland vegetation (i.e. forest-savanna ecotone), the results of the work conducted there are worth mentioning. Oyelaran (1991) reported that the rock shelter area had been occupied continuously since 300 B.C. Oyelaran (1991) unearthed a human skeleton which was dated to ca. 2,210 ± 80yrs B.P. This predates available dates from old Oyo and Ile-Ife. These two places, considered to be centres of Yoruba origin, have dates ranging from 12^{th} to 15^{th} century A.D. for human occupation of these areas (Alabi, 2004). Excavations in Apa southwestern Nigeria indicate that human occupation of the area is at least 2,670 ± 60yrs B.P (Alabi, 1998). The works of Oyelaran (1991) and Alabi (1998) provide dates about human occupation of the rainforests but are without a vegetation history of the rainforests themselves. Still on Western Nigeria, palynological studies at Ahanve and Ogudu near Lagos, show that the mangroves declined at Ahanve at 3,100 yrs B.P. (Sowunmi, 2004) and sometime at Ogudu (Orijemie, 2005). However, it remains to be known whether the periods of mangrove decline at the two sites are contemporaneous. This is because dates for the Ogudu core are, at the moment, unavailable. Furthermore, that research was without an archaeological content. The suggestion that humans probably contributed to the vegetation changes at Ahanve has come from archaeological excavations at Apa. This is regarded as indirect evidence. Oral history puts the present human occupation of Ahanve village at about 200 yrs ago (Chief Toyon—Baale of Ahanve, Pers Comm., 2008). This excludes the present inhabitants of the site as factors which might have contributed to the vegetation changes there. Therefore it is necessary to investigate the history of human occupation of Ahanve village, and whether humans could have had any effects on the vegetation changes. This is one of the main reasons for embarking on this research work. In addition, though studies at Ahanve and Ogudu referred to above gave some details about the rainforest, the results are, strictly speaking, only from one of its variants i.e. the mangrove swamp forest. It is therefore important that the Holocene vegetation history of the lowland rainforest (i.e. the rainforest, and its edaphic varieties—fresh water swamp and mangrove swamp forests) be studied. This is another major focus of this research work.

1.8 What are mangroves?

Mangroves form a unique and dominant ecosystem consisting of intertidal plants, mostly trees, few shrubs and lower plants (ferns). Mangrove swamp forests occur in tropical and sub-tropical coastal wetlands, lagoons and brackish tidal waters. They predominantly border tropical coastlines around the world. They are usually referred to as *Forest of the Sea*. These halophytic (salt tolerant) plants thrive in saline conditions and experience daily inundations at high tides. Majority of mangrove are distributed between the latitudes of 30°N and 30°S (Tomlinson, 1986). Mangroves are usually poor floristically compared to rainforests which may have several numbers of tree species per hectare. This may not be unconnected to the ecological limits defined by the diurnal tidal flow. According to Tomlinson (1986), the major mangroves include five families, nine genera and 54 species. Two centers of mangrove diversity are known in the world. They are the Eastern group (Australia, Southeast Asia, India, East Africa, and the Western Pacific) and the Western group (West Africa, Caribbean, Florida, Atlantic South America, and Pacific North and South America). The eastern group has 40 species while western group has eight. According to a recent study on world mangrove distribution, 42% of the world mangroves is in Asia, 21% in Africa, 15% in North and Central America, 12% in Oceania and 11% in South America (Singh *et al.*, 2010). Nigeria's mangroves are 4.7% of the world's distribution (Fig 1).

In Nigeria, *Rhizophora* species form the major mangrove species. Three *Rhizophora* species are known to occur in the country. These are *Rhizophora racemosa, R. harrisonii* and *R. mangle.* Of these, *R. racemosa* is the most common. Other mangrove species are *Avicennia africana, Laguncularia racemosa, Conocarpus erectus, Paspalum vaginatum* and the salt-water fern, *Acrostichum aureum.* Other plants which are not, strictly-speaking, mangrove species but grow on edges of swamps, mainly near the sea include *Drepanocarpus lunatus, Dalbergia ecastophyllum, Hibiscus tiliaceus, Ipomoea-pes-caprae* and *Telanthera maritima* (Keay, 1959).

1.8.1 Mangrove ecology

Mangroves are the most important parts of the coastal vegetation or habitat, which occur along intertidal zone. They usually form a link between the land and sea where they are under the influence of water (Lean, 2005). Mangroves, especially red mangroves, are viviparous therefore they are not washed away by inter-tidal currents. Blasco *et al.*, (1990:167) noted that the genus *Rhizophora* "occurs in ecological conditions that approach its limit of tolerance with regard to salinity of the water and soil, as well as the inundation regime". This means *Rhizophora* is a very important species of the mangrove swamp forest.

Mangroves also play a vital role in the health of the marine ecosystem, because they filter and block sediments from the unsuitable substrates of the wetlands, and prevent siltation of sea beds and coral reefs. This often leads to soil stabilization. One of the most important roles of mangroves is to eliminate pollutants such as sewage waste, pesticide run-off, and toxins in wastes dumped in the wetlands. Several factors affect mangroves. These include human impact (especially dredging and over harvesting of mangrove trees

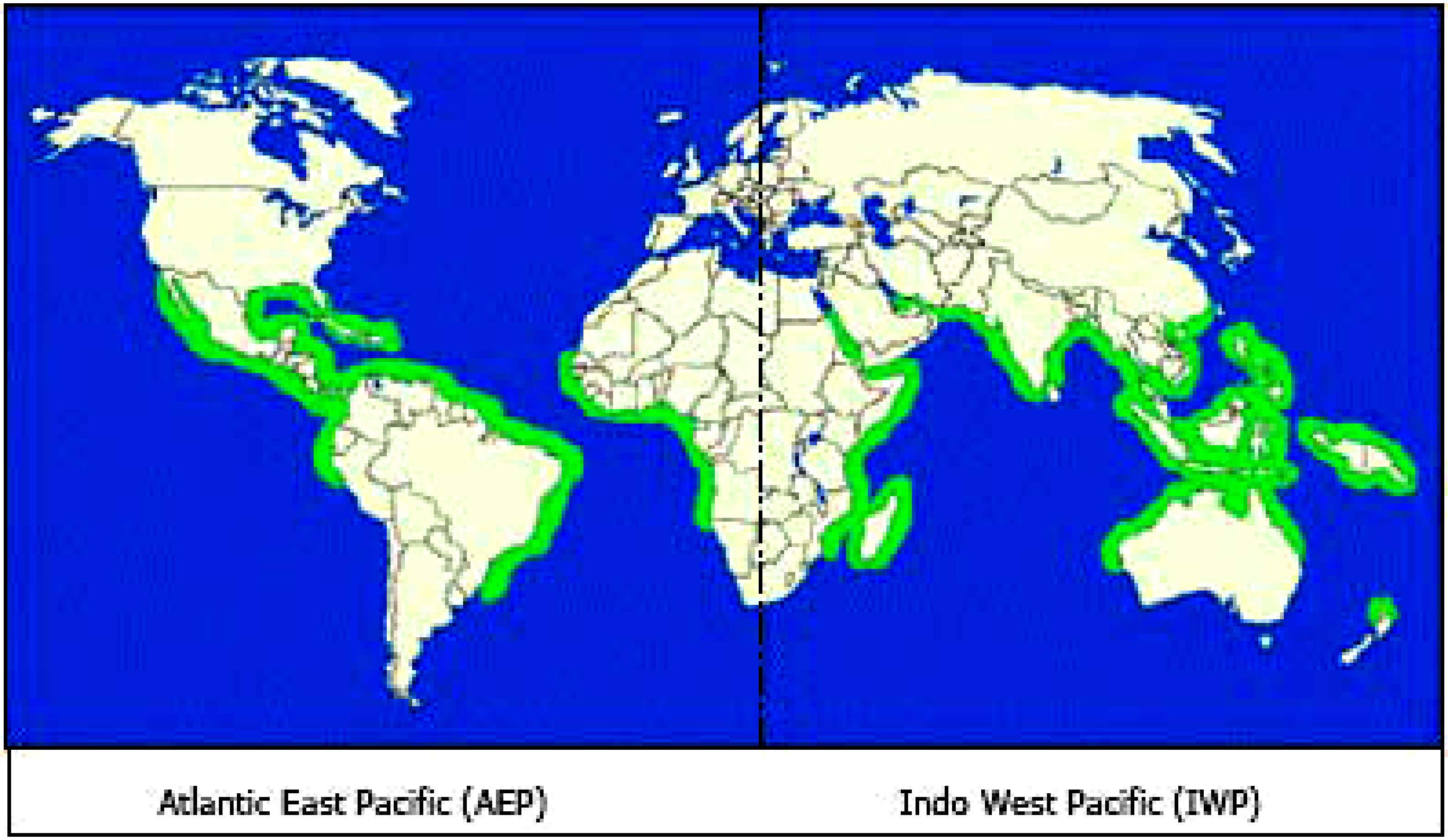


Fig 1: Distribution of the world's mangrove swamp forests (Burger, 2005)

and branches), lowered sea level, drought and pollution. Miyawaki (2000) reported that in Japan, when *Rhizophora stylosa* trees are cut, they only recover as stunted scrubs. If cut repeatedly, *R. stylosa* disappears completely. Most mangrove plants especially *Rhizophora* species are not capable of stump-sprouting, i.e when they are felled with just the stumps left, they eventually die off.

Under favourable environmental conditions, mangrove trees grow extensively and may reach 10–30m in height, usually forming continuous vegetation. This is better understood when viewed from the air. The world's most extensive mangrove swamp forests are found in India, Indonesia and West Africa. The Niger Delta, which has the largest mangrove forest vegetation in Africa, is characterized by meandering creeks, swamps and rivers, making accessibility to these areas quite difficult. Mangrove swamp forests are found along the coasts of the southern States in Nigeria namely: Lagos, Ogun, Ondo, Edo, Delta, Bayelsa, Rivers, Cross River and Akwa-Ibom. Extensive mangroves are found in the latter five Niger Delta States.

1.8.2 Benefits of mangroves

Mangroves are used for shoreline beautification. Some mangrove trees such as *Rhizophora mucronata* especially grow on the edge of estuarine channels, and are known to stabilize banks. Mangroves are a home to several birds, reptiles, amphibians and mammals which are endemic to the mangrove environment (Luther and Greenberg, 2009). They are also a niche for migratory birds and fish; in this case, mangroves provide protection and act as a food resource. One of the major benefits of mangroves is in estuarine and coastal shoreline protection. This is based on mangrove tree and stilt root structure, which reduces erosion and provides protection from ocean waves. Mangroves are exceptional for sediment trapping. Since they grow on depositional sediments, they can trap both water and airborne sediments, which in turn reduce turbidity of coastal waters.

In December 26, 2004, a tsunami which claimed over 160,000 lives struck eleven Asian countries. Worse hit were Indonesia, Sri-lanka and India which had had 60% of their mangrove swamp forests destroyed (Devinder, 2005). Neighbours of Sri-lanka such as Mynamar and Maldives suffered much less from the tsunami. In fact, a little over 100 human lives were lost. This was because these areas had abundant mangrove swamp forest. Simeuleu Island is located just 40km from the earthquake's epicenter. But just four deaths were recorded (Khor, 2005). The Island was saved by its extensive belt of mangroves swamp forest. In 1960 when a tsunami hit the coast of Bangladesh, not a single life was lost. At that time, the coast was lined with extensive mangroves which reduced the effect and energy of the tsunami. By 1991, most of the mangroves had been cleared for "industrialization" purposes. Unfortunately, when a tsunami of the same magnitude hit the region that same year, thousands were killed (Lean, 2005). In contrast, a team of scientists led by Andrew Baird claim that mangroves cannot adequately protect against tsunamis or cyclone storm surges. According to Baird and his team, relying on tree planting alone may not be enough to protect coastal communities against tsunamis. However, there is general agreement, based on both field and laboratory studies that mangroves act as shield against tsunamis and cyclones (Wells *et al.*, 2005; *Environmental Justice Foundation* Report, 2006).

Mangroves are an exceptional sink where carbon is bound within living plant biomass (Bouillon, 2011; Donato *et al.,* 2011). Mangroves possess specialized morphological characteristics such as pneumatophores otherwise called breathing roots (*Avicennia* spp.). These roots allow vital gas exchange in anaerobic sediments, and stilt roots (*Rhizophora* spp.), which provide support in soft sediments. As a result, a network of sturdy and overlapping stilt roots help to stabilize soils. This action causes a reduction in water movement and promotes sedimentation in areas that might otherwise be eroded. Mangroves are able to expell salt from their leaves and roots most likely because they possess a higher osmotic pressure than their surrounding. Mangroves provide vital structure as habitat and food for several fauna and flora which occupy or share similar ecosystems. The wood of mangroves is used for smoking fish and meat; the smoke of *Rhizophora racemosa* has been noted to possess antibacterial activity (Asita and Campbell 1990). This keeps the fish and meat preserved for a long time. Despite these benefits, mangroves are destroyed. It has been reported that "between 1980 and 2005, 35,000 square kilometres of mangroves were removed from coasts around the world for human development or the creation of shrimp farms. That represents an area roughly the size of Belgium" (*CBC News* March 24, 2011). In Southwestern Nigeria, the Ogudu-Alapere Bridge which was built over the Ogudu creek has cause the destruction of the mangrove swamp forest there (Orijemie, 2005). If afforestation plans are not carried out there the MSF might not be able to prevent the energies of any serious flood in the residential areas located near the forest.

1.9 Aims of Study

The aims of this study are five-fold: The first is to ascertain the antiquity of human settlement in Ahanve village, and secondly, to determine the impact of humans on the rainforest in southwestern Nigeria. The third is to study the vegetation history of the mangroves in SW Nigeria during the late Holocene. The fourth and fifth are to decipher in detail the botanical composition of the rainforest in southwestern Nigeria during this period, and infer the palaeoenvironment of the forest respectively.

1.10 Objectives

The research objectives are to find answers to the following questions:

1. Did humans have any contributions to the vegetation changes in the mangrove swamp forest at Ahanve, near Badagry?

2. When did humans start having impact on the rainforest vegetation of south-western Nigeria?

3. What was the composition of the lowland rainforest and mangrove swamp forest in south-western Nigeria during the late Holocene? and,

4. What were the palaeoenvironmental conditions of the lowland rainforest in south-western Nigeria at the same period?

This work is timely, as current researches in environmental archaeological studies focus on the interactions between humans and the terrestrial landscape (environment). The increasing awareness that humans contribute in a major way to factors which lead to current environment and climate change further underscores the importance of this study. Thus it is hoped that the results from this work will provide information on the palaeoenvironmental history of the rainforest, and how humans have been interacting with it. With such knowledge, humans can learn how best to interact with the environment in ways that will not lead to climate change or at least, ways of mitigating its effects. Furthermore, this information will be very useful in designing governmental programmes for the protection and conservation of the rainforest and mangrove swamp forest particularly their biodiversity, and provide guidelines for their sustainable management.

The Study Area

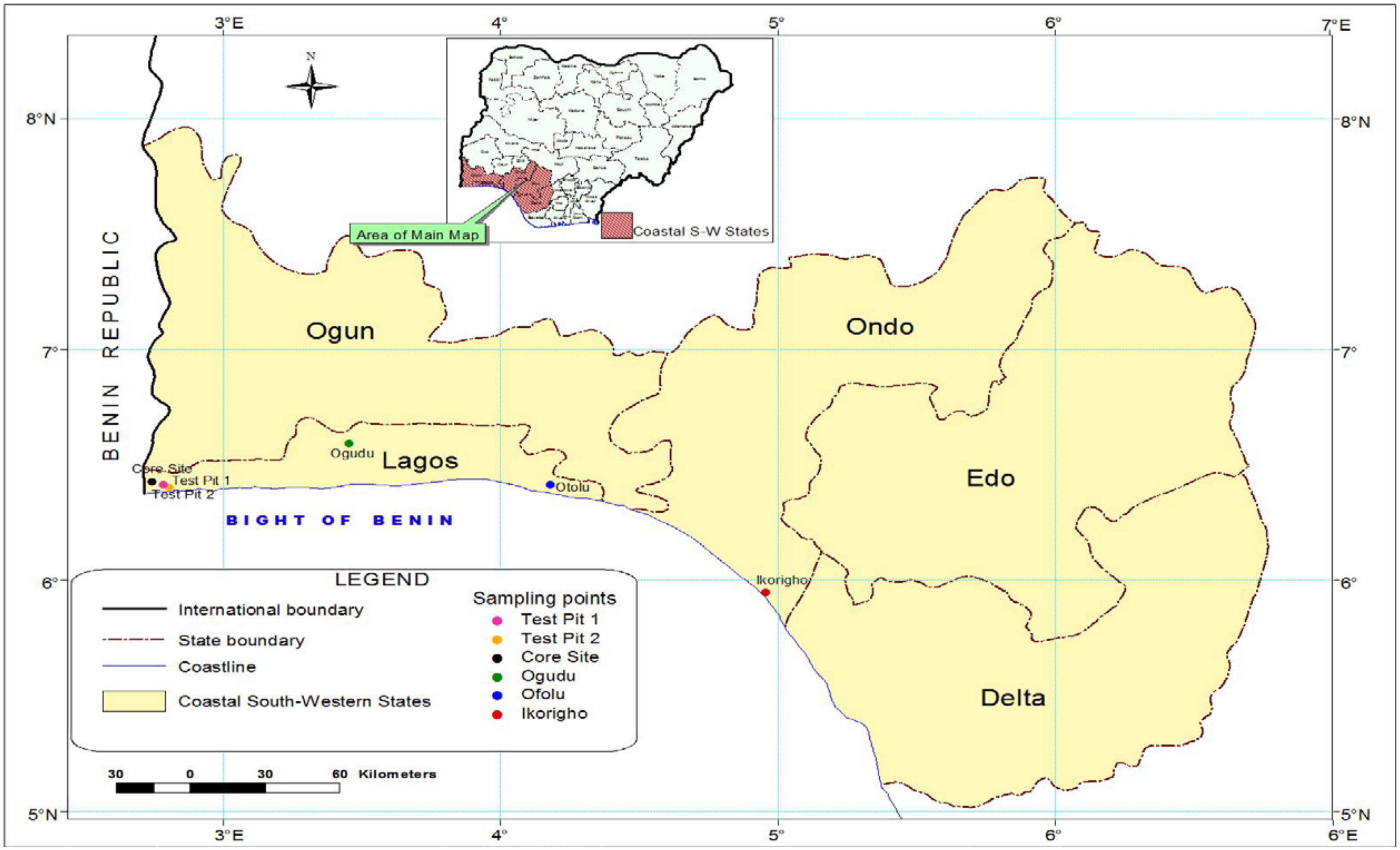


Fig 2: Map of the Study Area

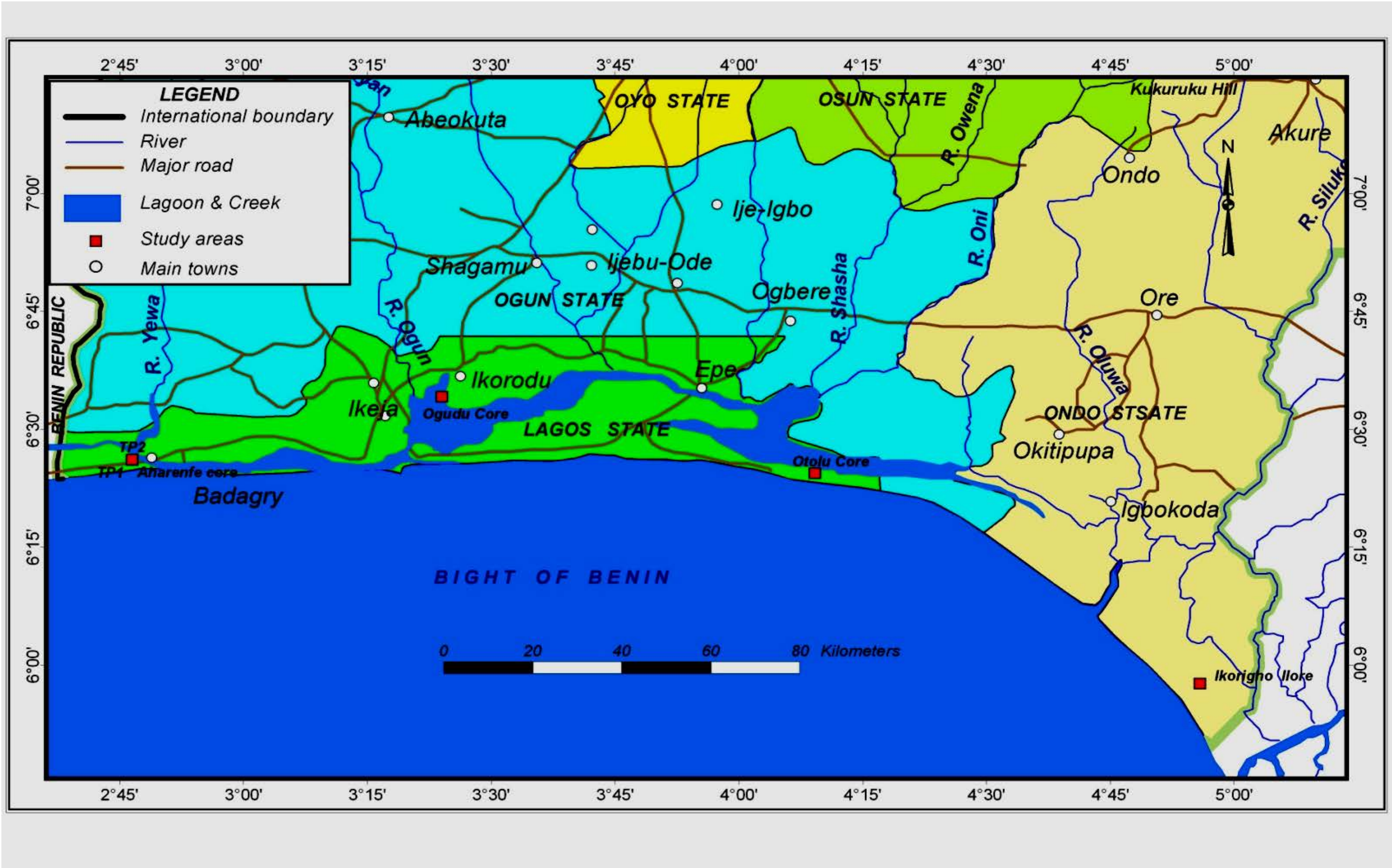


Fig 3: Rivers Shasha, Oni and Oshun in relation to Lagos lagoon and Ekiti-Ondo Uplands

Fig 4: Map of the Badagry Area

1.11 The Study Area: It is the coast of south-western Nigeria (fig 2-4). The climate and vegetation of the sites are described below**.**

1.11.1 Climate

Rainfall, in the coastal is area, is experienced for most part of the year i.e from February to November and may reach between 2,500 mm and 3,500 mm/year. As a result of the rains the area is heavily infested with mosquitoes. During the other part of the year i.e, December-early February, there is a dry season. This part of dry season is commonly known as the harmattan. During this season, the Inter Tropical Discontinuity (ITD) shifts southwards and dusty wind blows from the Sahara. Rainfall during this period is usually reduced. Temperature ranges from 27.5-30 °C. Mean annual temperature is 28 °C (Fig 5).

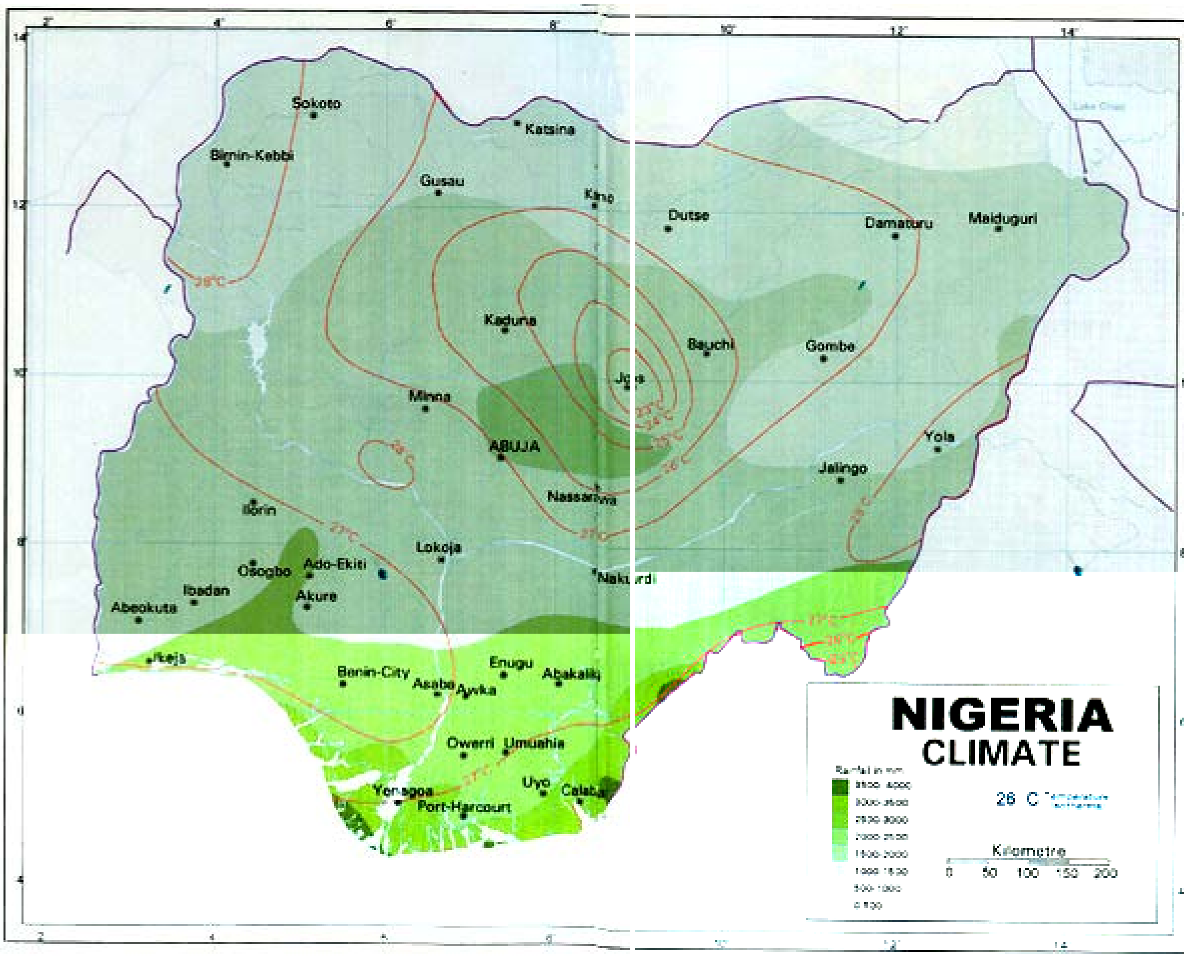


Fig 5: Rainfall map of Nigeria (Google maps)

1.11.2 Vegetation

Generally speaking, the vegetation along the coast of southern Nigeria consists of coastal forest, deltaic/freshwater swamps and mangrove swamp forest (Fig 6). However, there are perculiarities with different locations mainly because of the influence of man.

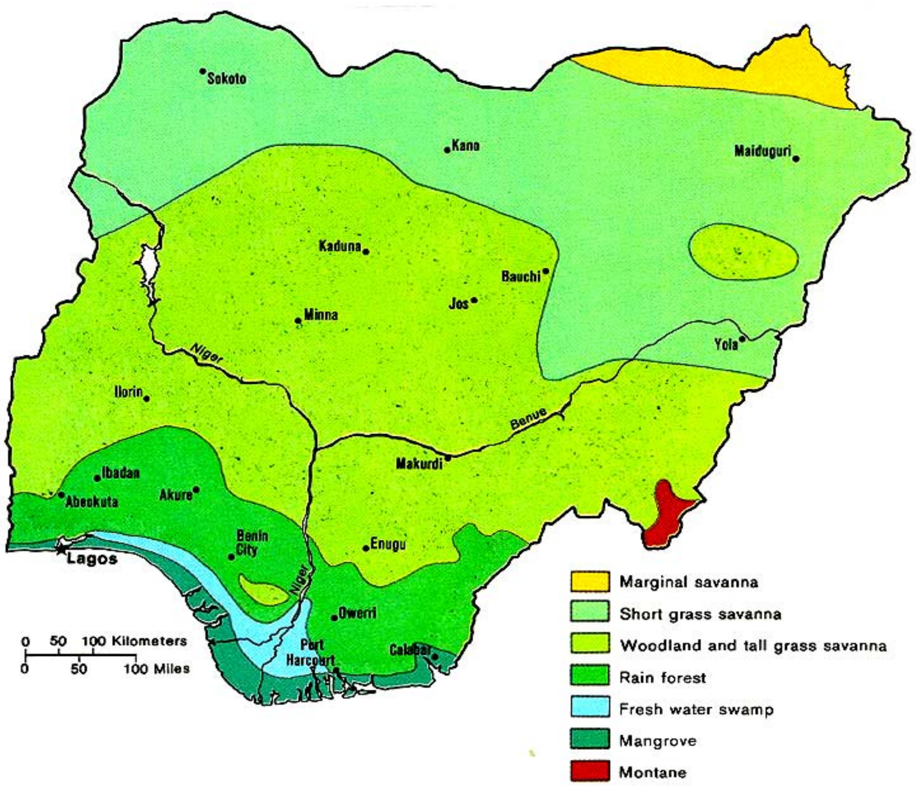


Fig 6: Vegetation map of Nigeria (Google maps)

Ogudu: (N 06° 56537′, E 003° 40086′ and 12m above sea level.)

The vegetation in this area is a mangrove swamp forest; the mangroves are stunted and occur in the swamp which is located on the Ogudu creek. This creek runs from the mouth of the Lagos lagoon through to the Ogudu area. The dominant species include *Rhizophora* sp., *Avicennia africana* and *Acrostichum aureum.* Others include *Alstonia booneii, Alchornea cordifolia, Eichhornia crassipes, Chromolaena odorata,* Cyperaceae*, Nymphaea lotus, Pistia stratiotes, Symphonia globulifera, Elaeis guineensis, Panicum maximum, Sida acuta,* and *Terminalia catapa.* Few cultivated plants (*Musa* sp, *Mangifera indica*) were noted on dry soil farther from the bank of the creek. The climate of the area is characterised by rainy and dry seasons. Temperatures are between 28ºC and 36ºC while annual rainfall ranges from 2,500 mm to 3,000 mm (Adegbehin, 1993).

Ahanve: (N 06° 43195′ E 002°. 77475′ at 0.5 m above sea level)

Ahanve is a village located about 25 km from Badagry. It is approximately 0.5-1.0m above sea level. It is bounded on the west by the Nigerian-Bénin border as well as adjoining villages, on the east by the Badagry creek and Yelwa River, on the north by the southern parts of Ogun State and on the south by the Kweme and Angorin beaches, as well as the Atlantic Ocean. The present-day vegetation is a freshwater swamp forest dominated by *Typha australis* (Sowunmi, 2004). At the periphery of this swamp are isolated clumps of *Acrostichum aureum, Alchornea* sp., *Mimosa pigra*, *Cocos nucifera* and *Elaeis guineensis*. Directly behind this *T. australis* community is a secondary and freshwater swamp forest. The main components of the secondary forest include *Newbouldia laevis*, *Triplochiton scleroxylon*, *Pycnanthus angolensis* and *Alchornea cordifolia*. *Phoenix reclinata, Raphia vinefera* and *Anthocleista liebrechtsiana* are the componnents of the latter forest. Crops are cultivated at the outer parts of the village; these include *Manihot esculentus* (cassvava), *Capsicum* sp. (pepper), *Colocasia* sp. (cocoyam), and *Citrus* sp. (orange). However, in sandy areas of the outermost fringes of the village are some Guinea savanna trees such as *Vitellaria paradoxa, Parkia biglobosa, Vitex doniana, Bridelia ferruginea, Annona senegalensis* and *Borassus* *aethiopum* (Sowunmi, 2004). The mean annual temperature ranges between 24˚C and 29˚C, but temperatures rarely exceed 30˚C. Rainfall is experienced almost throughout the year but the "months from November to April are comparatively dry" (Adejuwon, 1970:4). Annual rainfall is between 1,500 mm/yr and 1,800 mm/yr. Rainfall is controlled mainly by the movement of the ITD and southwest monsoon and harmattan winds.

Otolu: (N 06° 40314´, E 004° 15387´, 14m above sea level).

Otolu is approximately 0-10 m above sea level. The vegetation of Otolu is that of a mangrove swamp forest with the presence of some relicts of rainforest. The effects of the human impact on both forest types have created numerous gaps within it. Plants are cultivated at the outer fringes and openings within the forest. These plants include cassava (*Manihot esculentus*) cashew (*Anacardium occidentale*), mango (*Mangifera indica*) and the oil palm (*Elaeis guineensis*). Plants which can be found in the forest include *Alstonia boonei, Rhizophora* cf. *racemosa, Acrostichum aureum, Musanga cecropoides, Alchornea cordifolia* and Poaceae. The mean annual temperature ranges between 27ºC and 28ºC, but temperature hardly ever exceeds 28ºC. During the coldest months, temperature does not fall below 25ºC. The mean annual rainfall is between 1,800 mm and 2,000 mm.

Ikorigho (Ikorigho I: N 05° 95726´, E 004° 93099, 2 m above sea level; Ikorigho II: N 05° 95727´, E 004° 93097´, 2 m above sea level).

The vegetation is that of coastal rainforest made up of the two distinct edaphic varieties namely: Fresh water swamp forest and mangrove swamp forests. Though these two vegetation types lie somewhat adjacent to each other, there is some demarcation between them. As one approaches Ugbonla town leading to Ikorigho, one encounters the fresh water swamp forest first. After traveling some distance, one meets the mangrove swamp forest which continues down to the Benin River. In the mangrove swamp forest, *Avicennia africana* (white mangrove) trees with characteristic pneumatophores were noted growing in association with *Rhizophora* spp (red mangroves), the salt water fern (*Acrostichum aureum*) and the grass *Paspalum africanum*. Both mangrove trees—*Rhizophora* and *Avicennia africana*—grow to good height but *Rhizophora* trees grow taller reaching some ten to 20 m in height, while *Avicennia* hardly exceeds ten meters. This mangrove swamp forest is not rich in species; one finds *Rhizophora, Avicennia, Acrostichum aureum* and the *Paspalum vaginatum* grass everywhere. However, there are some cultivated plants such as maize *(Zea mays)*, plantain *(Musa sapientum)*, banana *(M. paradisiaca)* and cassava (*Manihot esculentus*). As one moves away from this community westwards to Ugbonla and Igbokoda areas, one encounters the fresh water swamp forest with the mangrove disappearing. This freshwater swamp vegetation is made up of grasses (Poaceae), *Typha australis, Elaeis guineesis, Raphia* spp, *Draceana arborea, Alchornea* spp., *Symphonia globulifera,* ferns, *Alstonia booenii, Musanga cecropoides, Nauclea diderrichi, Anthocleista* sp. *Napoleona imperalis,* epiphytes, Cyperaceae, *Andropogon* sp., *Eichornia crassipes,* Curcurbitaceae, *Bambusa vulgaris* and an unidentified scrub probably a Malvaceae. Other cultivated plants include *Mangifera indica, Terminalia catappa, Cocos nucifera, Sacccharum officinale,* and *Azadiractha indica*.

The rainforest is completely absent from the immediate vicinity. However, some gallery forests can be seen stretching to a distance of about 15-30 km to the west of the Oluwa River. The impact of humans on their immediate vicinity of Ikorigho is evident. The mangrove trees very close to the homes of the people are comparatively shorter than those in the interior of the main forest. Those close to the residential houses are about 3-5 m in height. This is in sharp contrast to those in the interior of the forest which reach 20 m. According to our informants (Messers Olarenwaju and Segede, and a young boy Ohunayo Owoetomo), the people use the wood of *Rhizophora* and *Avicennia* for practically all their domestic activities such as in the building of houses, fencing, as fuel in cooking, drying and smoking of fishes, and in constructing pedestrian bridges. In order to have a piece of land for building of houses, part of the mangrove swamp forest is cleared for this purpose. This action leads to reductions in the mangrove swamp forest. The occupation of the people is basically fishing. In the people's indigenous language i.e the *Ilaje* language, *Rhizophora* and *Avicennia* are called *Igi-Egba* and *Sekele* respectively.

1.11.3 Geology and Geomorphology

A simplified geology map of Nigeria is shown in Figure 7. The study area is the coast of south western Nigeria. This area is part of the coastline which stretches from Lagos to Calabar. This coastal area was created during the separation of the South American continent from Africa in the Cretaceous which consequently exposed the coastline to the Atlantic Ocean. Several recessions and advances of the coastline occurred during the Paleogene period becoming stable in the Pleistocene. The Nigerian coastal region is made up of sedimentary rocks. There are basically three sedimentary units in the stratigraphic sequence of the Nigerian coastline. These are (a) the Benin formation which consists mainly of sandstone and is about 2000 m thick, (b) The Agbada formation consists of sand and shale, and (c) the Akata formation. This latter formation is made mainly of marine shale. The sedimentary deposits of south western Nigeria consists of Quaternary basin which is made up of contenental shelf and marine deposits, Pleistocene and Holocene units. The Pleistocene consists of clayey sandy deposits while those of the Holocene are alluvium, silt and sand.

The Nigerian coastal area can be defined as the area that lies between the uppermost limit of the tidal influence and the continental shelf immediately next to the Atlantic Ocean. It is characterised by various rivers and water channels, lagoons and creeks. Generally, these areas are not more than 3 m above sea level. One of the major characteristics of the coast is the sand or barrier beaches which run from Lagos to Calabar. The soil in this area is referred to as the Barrier Lagoon complex; it is generally sandy, with some being of sandy loam and clay loams (CEDA, 1997). Although, the soil along the coast is sandy and well sorted, those of the Otolu area are finer than those in the Badagry and Lagos Lagoon. In addition, the Nigerian continental shelf is characterized by at least three distinct cayoons; these are namely the Avon Canyon (approximately 15 km wide and 730 m deep) located off the Lagos coast; the Mahin Canyon (approximately 1.6 km wide and 180-900 m deep) is located off the Mahin coast (Ondo State) and the Calabar Cayon (8 km wide and 180-450 m deep) which is located off Calabar in Cross River State (CEDA, 1997). These canyons function in channeling sand offshore.

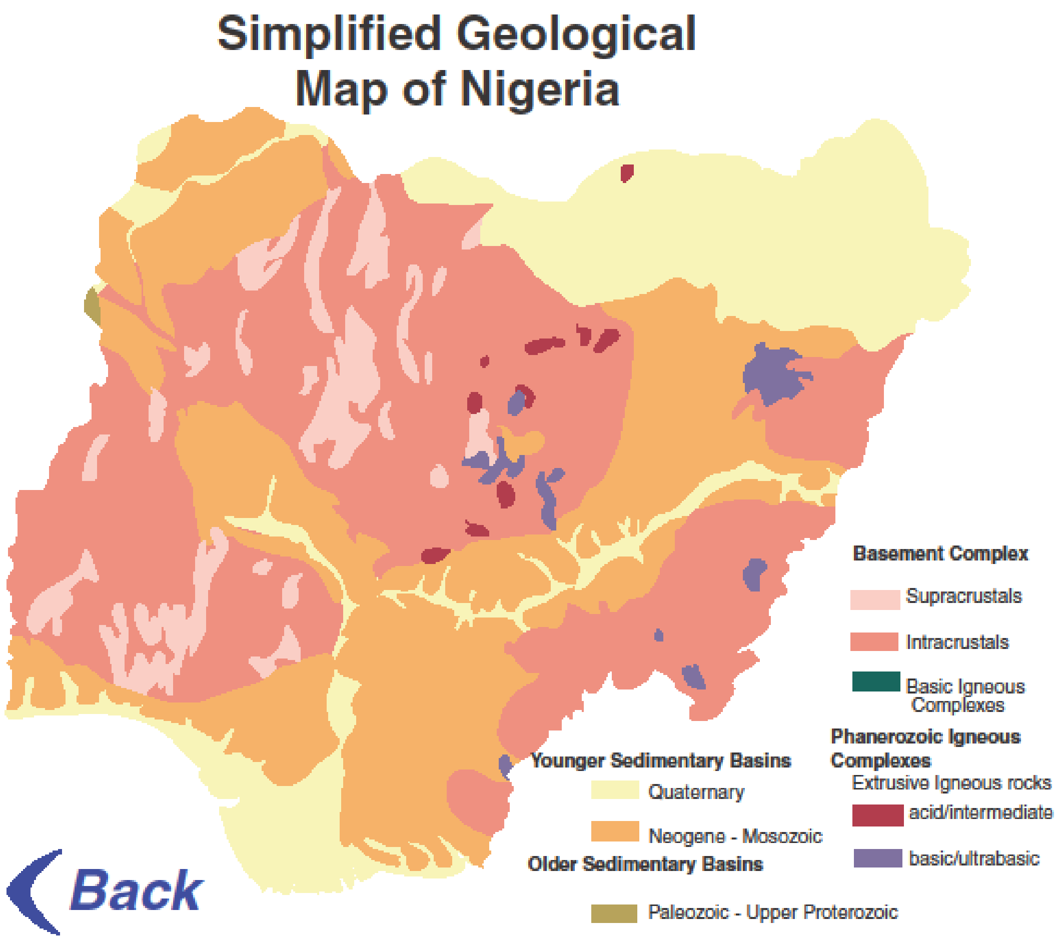


Fig 7: Geologic map of Nigeria showing Quaternary deposits (Google maps)

Adegoke *et al.*, (1980) recognised five geomorphologic units in the coastal region of southwestern Nigeria. These include the outer barrier beach, the creeks, barrier islands and tidal flats, inner barrier beach, marginal alluvial plain and the coastal plateau. Five types of soils are also recognised in the Nigeria coast. These soils are formed due to chemical weathering and include:

(i) Fresh water alluvial soils. These soils are grey, sandy loam and clay, (ii) The flood plain soils: These are clayey-loam and are strongly acidic in nature; organic content is low (4-5%). As a result they are not very suitable for agriculture; (iii) mangrove swamp soils are soft mud comprising mainly silt, clay and peat. These soils, dark grey in colour, have characteristic offensive odour due to the high content of iron sulphides or sulphuric acids. They sustain the mangrove swamp forest; (iv) saline sands: These soils are fine grained sand with very small amount of clay but also support some tree species particularly coconut (*Cocos nucifera*) and oil palm (*Elaeis guineensis*) plantations, and the fifth is the beach ridge sands: These are almost entirely sand. They are carried by rivers and other water channels and deposited by wave and current. This soil type is well drained and of very low fertility.

CHAPTER TWO

2.0 Literature Review

This section focuses on the review of relevant literature that deals with methods of obtaining proxy data used for reconstruction of rainforest environments.

2.1 Reconstruction of rainforest palaeoenvironments

The rainforest is a very important part of the world's ecosystem due to reasons stated earlier. A reconstruction of the rainforest vegetation is crucial to understanding its history as well as human interactions with it. There is evidence that the present rainforest was already fully developed in West Africa during the Cenozoic period ca. 65 million years B.P., (Letouzey, 1968 in: Sowunmi, 1981 a). However, the history of the rainforest can be reconstructed from palaeoenvironmental studies. There are several methods of reconstructing palaeoenvironments; these methods make use of proxy data. A proxy datum, according to Ingram *et al*., (1981:9), "is any material that provides an indirect measure of climate". But, proxy data do not provide direct but indirect and partial evidence of climate or environmental change.

In reconstructing past environments, it is usually the remains of plants and animals that are used. However, it is only the durable parts of plants and animals which are preserved in deposits that are suitable for palaeoenvironmental reconstruction. Another method, sedimentological, makes use of sediments as proxy data. The techniques used in palaeoenvironmental reconstructions include pollen analysis (i.e. analysis of pollen, spore and other microscopic organic structures and cells), sedimentology, phytolithology (study of phytoliths) anthracology (microscopic charcoal analysis), plant macrofossils (leaves, seeds, fruits and charcoal), dendochronology (study of tree rings) and paleontology (study of faunal remains and foraminifera). Each of these techniques has been used in reconstructing the environment with much success. Presented below are a few examples.

Pollen and spores on account of their ubiqituous and morphologically distinct nature have been used, more than any other proxy datum with greater success, in reconstructing the environment. For example, palynological studies of Lake Barombi

Mbo, Southern Cameroon showed that during the Great Inter-tropical Aridity (GITA), pollen of forest taxa became reduced while those of open vegetation were abundant.

From 20,000-14,000 yrs B.P, most of the rainforest vegetation became reduced while grasses and *Olea hochstetteri* increased. However, relicts of the forest vegetation remained around the lake during the GITA (Maley, 1996). Forest elements later increased during the beginning of the Holocene and became fully re-established some time between 9500 yrs B.P. and 9000yrs B.P. This evidence, therefore, indicates the onset of wetter climatic conditions (Maley, 1991). Therefore, the pollen record supports the proposed existence of a refugium in S.E. Cameroon (Maley, 1991).

On the basis of 19 to 21 fossil leaves recovered from a Mid Eocene (45.83 ± 0.17 Ma yrs B.P.) deposit in the Crater Lake in Mahenge, Northern Tanzania, Jacobs and Herendeen (2004) reconstructed the vegetation and climate of Mahenge. The recovered leaves were mainly of Leguminosae, sub families Caesalpinioideae and Mimosoideae. According to Jacobs and Herendeen (2004:121), "about 65% (of the Leguminosae family) of the leaves are Caesalpiniod and include *Cynometra*, *Aphanocalyx*, and two or three unnamed taxa" The morphology (leaf margin, surface area, base and shape) of the recovered leaves was used to estimate the precipitation of the area. These morphological features correlate well with temperature and precipitation parameters. In otherwords, the leaf-climate relationships are proxies for past climate. The annual rainfall obtained from the leaf-climate relationship model was a minimum of 643 ± 32 mm/yr and a maximum of 776 ± 39 mm/yr. This is consistent with woodland and miombo woodland vegetation structure. This indicated that the vegetation was savanna. A rainforest vegetation would require a minimum precipitation of 1,100 mm/yr. Thus it was concluded that at Mahenge during the mid Eocene, the "climate was as dry as today but precipitation may have been more equably distributed" (Jacobs and Herendeen, 2004:122).

Macrocharcoal particles retain details of the anatomical features of the plants from which they were derived and these aid in their identification. This technique is usually very valuable in archaeological investigations and "provide good evidence of the use of materials for food, firewood…" (Williams *et al.*, 1998:204). For example, wet and humid climatic conditions prevailed first at ca. 7000yrs B.P. and secondly at

5700yrs B.P. in the Sahara region (Neumann and Schulz, 1987; Neumann, 1989 and Neumann 1991). These climatic deductions were based on a recovery of charred wood remains of Sahelian plants (*Acacia raddiana, Salvadora persica,* cf. *Sterculia setigera, Crateva adansonii* and *Terminalia* sp) from several sites in Egypt, Niger and Sudan. The recovery of these plant remains, whose parent plants are naturally found in wetter Sahel regions, from a dry Sahara desert was an indication that there was at least a 300-500 km shift of Sahelian vegetation northwards during the mid Holocene. This vegetation shift was possible due to the prevailence of wet climatic conditions in the Sahara during that period.

Wood charcoal recovered from archaeological excavations in Kovacevo SW Bulgaria indicated that between 6,159 and 5,630 yrs cal. B.P., the vegetation of the area was open deciduous oak forest (Marinova and Theibault, 2008). This oak forest consisted of *Quercus* sp., *Carpinus orientalis, Fraxinus ornus, Acer campestris* and *Sorbus* sp.*).* The opening in the oak forest was caused by deforestation by humans—a situation ideal for grazing animals and for gathering fruits and vegetables.

Based on geomorphological evidence from lacustrine deposits of Lake Bosumtwi in Ghana, Talbot *et al.,* (1984) established that during the Great Intertropical Aridity (GITA) period 18,000to 14,500 yrs B.P., the lake fell below -30m and again to approximately the same level between 4,000 and 3,500 yrs B.P. These results were recently confirmed by Shanahan *et al*., (2006). In addition, the occurrence of these extreme dry periods has been noted in the pollen record throughout most parts of Africa, as mentioned earlier (Elenga *et al*., 1994; Maley 1991; Sowunmi, 2004). Pastouret *et al.*, (1979) noted a change from fine-grained sediment to abundant coarse sediment in deposits of the Niger delta. On the basis of this change, particularly the abundance of coarse grains, Pastouret *et al.,* (1979) opined that the environment witnessed a change from an open and dry to that characterized by abundant rainfall. This provided evidence for the beginning of wet and warm period in the early Holocene ca. 13,500 yrs B.P.onwards.

However, despite the successes achieved with these proxy data, each has its own challenges and limitations. These challenges and limitations notwithstanding, pollen analysis (palynology) is considered the best tool in palaeoenvironmental reconstructions

(Faegri and Iversen, 1988). This is mainly because of the following uniqueness of palynomorphs (pollen and spores): Firstly, palynomorphs possess a unique and inert chemical compound—sporopollenin—on their outermost surface (exine) which makes them extremely resistant to decay. This enables them to be preserved for very long periods, and thus can be retrieved from deposits million of years old. As a result, they can be found in deposits where other fossil types are absent. Till date, pollen and spores are among the best indicators of the occurrence of earliest land plants. In addition, it is the recovery of pollen that has provided evidence of, and elucidated several aspects of angiosperm evolution and diversification during the Cretaceous period (Walker and Doyle, 1975; Flenley, 1979). Secondly, they are usually produced in large numbers; for example palynological studies carried out at the Palynology Laboratory, Department of Archaeology and Anthropology, University of Ibadan Nigeria, shows that a single flower of *Bombax buonopozense* produces about 5.3 million pollen/flower (Sangolade, 1985), *Rhizophora harrisonii* produces 531,460 pollen/flower while *Acrostichum aureum* produces 2,453,770 pollen/flower (Adewole, 1994). Hence, their chances of preservation and subsequent retrieval are higher in contrast to other plant parts such as leaves, seeds and fruits. Thirdly, they are spread by many agents such as wind, insects, water, animals and man. Fourthly, once deposited, an action that is usually without human input, pollen and spores often fossilize provided the embedding medium is conducive for their preservation. Fifthly, usually the pollen grains or spores of a species have distinctive morphologic features (although there are some exceptions). These diagnostic features are located on the resistant part of the exine; they are thus preserved along with the palynomorph. As a result, they can be accurately identified based on these morphological features. Most importantly, palynomorphs provide a broad but good picture of both the local and regional vegetation and environment that produced them. This is basically because pollen and spores, being the male reproductive cells of plants which function in fertilization, are always being produced, and after production are dispersed into the environment. Thus, their presence in deposits of an area is an indication that the parent plants had been present in that area at that time.

But there are some limitations with palynology. The first is that sometimes, pollen and spores are destroyed under unfavourable conditions such as basic and oxidised soils. In such circumstances, palynology becomes less useful. Fortunately, most soils in Nigeria are acidic in nature under which pollen and spores are well preserved. Secondly, some pollen and spores are under-represented in deposits especially in the tropics. This is because many tropical plants are insect-pollinated and they produce comparatively few pollen. Thus their presence in or absence from sediments might not reflect the true status of their parent plants in the environment. This is in contrast to most European plants which produce much pollen, and are dispersed by wind. Thirdly, not all pollen of plants in a vegetation are found in the fossil record. This means that, for obvious reasons, the recovered fossil pollen and spores from a deposit do not represent the whole vegetation (Daraojimba, 2010). Fourthly, the pollen of some plants belonging to different families as well as those belonging to the same family are indistinguishable with the light microscope. This light microscope is what is used for routine palynological research. Examples of the first category of limitation include Amaranthaceae and Chenopodiaceae; Combretaceae and Melastomataceae; while the second category includes Poaceae and Meliaceae. Fifthly, there are few cases where plants which naturally inhabit different ecological zones produce quite similar pollen. Examples of this phenomenon in Nigeria are *Lophira alata* and *L. lanceolata*. The habitat of the former is the rainforest while that of the latter is savanna. The phenomena stated in the fourth and fifth examples limit palynological interpretations in cases where such pollen are found. These limitations notwithstanding, the advantages of palynology (pollen analysis) far outweigh its disadvantages. Hence the focus of the following section is primarily on pollen analysis.

2.2 Palaeopalynological studies in Africa

In Equatorial Africa, palynological studies on Late Pleistocene environments have concentrated on East and Central Africa for three main reasons: (1) the nature of the soils and occurrence of rapid sedimentation rates which ensure excellent preservation of plant (and animal) fossils; (2) the presence of abundant and deep lakes. Lake deposits are among the best sediments for pollen preservation and therefore, pollen analysis. As a result of the attention these areas have received, many environmental reconstructions and palynological studies have been carried out there (e.g. Elenga *et al.*, 1994; Maley, 1991; Sowunmi, 1992; Jolly *et al.,* 1997; Debusk, 1998), and (3) volcanic activities in these areas provide datable materials far beyond the limits of radiocarbon dating (Potassium/Argon analysis). In contrast, however, comparatively fewer palaeopalynological works have been carried out on lakes in West Africa. These include those from lakes Bosumtwi, Southern Ghana and Barombi Mbo, South-Western Cameroon (Maley, 1991) and Sélé, Southern Benin (Salzmann and Hoelzmann, 2005). Palynological analyses have also been carried out on terrestrial cores, some of which include those from Yèvié, Dogla-Alago and Goho in Southern Bènin (Tossou *et al.*, 2008), Ofuabo creek, Southern Nigeria (Sowunmi, 1981a&b) and Ahanve, South Western Nigeria, (Sowunmi, 2004). Unfortunately, the core from Ofuabo creek was without a complete palynological record due to the occurrence of a hiatus in a section of the core (Sowunmi, 1981b). So far, there has not been a report on the complete sequence of the Holocene in Nigeria. Consequently details about the vegetation history of the rainforest in the late Holocene are not well known.

Generally, as part of the foci of Late Quaternary environmental studies in tropical Africa, palynologists are particularly interested in environmental conditions prior to, during, and after the Great Inter Tropical Aridity (GITA), called the Late Glacial Maximum (LGM) in Europe. The GITA was a period of severe aridity in Africa, which lasted from 20,000 to 13,500 yrs B.P. i.e., the beginning of the Holocene (Pastouret *et al.,* 1979). There are proponents of the view that forest refugia existed during the GITA (Maley, 1991, Talbot *et. al.*, 1984; Shanahan *et al.*, 2006). The proposed refugia in Africa, which are generally accepted, are Upper Guinea Centre (Sierra Leone and Liberia), Lower Guinea Centre (S.W. Cameroon and S.E. Nigeria), Zambezi-Congo Watershed (Zambezi and the Congo Rivers) and the Kivu Centre (Congo, Rwanda and Burundi) (Linder, 2001).

The GITA and refugia (or centres of species endemism) have been debated in palynological studies particularly in the tropics. As noted by Linder (2001: 170), “the existence of refugia in the Amazon basin has attracted many criticisms, while the African refugia appear to have been accepted”. Although there seems to be an agreement on the number and locations of the forest refugia in tropical Africa, the geographical sizes and botanical compositions of these refugia are still not well understood (Daïnou *et al.,* 2010). For instance the nature, as well as the spatial extent and botanical composition of the forest refugia of S.E. Nigeria are currently not known. Yet this is one of the centers of forest refugia during the GITA. Therefore, another focus of most palynological research in the tropics centres on the spatial extent, characteristics and botanical compositions of the proposed forest refugia. A third focus borders on the impact of humans on forest vegetations particularly in the late Holocene. This latter focus has been the crux of most palaeoenvironmental studies in the last 70years.

In the rainforests of tropical Africa, humans have been linked to vegetation change especially forest clearance beginning from at least 4,000-3,000 yrs B.P. (Perrot, 1987; Sowunmi 1981a&b). However, whether humans were involved in the destruction of forest vegetations in certain areas during the late Holocene is still a subject of controversy. It has been argued by Maley (2001) in: Neumann (2003:74) that "the distinct vegetation changes, including the spread of the oil palm, in the Central African rain forest between 2,800 and 2,500 yrs B.P, are most probably due to an abrupt climatic deterioration and not to large-scale human activities". In southern Bènin, rainforest and mangrove swamp forest vegetation, which were hitherto abundant and diverse, were noted to have disappeared and been replaced by coastal savannas. This occurred twice at Lac Sélé, Southern Bènin first, between 4,500 and 3,400 yrs B.P., and second, at 1,100 yrs B.P. (Salzmann and Hoelzmann, 2005). Similar results were also obtained from Yèvié and Goho, Southern Bènin. In the latter two sites, semi-deciduous and mangrove swamp forests which were abundant in the early and mid-Holocene disappeared and were replaced by fresh water vegetation ca. 2,500 yrs B.P. (Tossou *et al.,* 2008). Salzmann and Hoelzmann (2005) stated that the spread of coastal savanna in Lac Sélé, southern Bènin could not be attributed to human activities but rather, the vegetation change was due to the appearance of a little dry season. Salzmann and Hoelzmann (2005:198) opined that this dry season, which was associated with cold-water upwelling in the Gulf of Guinea, "was clearly the driving force which caused a rapid deterioration of the closed semi-evergreen rain forest which covered the Dahomey Gap during the early and mid-Holocene". In contrast, Sowunmi (1981a&b) established that humans contributed to vegetation change in the forests of the Niger Delta area some 3,000 yrs B.P. This was based on the unprecedented increase in the pollen of *Elaeis guineensis* (oil palm) and those of weeds associated with human habitation, as well as a concomitant and significant reduction in forest pollen at 2,800 yrs B.P. Recently, Sowunmi (2011) proposed four palynological criteria for establishing that clearance of forests including areas near stream valleys and dry fringes of forest in West Africa, for the purpose of cultivation can be attributed to humans.

These criteria are:

1. Significant and sudden increase in the pollen of *Elaeis guineensis* and *Alchornea*,
2. Relative decrease in forest trees,
3. Increased abundance of fresh water and riverine forest taxa, and
4. Concomitant increase in the pollen of weeds of cultivated land and waste places.

A fifth and equally important criterion, which can be added to the above list, is the recovery of significant amount of microscopic charcoal in a pollen record. The continued occurrence of significantly high amounts of microscopic charcoal in the fossil record is an indication that the charcoal particles were either natural or anthropogenic in nature. Sowunmi (2001:78) stated that “natural fires are lit by lightning in areas where there is sufficient combustible vegetal litter”. However, where such high amount of microscopic charcoal in a pollen record is noted during an inferred wet period, it is an indication that the fires were deliberately set by humans. This is because it is difficult to achieve a continuous occurrence of fire during a predominantly wet period without any anthropogenic influence. Furthermore, only humans are known to have the capacity to make fire. Therefore, where these five criteria are met, it would be sufficient to infer that forest reduction was due, at least in part, to human impact. These criteria become significant particularly in the absence of direct evidence of human impact on forest vegetation such as occurrence of pollen of cultivated crops or macro-archaeobotanical remains such as leaves, seeds, fruits, and man-made tools.

However, whether humans actually played any roles in the decline and eventual disappearance of the mangrove swamp forest at Ahanve (Badagry) some 3,000 yrs ago, is not certain (Sowunmi, 2004; Orijemie, 2005). Thus there is need for caution as it seems that vegetation changes which coincided with human presence at a site may not be a direct result of human impact. The assumption that humans were largely responsible for change in vegetation in the Holocene should be carefully considered. Except where there are unequivocal proofs linking the presence of humans and their activities with environmental change in an area (e.g. Piperno *et al.,* 1990; Pasveer, 2002; Stevenson, 2004; Sowunmi, 2011), other causative factors should be considered. Currently, many palynologists have argued for another factor which has an equally devastating effect on forest vegetations. This factor is climate. However, some have favoured a combination of both factors, i.e. climate and humans, as reason for forest changes recorded significantly in the late Holocene. Some palaeoenvironmentalists have also argued that natural vegetation changes often mask the effects of human impact especially when they coincide with the influence of the latter on the environment. Furthermore, distinguishing human-induced changes from natural changes in the palaeoecological record (after the advent of agriculture) is now being viewed as a complex exercise (Ssemmanda *et al*., 2005). That notwithstanding, there have been very obvious effects of humans on the environment especially during the last 250 years, some of which have led and are still leading to serious environmental problems including drastic changes in terrestrial landscapes, forests, coastal and marine ecosystems and global warming. Such ecological changes have been noted in the mangrove swamp forests of southern Nigeria (Orijemie, 2005). If efforts are not taken to stem the current trends, the livelihood of thousands living in coastal areas will be seriously threatened.

Despite the difficulties experienced in distinguishing natural from human-induced environmental changes in certain areas, an improvement of the present methods and techniques employed in palaeoenvironmental research is producing promising results (Piperno, 2007). For example the combined use of fossil starch grains, phytolith analysis and palynology has led to a better understanding of past land use, agricultural practices and human occupation of the rainforest in Central and South America, and Central Africa (Piperno, 2007; Mbida *et al.,* 2001). The identification of starch grains provided evidence for the cultivation of manioc, maize, yams, arrowroot, beans and other plants from 9,000-4,000 yrs B.P. This provided evidence for the antiquity of tropical forest agriculture in Central and South America (Piperno, 2007). In other words, human interactions with the environment and the practice of agriculture in the rainforest in Central and South America is at least 9,000 yrs old. In Cameroon, phytoliths and starch grains identified to be those of *Musa paradisiaca* (banana) were recovered from rainforest deposits and dated to ca. 2,100 yrs B.P. This evidence indicated that human domestication of banana and their occupation of the forest in Cameroon are at least 2,100 yrs old (Mbida *et al*., 2001).

Palynological research in equatorial lowland rainforests carried out for most parts of the world—Amazonia, Africa, South–East Asia and Australia have indicated the occurrence of environmental changes at certain periods; particularly well known are those that occurred in the Late Pleistocene and Holocene. During these times, plant communities within the forest zones were affected but the effects of the changes varied from place to place. The main results of the palynological studies in the late Pleistocene-Holocene are presented below.

The GITA period, a period known for its severe aridity, is generally agreed to have occurred from ca. 20,000 to 13,500 yrs B.P. in Africa. However, the time for this global event is not entirely synchronous as it was recorded at different times for different places in the tropics. Evidences from Ghana and Cameroon show that the GITA lasted from 19,000 to 15,000 yrs B.P. (Maley, 1996); 20,500 to 14,500 yrs B.P. for Brazil (Behling and Negrelle, 2001); 24,000 to 13,000 yrs B.P. for Congo (Elenga *et al.*, 1994) and 20,000 yrs B.P. to 13,500 yrs B.P. for Nigeria (Pastouret *et al.*, 1979). In Europe, the time for this dry and cold period was comparatively longer (22,000 to 10, 000yrs B.P.)

This GITA period was characterised by a lowering of temperature in the tropics by at least 5°C (Piperno *et al.*, 1990; Maley, 1991), resulting in much colder climate than now, reduced precipitation and major changes in forest vegetation. There was drastic reduction of tropical rainforest and mangrove swamp forest species, which allowed for the subsequent growth and temporary establishment of savanna vegetation into areas once occupied by forest. However, in view of new evidence obtained from more recent studies, reconstructed environmental conditions of the lowland tropical rainforest during the GITA are currently being reconsidered. Below is a review of some of the studies.

2.3 Palaeoenvironments of the rainforest in the humid tropics during the Late Pleistocene period ca. 30,000 yrs to ca. 14,000 yrs B.P.

2.3.1 South America (Amazonian forest)

The environmental history of South America and equatorial Africa from ca. 20,000 to 14,000 yrs B.P. has been found to be similar (Kadomura, 1995). There are evidences that during this time, there were reductions in forest species under a very dry climate. This period (20,000–14,000 yrs B.P.) was immediately followed by slow return or regeneration of forest species in the early Holocene. Studies on events that occurred during the Great Intertropical Aridity (GITA) have elucidated the understanding of the effects of environmental stress on vegetation communities. Such research also helps in the understanding of the adaptive strategies humans used to make a living in such an inhospitable natural environment and their culutral responses to environmental stress during the GITA. Furthermore, the Pleistocene refugia theory has been put forward as a plausible explanation for species diversity in the Amazon Basin. This theory states that during the very dry periods of the GITA, when savanna species dominated forest landscapes, forest species were restricted to small blocks. These small blocks comprised forest plants that survived the dry period, and are known as forest refugia. However, as noted by Kadomura (1995) and Delègue *et al.,* (2001), there are still debates on the true positions and status of the GITA rainforest refugia.

Palaeoecological analyses of 14 sediments from San Juan Bosco and Mera sites in Ecuadorian Amazonia were carried out by Bush *et al.,* (1990) to ascertain Late Pleistocene temperature depression and vegetation changes during the last 33,000 yrs B.P. Palaeoclimatic deductions suggest a temperature depression between 33,000 and 30,000 yrs B.P. This was deduced from the occurrence of high values of *Alnus* (45%) and Poaceae (Gramineae) (17%) pollen at lower altitudes of between 970m and 1100m. *Alnus* is currently found above 2400m; its association with abundant Poaceae (gramineae) suggests a regional cooling of 7.5°C. This was proposed by the authors based on a minimum depression of 1500m and a moist lapse rate of 5^0C per 1000 m. From 30,000 to 26,000 yrs B.P., *Alnus* and Poaceae (Gramineae) reduced drastically with an upsurge of lowland forest elements (Marantaceae, Proteaceae, *Rhus, Erythrina* etc.) and abundance of montane elements *Drimys*, *Podocarpus*, *Hedyosmum* and *Weinmannia*-type). These plants, today, are characteristic of altitudes of 2000 m and above. This mixed assemblage of lowland and montane taxa indicates the possible occurrence of tectonism. In which case there was uplift in the tropical areas. From 25,000 yrs B.P. onwards, there was a downward movement of montane species (e.g. *Alnus, Drimys, Thalictrum*, *Weinmannia* and *Podocarpus*) at both sites studied. The colonisation of montane species in areas with lower altitudes indicated that temperatures must have been very low making it possible for the montane species to occupy the lowland forest environment. This also meant that forest species were much reduced than previous times as most of the forest trees do not survive such a deleterious climate. Though Bush *et al.,* (1990) acknowledged the possibility of the survival of some lowland forest species at these sites they dismissed the likely occurrence of whole communities of lowland rainforest plants remaining intact during this period. The occurrence of such an intact lowland forest during this time would have supported the argument for a forest refugium in the area. Bush *et al.,* (1990) therefore rejected the existence of any forest refugium during the Late Pleistocene in Ecuadorian Amazonia. This was because no evidence was recorded to suggest a long continuous history of unchanging rainforest habitats in Mera and San Juan Bosco. Both areas lie within the proposed forest refugium. Furthermore, Bush *et al.,* (1990) argued that if the LGM dated to 25,000–18,000yrs B.P. for northern hemisphere and temperate regions was associated with a synchronous cooling in the tropics, freezing temperatures would have been observed in lowland Amazonia but such reduced temperatures are yet to be recorded. Thus, the 7.5°C cooling inferred from their research indicates that the coldest times in the South American tropics during the GITA may not be synchronous with the Last Glacial maximum (LGM) in Europe. Therefore, the dating of the coldest period in the tropics during the GITA is far from being concluded. But a 7°C– 8°C probable cooling has been fixed for the GITA.

In another palynological study of three sites in the Amazon fan, Hoorn (1997) investigated the Pleistocene glacial/interglacial cycles of the fan. One of the main objectives of this work was to “provide insight into the effect that Pleistocene climate changes had on vegetation in the Amazon drainage basin” (Hoorn, 1997: 397). Hoorn

(1997) noted that in the Andes montane climatic conditions are reflected in the palynological assemblages by high values of *Quercus, Weinmannia, Podocarpus, Hedyosmum,* Melastomataceae, Cyathaceae and monolete Pteridophytic spores" during the GITA. Interestingly, it was found that Pleistocene sediments in the fan provide only a part of the evidence about the palaeoenvrionment of the drainage basin of the Amazon rainforest. Hoorn (1997) reported that there was no evidence in the pollen composition of samples from the Amazon fan for a decrease in the rainforest and an expansion of savanna vegetation during the Pleistocene glacial intervals. Hoorn (1997) argued that an increase in the savanna area in the Amazon lowlands during the Pleistocene would imply an increase in savanna elements such as Poaceae (Gramineae) and Asteraceae (Compositae). Savanna species such as *Curatella* and *Brysonima* were found to have occurred in low percentages in the fan sediments during this time. Hoorn (1997:408) therefore concluded that the result of her work "does not present indications of large-scale vegetational changes in the drainage basin of Amazon lowlands during the Pleistocene glacial intervals". This is in contrast to the widely held view that during the GITA, much of the Amazon lowland rainforests was fragmented resulting in the wide spread expansion of savanna (Hoorn, 1997).

Similarly, Haberle (1997) studied six sites from the Amazon fan with the aim of understanding the vegetation and climatic history of the Amazon basin in the Late Pleistocene period. Haberle (1997) correlated marine and terrestial pollen records and found well-preserved pollen derived from the forest, savanna and mangrove vegetations. The pollen assemblages reflected the vegetation changes in the Amazon fan. Cold-adapted taxa were found to have increased during the GITA (LGM) but Haberle (1997:392) suggested that "only moderate expansion of savanna at the expense of rainforest" occurred during the GITA (LGM). This was arrived at by comparing two models of LGM vegetation.

Ledru *et al.,* (1998), lamented the absence of last glacial maximum records in South American tropical lowland forests. They reviewed the results of seven lacustrine cores obtained from Pata, Carajas, Aguas Emandada, Crominia Salitre, Serra Negra and Itapeva in Brazil. The lake sites were specifically chosen according to their locations in lowland tropical forest…"and their chronological control with C^{14} dates right before and after the LGM" (Ledru *et al.,* 1998: 236). Sediments from all the seven cores showed hiatuses lasting at least from 9,000 yrs (Itapeva) to at most 17,000 yrs (Serra Negra). These hiatuses included the GITA. Though the changes in the sediments seem to suggest the occurrence of drier climates between ca. 24000 and 17,000 yrs B.P., they maintained that the LGM was not recorded in South American tropical lowlands.

But palynological results from the study of a 5.76 m core in Southern Brazil, dated to ca. 37,500 yrs B.P. to the Present showed a predominance of grassland-type vegetation during the Late Pleistocene (Behling and Negrelle, 2001). The results showed that between 37,500 and ca. 27,500 yrs B.P., the vegetation was characterised by grasses and few cold-adapted forest trees. Tropical forest elements (Arecaceae, *Alchornea* and Moraceae/Urticaceae) were rare, suggesting a cold climate. During the GITA (LGM) period, (20,500–ca. 14,500 yrs B.P.) there was an extensive growth of grassland. Asteraceae, *Eryngium xyris, Moritzia dasiantha* were common with few cold-adapted trees. There was also an almost complete absence of tropical forest trees. This vegetation type (i.e. abundant grasses and cold-adapted forest trees with near absence of tropical forest trees) is today found in highland regions of Santa Catarina with elevations higher than 1000 m. The authors, by comparing modern climate of grassland with that in the studied region, arrived at 3–7°C lower average annual temperature for the GITA (LGM) period. During this time, "the tropical Atlantic rainforest was markedly reduced in both extent and diversity, especially during the full glacial period" (Behling and Negrelle, 2001:389). A dense Atlantic rainforest with abundant forest species (Myrtaceae, Arecaceae, Moraceae/Urticaceae, *Alchornea, Myrsine* and *Weinmannia*) became re-established during the mid-Holocene (ca. 8,500 yrs B.P.) in southern Brazil (Behling and Negrelle, 2001).

In Colombia, Marchant *et al.,* (2004) made a comparison of model-based and pollen-based biome reconstructions of vegetation that occurred during the GITA (LGM). The main aims of the investigation were firstly, to understand the dynamics of how vegetation and climate system interactions developed under changing environmental conditions such as changes in precipitation and temperature. Secondly, indications of the degree of environmental change required to invoke the changes recorded from the pollen data, were expected to be derived from the first aim. And thirdly, “the pollen data were expected to provide information for validating the model-derived reconstructions…” (Marchant *et al.*, 2004:722). The work revealed that the climate was colder during the GITA, with reduced precipitation. But the vegetation changes varied according to differing altitudes. Marchant *et al*., (2004) found that vegetations of higher altitudes were more affected by change in temperature while those at lower altitudes were more precipitation– and moisture–dependent. It then appeared that vegetations located at higher altitudes probably experienced greater cooling during the GITA than those at low altitudes. However, the precise dating of the GITA in Colombia is still a matter of debate (Marchant *et al.*, 2004). However, the suggested age of the LGM ranges from 19,700 to 13,000 yrs B.P. In conclusion, Marchant *et al.*, (2004:729) suggested that ‘since inter-site vegetation responses vary considerably, the notion that climate change would at any one time give the same signal throughout a region becomes a misconception’. It therefore becomes necessary for new techniques to be used for a re-evaluation of how vegetation reflected climate change or responded to envrionmental changes during the GITA. Marchant *et al.*, (2004) suggested that such a new approach should include changes in carbon dixode (CO_2) concentration which give new insights into the balance between C_3 and C_4 plants during past climate change. C_4 plants are mostly grasses and are characteristic of savanna vegetation while C_3 plants are mainly of arboreal forest taxa. Therefore, a dry and cold climate will favour the abundance of C_4 plants in the palaeoecological record. But Helmens *et al.,* (1996), based on multiproxy data derived from pollen, palaeosols and glacial advances in the eastern Cordilerra of Colombia, have indicated that the “period between 19,500 and 17,000 yrs B.P. was relatively warm compared to the immediately preceding and following periods”. Helmens *et al.*,’s (1996) submission is in sharp contrast to the general view, including those expressed by Marchant *et al.*, (2004) that climatic conditions in Columbia were cold and dry during the GITA period.

2.3.2 Africa: Central and East Africa

Palaeoecological evidences for palaeoenvironments in Central and East Africa have come mainly from mountains and highlands as well as few lowland rainforest regions. It must be acknowledged that studies in these places have produced numerous and interesting results. Below is a summary of the results from these works:

Taylor (1992)'s palynological study of a 16.1m-core obtained from Muckoya swamp in the Rukiga highlands indicated that there was increased wetness from 20,200 to 15,700 yrs B.P. This was attributed to reduced evaporation and changes in seasonal timing of wet seasons. The reduction in evaporation led to the formation of a lake at Muchoya at that period.

Jolly *et al.,* (1997) studied vegetation dynamics in the forest of Central Africa from 18,000 yrs to the present. This work is significant because it discusses the palaeoenvironmental reconstructions of the sites during the GITA from three different countries and the impact of humans on the vegetation. Jolley *et al.,* (1997) obtained six different cores from five different sites in Burundi, Rwanda and Western Uganda highlands. The main focus of their work was to understand palaeoenvironments of the highland forest during the GITA, and the history of human impacts on the vegetation. Jolly *et al.,* (1997) sought to answer questions such as: Did forests in tropical Africa respond as a homogenous unit or were there differences in response times, as in more temperate regions? What areas attracted the first or early settlers in the region? Of the five sites studied, three were from Southwest Uganda (Ahakagyezi, 1830 m; Mubwindi, 2100 m and Muchoya swamps, 2260 m), while one each was from Burundi (Kuruyange, 2000 m) and Rwanda (Kamironzovu, 1950 m).

During the GITA, ca. 18,000 yrs B.P., an abundance of *Hagenia, Anthospermum* and Poaceae, and the occurrence of other montane species (*Olea* and *Podocarpus*) were noted in Kamironzovu (Rwanda) and in the S.W. Ugandan sites. The occurrence of the pollen of these species indicated the presence of a dry climate or patches of open-canopied upper montane forest during that period. Pollen of broad-based montane forest trees were absent at the time. This, according to the authors, indicated a treeless landscape around the swamp. It has been proposed that this is a reflection of the severity of dry conditions during the GITA. After this period, between 15,800 yrs and 9,800 yrs

B.P., there was an expansion of upper montane forest. This occurred first at the Muchoya site, (S.W. Uganda). In other words, this occurrence preceded that of other sites. Muchoya is situated at 2260 m above sea level and it is the highest of the five sites studied. It can thus be inferred that the expansion of the upper montane forest probably began in places with higher altitudes. During the Holocene, ca. 11,300 yrs B.P., there was a marked increase in pollen from upper montane forest taxa especially *Hagenia* with the exception of the Rwandan site. *Hagenia* is a species naturally found in upper altitudinal montane forest. This indicated a dominance of upper montane forest species.

Thereafter, there was an expansion of lower altitudinal forms of montane forest with fluctuations in abundance of pollen from tropical forest species. However, from 10,000 yrs B.P. onwards, there appeared a richer forest flora indicated by increase in *Alchornea, Celtis, Macaranga* and *Vernonia* species. This was regarded as a dramatic change in vegetation as upper montane forest was replaced by lower altitude species. Very significant forest clearance began in the Holocene at a time around 2,300 yrs B.P. Iron Age Bantu-speaking people are presumably those responsible for forest clearance as they sought more lands for cultivation and for wood as fuel in metalworking (Jolly *et al.,* 1997). Severe forest deforestation was first recorded at the Muchoya site 1000 yrs before the lower altitude sites of Ahakagyezi and Kuruyange. Jolly *et al.,* (1997) have thus suggested that the highlands were more attractive to the earliest settlers of the region. This was probably due to a number of factors which were lacking at lowlands e.g. lower incidence of diseases, more available fertile soils or less dense forest.

Debusk (1998) presented what is regarded as the first detailed stratigraphic pollen record from Lake Malawi sites located between 2°S and 24 °S based on a 40,000 year-continuous pollen record. In this work which covered the late Pleistocene period, DeBusk (1998) was able to reconstruct the vegetation and climatic history of the area.

The aim of the work was to test the strength of two biogeographic hypotheses:

1. The recent biotic interchange between the montane zones of East and West Africa, evidenced by phytogeographic and zoogeographic similarities, was through a northern route (Debusk, 1998).

2. The montane grasslands, within which are some montane forest trees, were established due to human action and not climate (Hamilton *et. al.,* 1986).

The results, from the two lake cores drilled indicated that from 40,000 to 35,900 yrs B.P., climatic conditions were both cool and slightly dry. During this period, pollen of *Hyphaene*, Poaceae, *Typha, Podocarpus* and *Acacia* were relatively abundant around the lakes' catchment areas. From 35,900 to 26,400 yrs B.P., conditions fluctuated between drier and colder climates. The most interesting results came from the period between 26,400 yrs B.P. and 17,500 yrs B.P. The pollen record for this period contained about 40% of montane forest taxa. The inferred environment was thought to be moist but colder than before. Debusk (1998) thus interpreted this as an increase in moisture availability between Equatorial Africa and Lake Malawi during the GITA. The expansion of montane forest would favour the spread of these montane species from East to West Africa**.** This inferred moist condition that led to montane forest expansion in southern tropical Africa would therefore point a northern route for biotic interchange between the montane zones of East and West Africa. The occurrence of a forest refugium in Lake Barombi in South West Cameroon during the GITA therefore confirms this evidence (Maley, 1991). The results of this work will be discussed shortly. From 17,500 yrs B.P, onwards, pollen of evergreen forest and woodland species became reduced. This was interpreted as the occurrence of low percentages of montane and evergreen forest species. Wet climatic conditions returned at about the early Holocene (12,000–10,000 yrs B.P.) in one of the two sites. At about 3,000 yrs B.P., there was a decrease in percentage of montane forest taxa and a general abundance of *Brachystegia*, Melastomataceae–Combretaceae, *Hymenocardia, Uapaca, Acalypha* and *Moclura*– type pollen. These species are characteristic of woodland and/or secondary forest; all these indicated that conditions became wetter and similar to modern climate. Late Holocene forest decline was recorded with the appearance of Iron Age settlements in Lake Malawi area around 1,200 yrs B.P. But a drying event was noted at about the same period in the area. This drying event was indicated by two prehistoric lowstands in Lake Malawi. The occurrence of this dry period indicated that climatic factors were probably responsible for forest decline. However, considering the occurrence of low-lake levels and Iron-age occupation of the investigated areas at about the same time, a combination of both climatic and anthropogenic factors was favoured as the most plausible reasons for forest decline (Debusk, 1998).

Kiage and Liu (2006) made a review of late Quaternary paleoenvironmental changes in East Africa using evidence from palynology and sedimentology. The authors found that prior to 42,000 yrs B.P., the environment was characterized by warm climate, cold and dry climatic conditions existed between 42,000 and 30,000 yrs B.P., cold and moist climate occurred between 30,000 and 21,000 yrs b.p. and during the GITA i.e from 21,000 to just before 12,500 yrs, climate was extremely dry and cold.

2.3.3 West Africa

Palynological studies, based on two lakes namely: Lakes Barombi Mbo in S.W. Cameroon and Bosumtwi in S.E. Ghana in West Africa, have provided evidence of palaeoenvironmental changes in the forests of West Africa during the Late Pleistocene (Maley, 1991). The pollen record from Lake Barombi Mbo, S.W. Cameroon (an altitude of 300 m) shows that the forest persisted there from about 24,000 yrs B.P though with a decline during the GITA (tree pollen was about 50% of pollen sum). During the GITA, there were increases in the pollen of grasses and montane taxon such as *Olea hochstetteri* (mountain olive). The forest elements later increased during the beginning of the Holocene and became fully re-established some time between 9500 and 9000 yrs B.P. These vegetation changes indicate the onset of wetter climatic conditions (Maley, 1991). Therefore, the pollen record supports the proposed existence of a refugium in S.E. Cameroon.

The pollen record from Lake Bosumtwi, S.E. Ghana (500-600 m in altitude) is different from that of Lake Barombi Mbo in SE Cameroon. In Lake Bosuntwi, the pollen record shows that during the GITA (19,000–15,000 yrs B.P.) forest was replaced by montane trees and grasses. During this time, pollen of grasses and montane species (*Olea hochstetteri*) became very abundant while lowland forest species completely disappeared from the lake. Tree pollen was less than 5% of the pollen sum. This situation persisted until the beginning of the Holocene ca 12,500 yrs B.P when forest species began to increase. Thus, the pollen record showed that during the GITA, though the forest became reduced, it persisted in SE Cameroon. In contrast, forest completely disappeared from S.E. Ghana as evidenced by Lake Bosumtwi pollen records. In other words, the cold and dry conditions of the GITA were more severe in the western part (S.E. Ghana) than in the eastern part (S.W. Cameroon) of West Africa.

In conclusion therefore, the reconstructed palaeoenvironment of the late Pleistocene period in the humid tropics based on evidence from palynology is summarized below. Prior to 40,000 yrs B.P., the rainforest was an open one with "coastal mangrove swamp forest being restricted to small localized strips in brackish-water creeks" (Sowunmi, 1998:68–69). Montane, fresh water and few forest taxa characterized this period. Between 40,000 and 30,000 yrs B.P., climatic conditions became wet, with a rise in sea level, re-establishment of the mangrove swamp forest and expansion of the forest zone. However, cold and dry conditions were noted during this same period in parts of Eastern Africa (Kiage and Liu, 2006). Conditions deteriorated thereafter (i.e. from 30,000–ca. 14, 000 yrs) with cold and dry conditions reaching a peak during the GITA [20,000–15,000 yrs B.P.] (Kadomura, 1995). While forest vegetations were reduced in some places (e.g lake Barombi Mbo, SW Cameroon), it completely disappeared in others (e.g lake Bosuntwi, SE Ghana), while *Olea* sp, *Ilex mitis, Podocarpus*, Poaceae and abundant savanna taxa dominated the landscape. In other words, there was a forest refugium in SE Cameroon between 20,000 yrs and 13,000 yrs B.P. Moreover, compared to other areas considered such as those in Central and East Africa, there are limited examples of reconstructed environment dated to late Pliestocene.–mid Holocene period from West Africa. Therefore, there is an urgent need for more palynological studies of sediments dated to these periods to be carried out in West Africa. Having discussed some of the palaeoecological studies done on the general rainforest environments, a brief exposition on the tropical rainforest paleo-vegetation will now be presented.

2.4 Palaeoenvironment of rainforest and environmental changes in the humid tropics during the Holocene: a brief review

The Holocene period, for the purpose of this work, began about 13,500 yrs B.P. (Pastouret *et al*., 1979). The environment of the early Holocene is believed to have been wet and humid characterized by a re-establishment and expansion of lowland rainforest vegetation following its destruction or marked reduction in the preceeding dry phase.

The mangrove swamp forest (MSF) in coastal areas was also thought to have expanded consequent upon sea transgression especially during the Mid Holocene (8,500-5,500 yrs B.P.) There was a dry period during the late Holocene from ca. 4,500-2,500 yrs B.P., but conditions became wet and warm from 2,500 yrs B.P although the impact of humans which became very noticeable during this latter period led to the occurrence of anthropogenically-induced environmental changes. These deductions have been based on mineralogical studies of sediments off the Niger Delta (Pastouret *et al.,* 1979) and palynology (Rossignol-Strick and Duzer, 1979; Sowunmi, 1981a). However, there are also results from other parts of West, East and Central Africa, and South America.

Nigeria

Palynological results of Sowunmi (1981a and b) have been discussed elsewhere. Therefore, a summary of those Sowunmi (1981a and b) and Pastouret *et al*., (1979) will be presented. The Niger delta environment was mainly wet during the early Holocene (13,500-8,500yrs B.P.). From ca. 7,500 to 2,900 yrs B.P., there were fluctuations in the climate characterized by alternating dry and wet periods: 7,500-6,900 yrs B.P. (wet period); 6,900-5,400 yrs B.P. (dry period); 5,400-4,800 (wet period); 4,800-3,900 yrs B.P. (dry period) and 3,500-2,900 yrs B.P. (wet period). From 2,900 yrs B.P. till date, there have been increases in *Elaeis guineensis* concomitantly with reductions in forest trees, and fluctuations in MSF taxa especially *Rhizophora*. Sowunmi (1981a) opined that this period marked the onset of a significant impact on the vegetation of the rainforest zone by humans.

Bénin

Only a summary will be presented here since these have been discussed in some details elsewhere. From 12,200 to 4,400 yrs B.P., conditions were generally wet but two periods of sea transgression occurred at 12,200 and 8,400 yrs B.P. From sometime ca. 3,320 and at 2,500 yrs B.P., the mangroves completely disappeared while the forest drastically decreased. These vegetation changes were due to the late Holocene dry climatic conditions. During this same period, the Dahomey Gap was re-opened and has been maintained by anthropogenic fires.

In summary therefore, the early-middle Holocene period in West Africa was characterized by a tropical rainforest that was far more extensive and diverse than the present situation. Climate was generally wet and warm. The wettest periods were between 8,400 and 5,000 yrs B.P., a time characterised by a very significant rise in sea level. Drier conditions began first around 4,500 yrs B.P. but very dry conditions reached a climax between 4,000 and 2,500 yrs B.P. Environmental conditions have fluctuated since then, and have also been influenced by human activities especially forest clearance, bush burning, burning of fossil fuel and release of toxic industrial materials into the environment. The results of the latter have been linked to human-induced environmental changes.

There are evidences of similar environmental conditions during the Holocene in other parts of the world outside West Africa. The next section deals with few case studies from Oman, Indonesia, Tonga, Brazil, Congo, Gabon, Uganda, Kenya and Venezuela.

Oman

In the south eastern part of Oman, tropical climate was found to have prevailed ca. 6,000–4,500 yrs B.P. in the mangrove swamp forest of Suwayh, Oman. This period was marked by high summer rains and the mangrove swamp forest was characterised by *Rhizophora* and *Avicennia* (Lezine *et al.,* 2002). The authors stated that the occurrence of fresh water taxon *Typha* and ferns suggests that there were inputs of fresh water into the study area. In addition, the presence of oysters and marine species of foraminifera such as *Ammonia beccari*, *Quinqueloculina semilunum*, *Q. akneriana* and *Elphidium striatula* indicated an influence of open sea water in the area of Suwayh near 6,000 yrs B.P (Lezine *et al.,* 2002:227). The abundance and expansion of mangroves which occurred during this period i.e from 6,000-5,000 yrs B.P. was conducive for the occurrence of marine and sea foods such as green turtles, dolphins, clams and fish—marine sea foods whose habitats are within the MSF. These food resources were exploited by humans who lived in the Oman region during the Mid-Holocene period. The presence of mangroves and associated food resources was considered “ideal conditions for food procurements for local populations and allowed human settlements to expand throughout the area” (Lezine *et al.,* 2002:229). Environmental conditions became unstable after 5,000 yrs B.P and conditions deteriorated as from 4,500 yrs B.P. and this led to vegetation changes. These vegetation changes included the disappearance of *Avicennia*, increase in pollen of semi-desert type (*Acacia-Prosopis*) and reduction of marine foods which were abundant from 6,000-5,000 yrs B.P.

Indonesia

The palynological study of a 4 m core from the Kalimantan region (SW Borneo) of Indonesia indicated local record of environmental changes in the area (Anshari *et al.*, 2001). Although the core was dated to the Late Pleistocene i.e. ca. 30, 000 yrs B.P., only the Holocene period is of importance to us in this section. From 13,000-3,000 yrs B.P., there were changes in the vegetation from one dominated by *Gluta renghas, Podocarpus, Phyllocadus, Quercus* and Ericaceae to that of *Barringtonia*, Cyperaceae and Poaceae. This indicated a wetter and warmer but open forest environment. Although, charcoal particles were noted throughout the length of the studied core, there were marked increases in charcoal some time after 3,000 yrs B.P. From 1,400 yrs B.P., significant increases in the pollen of taxa indicative of disturbances (*Terminalia, Trema* and *Pandanus*), woody plants and grasses were noted in the pollen record. According to the authors, the occurrence of these pollen as well as highest increase in charcoal particles was taken as evidence of human disturbance. This, according to the authors, was in support of continued presence of humans in the area during the late Holocene.

Avai O' Vuna Swamp, Vavu U', Kingdom of Tonga

During the early late Holocene period ca. 4,500 yrs B.P., sea level at Avai O Vuna Swamp, Kingdom of Tonga, was at least 1.5 m higher than today, and the mangrove swamp forest was more extensive and well developed (Fall, 2005). However, from 3,500 yrs B.P. onwards, there was a sea regression. This was indicated by decrease in pollen of mangrove swamp forest such as *Rhizophora mangle*, and those of coastal vegetation such as *Barringtonia asiatica* (Fall, 2005). The occurrence of this event coincided with increase in taxa associated with the movement of Polynesians into the area. The plant taxa included *Cocos nucifera*, *Casuarina equisetifolia*, and freshwater species such as *Pandanus tectotius* and *Excoecaria agallocha.* The arrival of these Polynesians in Tonga was signalled by the appearance and increase in microscopic charcoal in the pollen profile from ca. 2,600 yrs B.P. This was taken to be indicative of the felling and burning of forest trees by humans. The affected trees included *Hedycarya dorstenoides, Guettarda speciosa,* and *Calophyllum nea-ebudicum*. The second change following the reduction in forest trees was a reduction in the number of native birds and bats because their habitats–forest trees–were destroyed. This, subsequently, led to the loss of some forest trees whose seeds were dispersed by these birds. Thus, it can be deduced that the forest vegetation around the Avai O Vuna swamp was quite dense and extensive during the early late-Holocene. As from the latter part of the late Holocene ca. 2,600 yrs B.P., the arrival of Polynesians and their settlement in the area "altered the species composition of the tropical hardwood forest in Vava 'U' (Fall, 2005:459).

Brazil

At`the North East coastal State of Pará in Brazil, a 4.5 m core which was recovered from Taperebal was studied (Vedel *et al.*, 2006:120). Before 6,500 yrs B.P. i.e. from ca. 10, 000 to 7,000 yrs B.P., the mangrove swamp forest was well developed, the dominant mangrove species being *Avicennia*. The presence of Amazon rain forest pollen in high amount showed that the "area was partly covered with coastal rainforest during the early Holocene". However, the abundance of *Avicennia* over *Rhizphora* pollen suggested that the area was not inundated by marine water, and that sea level was lower than the present. This suggestion was based on the ecology of mangrove species especially *Rhizophora* and *Avicennia*. *Rhizophora mangle* is usually found in lower lying areas while *Avicennia* grows mainly on areas with greater elevation. Therefore, the vegetation type dominated by *Avicennia* indicates a lower sea level. This inference was reached because the composition and distribution of the marine vegetation are greatly dependent on sea level changes.

After ca. 6,500 yrs B.P., there was expansion of *Rhizophora* pollen which far exceeded that of *Avicennia*, which decreased. There was also a significant decrease in rainforest species with the mangrove vegetation was dominated by *Rhizophora* indicating a rise in sea level as well as increase in sea incursions into the hinterland. After this period there were fluctuations in the vegetation. These fluctuations were basically the dominance of *Rhizophora* over *Avicennia* and vice-versa, and fluctuations in Amazon rainforest. These events were noted at level which is thought to be recent. Consequently, the authors opined that the development and dynamics of the coastal vegetation at NE Pará State were regulated by relative sea level without human actions (Vedel *et al.*, 2006). Had the authors counted charcoal particles, the results would have validated or refuted the conclusions of the authors that the vegetation changes which occurred at ca. 6500yrs B.P. had no anthropogenic impact. But charcoal particles were not counted "because of the very high presence of pyrite in the samples which made the counting difficult" (Vedel *et al.*, 2006:117).

In summary, Vedel *et al.*, (2006), concluded that the vegetation of Taperedal NE Brazil Pará State during the early Holocene was that of an *Avicennia*-dominated mangrove swamp forest. During the mid-Holocene, ca. 6,500yrs B.P. and after, the vegetation became dominated by *Rhizophora*. This was indicative of a rise in sea level. From the mid-Holocene to recent, there were fluctuations in the vegetation influenced mainly by a natural cause—sea level change.

Congo

Vincens *et al.*, (1997) studied a core drilled at Lake Sinnda, southern Congo and noted that before 4,200 yrs, the environment was dominated by abundant forest taxa and few grasses. However, major climatic changes occurred around 3,800 and 1,300 yrs B.P., when the lake dried up due to the late Holocene dry climate. This dry phase commenced at 4,200 yrs and caused a reduction of dense forest to semi-decidous forest. Based on the above, the authors inferred that there were more seasonal climatic conditions between 4,200-3,800 yrs B.P. The increased amount of calcite and talc (reduction in quartz and kaolinite) noted in the core section dated to between 3,800 and 2,500 yrs B.P. indicated the occurrence of reduced rainfall and longer dry season at Lake Sinnda. This dry climate led to the complete disappearance of the forest and drying up of the lake sometime between 3,800 and 1,300 yrs B.P. It was inferred that conditions were too dry for the survival of forest vegetation hence their complete disappearance. In contrast, the persistence of humid forest around lakes Ossa and Barombi Mbo in Cameroon until 2,700 and 2,500 yrs B.P. was linked to the occurrence of stratiform clouds and permanent fog cover over the region. In conclusion, the authors opined that the pollen evidence from Lake Sinnda revealed that there was a progressive increase towards aridity from 4,200 yrs but the driest period was between 3,000 yrs and 2,500 yrs B.P. Increase in the amount of quartz and kaolinite in the lake at 1,300 yrs B.P. was attributed to a re-filling of the lake. This phenomenon was indicative of a return of wetter climatic conditions. However, the authors did not mention the climatic conditions that prevailed immediately after the driest period i.e. 2,500 yrs and when conditions became wet ca. 1,300 yrs B.P. Such information would have shown if the inferred wet climate at 1,300 yrs B.P. was abrupt or progressive from 2,500 yrs B.P.

Gabon

Ngomanda *et al.,* (2009) carried out pollen analyses of two cores from Lakes Mandor and Nguene in Gabon. The results of these analyses showed that there were hydrological changes at 4,500 yrs due to onset of dry climate. Between 4,200 and 4,000 yrs B.P., there was further deterioration of climate which became very dry between 2,700 and 2,400 yrs B.P. During this period, the area covered by forest vegetation during the early-late Holocene i.e. before 4,500yrs B.P. became reduced and was replaced by coastal savanna vegetation. This was corroborated by Delègue *et al.,* (2001) who carried out independent research in the coastal forest of Gabon.

Uganda

Taylor (1992) noted that at the Muckoya swamp in the Rukiga highlands, between 12,000 and 2,200 yrs B.P., the site was colonized by montane forest taxa reflecting a generally wet climate characterized by increases in precipitation and temperature. However, at 3,400 yrs B.P., an increase in the pollen of *Podocarpus milanjianus* with concomitant reduction in wet montane taxa were noted. *Podocarpus milanjianus* is naturally found in drier soils in montane areas. Its increase therefore indicated the onset of drier climate. This represented the first siginificant reduction in the montane forest. At 2,200 yrs B.P., another reduction in the extent of primary montane forest occurred. This was attributed to degrading of soils resulting from forest clearance. Increase in the pollen of *Dodonaea, Pteridium* and *Vernonia* indicated presence of "permanently cleared land on the hill sides adjacent to the swamp" (Taylor, 1992:81). Furthermore, increase in the pollen of plants naturally found in regenerating moist montane soils (*Dombeya, Polyscias*, *Croton* and *Trema*) during this same period showed that this second reduction in montane forest was anthropogenically driven. Taylor (1992) concluded that between 20,200 and 3,500 yrs B.P., climate was generally humid while wet montane taxa expanded. At 3,400 and 2,200 yrs the montane forest experienced major reductions; the former was attributed to the effects of the late Holocene dry phase while the latter was due to clearance of forest by humans.

Taylor *et al.,* (1999) studying the environmental changes in Kabata Swamp, Ndale volcanic field, Uganda noted that just before 11,460 ± 90 yrs B.P., a lake formed around the site and it was characterized by a wet climate and an open vegetation dominated by *Olea capensis*. The wet period inferred to have occurred at 11,460 ± 90 yrs B.P was as a result of increased precipitation. Immediately after 11,460 ± 90yrs B.P. the pollen of *Celtis* cf. *durandii* increased. This was interpreted as an evidence for a regeneration of medium altitude forest. Forest disturbances noted at 3,070 ± 50yrs B.P. coincided with increased charcoal particles. The latter phenomenon was interpreted as an increase in burning activities. The subsequent increase in the pollen of forest-edge taxa and that of *Olea welwitschii* at 2,500 yrs B.P. were evidences of disturbed soils or degraded forests due to permanent forms of farming. At 400 ± 60 yrs, there was another extensive phase of forest disturbances as well as increases in the pollen of taxa associated with regenerating forest or open vegetation. This second forest disturbance was due to the combined effect of increased aridity and large-scale farming practices

Kenya

Lamb *et al*., (2003) carried out a study on the vegetation response to rainfall variation and human impact in Central Kenya. Lamb *et al.*, (2003) found out that in the last 1,000 yrs the vegetation of the area responded to changing amounts of rainfall in two broad ways; **(a)** during periods of increased or high rainfall, woody taxa (afromontane and woodland or bushland taxa) increased, and **(b)** during periods of reduced or low rainfall, grasses increased. This was generally reflected in the pollen record at ca. AD 1200. Human impact in the area became detectable from 17th and 18th centuries—the period of Kikuyu farmers. It was during this time that pollen of *Zea mays* and *Ricinus communis* became abundant. This was also followed by the appearance and increase in pollen of Asteraceae and Amaranthaceae/Chenopodiaceae—pollen indicative of human presence and agriculture.

East Africa

Kiage and Liu (2006) noted that during the Early and Middle Holocene, climate was warm and wet, with abundant pollen of forest taxa and few pollen of Poaceae (grasses) as well as extended moist montane forest in the highlands. Although there were evidences of human presence in East Africa during the early-middle Holocene, they had no significant impact on the environment. From the middle to late Holocene, there were general reductions in moisture and forest vegetation, abundant Poaceae and increased human impact in the area. These vegetation changes were the resultant effects of the late Holocene dry phase. However, the authors stated that the early-middle Holocene was not entirely wet. They documented two brief periods of dry climate at 8,300 yrs and 5,200 yrs B.P. but noted that there was a longer occurrence of dessication beginning from 4,000 yrs B.P. This latter dry condition is consistent with the dry late Holocene environments in the tropical Africa.

Venezuela

In Venezuela, at about 6,960 ± 70yrs B.P., Vilarrubia and Rull (2002) found that the vegetation of Playa Medina mangrove was dominated by *Avicennia* and *Rhizophora* as well as pollen of Sapotaceae, Myrtaceae, Anacardiaceae and *Bursera* sp., which are characteristic of dense forest. The combined pollen sum of *Rhizophora* and *Avicennia* at that period was 33% with *Avicennia* constituting 18% of this sum. Based on the high percentage value of *Avicennia*, it was concluded that the sediments were deposited where *Avicennia* was more abundant than *Rhizophora*. From then till the Late Holocene, mangrove vegetation was quite abundant. Despite some environmental changes which affected the vegetation such as inundation of the MSF by sea water, the MSF remained, and were sources of good food resources for the Paria people. Vilarrubia and Rull, (2002:74-75) reported that the "arrival of Europeans caused great disturbances in the mangrove swamp forest through clearing and expansion of cultivated plants [coconut, coffee and cocoa]"

From the review above, the following can be summarised as the environmental conditions of the humid tropics during the Holocene. The beginning of the Holocene (13,500–9,500 yrs B.P) was characterised by wet periods. From 7,500 to 4,500 yrs B.P., there were alternations between wet and dry periods. A dry phase existed between 4,500 and 2,500 yrs B.P. and caused fragementation of the forest and expansion of savanna into hitherto forested areas. From ca 3,000 yrs B.P. onwards, significant human impact on the natural vegetation became more pronounced. This led to the loss of many plant species and other life forms (birds, bats, fish, and other sea animals) whose natural habitats, located within the lowland rainforest vegetation, were altered in the process.

2.5 Humans and the environment (outside West Africa): palynological, archaeological and palaeontological evidence

In this section, attention will be focused on human-environment interactions and the main line of evidence is drawn from palynological studies while a few results from archaeological and palaeontological studies are included. These studies are those conducted outside West Africa.

Humans have always interacted with their environment for their basic material needs such as food, clothing, water and shelter. But with the increase in human populations, demands for these basic needs have increased. Man's over-reliance on the environment has often resulted in some consequences which have led to environmental change especially in the last 1,000 yrs B.P. There is the debate of how changes resulting from human impact can be distinguished from those resulting from natural causes especially when human impact coincide with natural causes of environmental changes. Despite the controversies, palynologists (palaeoecologists) have maintained that in many cases, human impact especially on the forest can be detected in the palaeoecological record.

Palynologists believe that changes arising from human activities are abrupt, very fast and occur frequently within a short period of time, usually centuries. In contrast, environmental changes resulting from natural forces are usually gradual, slow and take a long time (sometimes millennia) to build up (Steffen and Tyson, 2001). The abundance and luxuriant growths of certain plants (heliophytes and weeds) have been found to be made possible by openings in forests due to natural factors or artificial clearance by humans. According to Niinemets and Soarse (2006:11) “pre-agrarian human impact can be detected in the abundance of apophytes (weeds) changes in tree pollen spectra, ratio of arboreal pollen to non-aboreal pollen and charcoal dust”. As a result, the retrieval of the pollen of such plants from the fossil record is usually associated with human impact (Sowunmi, 1999). Furthermore, the discovery of material cultural remains and/or artefacts from archaeological excavations is a clear evidence of human presence in an area (Oyelaran, 1991; Alabi, 1999). Therefore, palynological and archaeological evidences complement one another in environmental archaeological investigations

The popular view that early hominins evolved and first occurred in savanna plains has been challenged by the report of the discovery of *Australopithecus africanus* in Limeworks Cave at Hadar, Ethiopia, and Laetoli, Tanzania. Palaeoenvironmental studies carried out in the cave revealed that the habitat which prevailed at that time was a “mixture of forest, closed woodland and grassland around the Rift Lakes” (Bunney, 1993:16). It was further suggested that in deciphering the physical and social characteristics of our earlier hominin ancestors, attention should be focused on forests and woodlands but not grasslands. This work was reported to support the findings of Christophe and Boesch who studied forest chimpanzees of West Africa. Chimpanzees and Bonobo (dwarf chimpanzee) are regarded as the non-human primates closest to humans.

In another study, Arlington (2004) reported that early human ancestors *(Australopithecus afarensis)* who existed 3.4 million years ago were adapted to different climates and vegetation types. A team of researchers analysed fossil pollen from stratified rock formations near Hadar, Ethiopia from where the remains of *A. afarensis* were recovered. They identified four plant communities namely: steppe, tropical, temperate forests and a kind of forest that contained plants adapted to both cooler and wetter climates. This fourth vegetation type has been reported to correspond to periods of both cooler and wetter climate conditions in Hadar (National Science Foundation, Report, 2004). This evidence shows that hominins occupied and were adapted to forest regions.

Piperno *et al.,* (1990) studied human-land interactions in La Yeguada, Panama. The pollen, phytolith and carbon data indicated that humans had an impact on the forest in that area ca. 11,000 yrs B.P. According to the researchers, burning was indicated by high levels of particulate carbon (in pollen and phytolith samples), phytoliths, and carbon coating on weed phytoliths. Furthermore, there was increase in secondary forest species e.g. *Heliconia, Byrsonima, Trema, Cecroipia, Acalypha* and Poaceae. The occurrence of these pollen indicated that there were disturbances in the forest. These disturbances in the forest, according to the palynological record, appear to have started suddenly and even continued despite occurrence of increased rainfall. In summary, the increased frequencies of particulate carbon and carbon-coated phytoliths of weedy plants were regarded as indicators of uninterrupted occupation of the forest areas from ca. 11,000 yrs B.P. till present times. Piperno *et al.,* (1990) inferred that paleo-Indians modified the La Yeguada forest through the use of fire beginning 11, 000 yrs B.P. to present–a date that is archaeologically consistent with the early presence of humans in the area (Bird and Cooke, 1978 and Lynch, 1983: in Piperno *et al*., 1990).

Palynological studies of sediments from Serra do Aracatoba Coastal mountains carried out by Behling (2007) indicated that the mountain area was covered by grassland vegetation in the late LGM, and conditions were dry. During the Holocene period the vegetation was characterized by Poaceae, Cyperaceae, Asteraceae and *Plantago*. From Early to Late Holocene, high frequencies of Poaceae, *Eryngium*, and low percentages of *Araucaria* and Atlantic rainforest occurred. Their occurrence was suggestive of relatively dry climate. Increase in *Araucaria* and Atlantic rainforest pollen occurred before 2000 ± 500 B.P. The very few amounts of charcoal particles recovered from Late Glacial and in the greater part of the Holocene period indicated that natural fires were less frequent during these periods. However, charcoal particles representing fires became more frequent after 2000 ± 500 B.P.—a period considered to have been generally wet, and characterised by an expansion of Atlantic rainforest. This was an evidence of anthropogenic fires in the study area. During the latest Holocene period, ca 690 B.P., pollen of *Ilex* sp., *Aruacaria* forest and Atlantic rainforest decreased significantly. The decrease in *Ilex* sp in this area is indicative of deforestation. The reduction in the pollen of the plant groups and *Ilex* stated above coincided with post Columbian settlement of farmers. This reduction in forest and *Ilex* pollen signaled increased human activities i.e. burning and pasturing. These human activities prevented the re-expansion of natural forest accounting for the few pollen of Atlantic rainforest recorded in the area.

In South West Uganda, evidence for early agriculture practiced by humans was obtained from pollen profiles by Hamilton *et al.,* (1986). The evidence was the drastic reduction in pollen of forest species beginning at 4,800 yrs B.P. The pollen record showed two phases of forest reduction. These two phases (4,200–4,800 yrs and 2500–3,700yrs B.P.) were associated with highest values of Poaceae, burning and soil erosion. Furthermore, between 2,500 yrs and 3,400 yrs B.P., pollen of plants associated with human disturbances (*Bidens, Dodonaea, Nuxia, Polyscias* and *Rumex*) became abundant. From the above evidence, Hamilton *et al.,* (1986) concluded that the reduction of forest was due to clearance by humans. Thus, human action in the South West Ugandian area is reported to have been at least 4,800 yrs old. Though the researchers agree that there is no direct evidence or reason why there was a reduction in forest trees, they maintained that cultivation was the most likely reason for such an occurrence.

In North Western Madagascar, Burney *et al.,* (1997) investigated environmental changes and extinction (regional and local) of certain large mammals from Anjohibe cave sampels. Humans have been traditionally suspected as agents of the extinction of animals such as Archaeolemur, Cuckoos [*Coiua gigas, C. primavea,* and *C. berthae*], white-browed owl [*Ninox superciliaris*]; large extinct lemur *Babakotia radofilai;* and Pygmy hippopotamus [*Hippopotamus* cf. *lemerlie*] in the area. The researchers using paleoentological, archaeological and palynological methods found that the initial phases of some animal extinction occurred at about 8,000 yrs B.P. The remains of a large terrestrial bird were found to have been present there until 2,380 ± 70 yrs B.P. when they disappeared from this region in Madagascar. This date precedes the date for the arrival of humans in the area, suggesting that humans were not responsible for the disappearance of the animals. The occurrence of charred grass cuticles found in samples dated to Late Pleistocene–Holocene period was an indication of fire in the area. Burney *et al.,* (1997) therefore concluded that "long before humans were present to set them, fires were occurring on the surface nearby" (Burney *et al.,* 1997: 764). Humans only started affecting the environment when their population increased in the region some 500 yrs ago. It was concluded therefore, that humans were not responsible for the initial extinctions of certain fauna and (possibly flora) during the early Holocene in the Anjohibe caves, Madagascar.

In a 8,000 yr stratigraphic record of vegetation change from Sierra de Apaneca, El Salvador, pollen evidence revealed that lowland tropical plant species were growing at elevations 200–250 m higher than at present during the mid Holocene (Dull, 2004) and that climatic conditions with temperatures 1ºC warmer than those currently available occurred in the area during the Mid Holocene. The increase in pollen of weedy plants associated with agriculture ca. 5,000 yr B.P. and the first appearance of *Zea mays* pollen at ca. 4,440 cal yr B.P. were regarded as evidences for the beginning of agriculture and human impact on forest vegetations in the area (Dull, 2004). Record of human impact in the tropical lowlands of Mexican Gulf during the Holocene was obtained from a 6 m–sediment core from the Lago Verde Lake (Socorro *et. al.,* 2005). In this study, the sudden change in the pollen stratigraphy followed by significant rise in Poaceae, *Ambrosia* (Asteraceae) and *Zea mays* ca. 2,000 yrs B.P. were regarded as indicators of human activitiy in the area. This change in vegetation was also associated with changes in the limnological conditions around the lake. The disappearance of *Zea mays* from the pollen record at about 1,200 yrs B.P. suggested that there was an abandonment of the area, probably due to very dry conditions. According to Socorro *et al.,* (2005), the last 150 yrs B.P. have witnessed significant changes as a result of deforestation. These changes resulted in the reduction of pollen of tropical forest trees, increased presence of *Zea mays,* increased erosion, turbidity and euthropication in the lake.

Mercader *et al.*, (2001) reported results from an archaeological investigation at a rock shelter in Matangai Turu, Democratic Republic of Congo (DRC). The results of this work were the recovery of a single skeleton dated to 810 yrs B.P. The remains were associated with Late Stone Age lithics, animal bone and remains of fruits from forest trees. Other discoveries were phytoliths from tropical forest plants and Iron Age ceramics. Analysis of the phytoliths indicated that the environment at that time was a dense forest habitat. However, no evidence of domesticated plants used as food was found. In another situation, human presence was noted in the lowland forest at Niah, Sarawak, Malaysian Borneo. In this area, archaeological materials are difficult to find so palynology was employed to ascertain presence of humans in the area and their impact on the vegetation. To achieve this, a palynological study was carried out by Hunt and Rushworth (2005).

Two cores were obtained from areas close to the Niah cave: GanKira (4.62 m) and Kampong Irang (5.15 m). These sites were named GK and K1 respectively. The pollen zones of the cores were named GK 1-3 and Kl 1-2. At the bottom of both cores i.e. at GK-l and KI-l, the vegetation was dominated by abundant mangrove swamp forest trees *(Bruguiera* and *Ceriops)* and some forest species. The appearance of abundant thermally-mature materials and spherules was noted at both GK-1 and KI-l. Though the researchers admitted that the origin of these materials, anthropogenic or natural, was not certain, they were considered an evidence of the occurrence of fire. At the beginning of zone GK-2 dated to 6480 cal yrs B.P., there were peaks in Poaceae and Cyperaceae and rise in *Pteropsida*. This occurred with a concomitant decrease in mangrove and forest trees. Similarly at the beginning of KI-2, dated to 5,920 cal yrs B.P., there was a sharp increase in *Pteropsida* as against a reduction in *Brugitiera* sp. and *Ceriops* sp. The increase in the above-named taxon was evidence of large scale clearance within the lowland forest. The recovery of cereal pollen grains, considered similar to those of modern rice pollen pointed to an unequivocal evidence for the cultivation of rice and forest clearance using local traditional implements at Niah. The date for the end of the clearance of forest was not clear at Kampong Irang. However the end of the clearance as noted from the pollen record occurred at 2,350 cal yrs B.P in GanKira. This date coincided with

2,308 ± 35 cal yrs B.P.—the time recorded for the last burials of Neolithic cemetery in the Great Caves at Niah. The researchers suggested that the people who buried their dead in the cemetery also cultivated rice in the area. Archaeological evidence of rice cultivation has come from some rice impressions in potsherds recovered from the cemetery at the Great caves at Niah. Thus Hunt and Rushworth (2005) opined that the people who occupied the area in the Middle Holocene cleared the forest, cultivated rice and buried their dead in the cave at Niah. Subsequently, mangrove swamp disappeared while the forest pollen became greatly reduced. The disappearance of the mangroves led to the replacement of peat with clays. The clays were thought to be of alluvial origin and indicative of subsidence, submergence and/orerosion. The loss of vegetation cover and widespread fires were considered responsible for the erosion. In addition, there were abundance of Poaceae, Cyperaceae, Asteraceae and weeds during GK-3 and KI-2 periods. The continued abundance of spherules and dark-coloured thermally mature materials was evidence of the repeated occurrence of fire. This was noted as a reflection of human interference with the vegetation. Thus, in this case, palynological record was used to complement the scanty archaeological records in the area. The combined evidence was used to establish the presence and impact of humans on the vegetation, the environment and, their agricultural practices as well as the crops cultivated during the mid Holocene ca. 6,480 yrs B.P.

The next three examples are not from tropical rain forest environment but they are worth mentioning because their results are important and provide clear palynological, anthracological and archaeological evidence of human/anthropogenic impact on the environment.

Gobet *et al.,* (2003) in ascertaining the role of man and fire in vegetation changes in the Upper Engadine area of the Swiss Alps carried out a palynological study of a core retrieved from Upper Engadine. The authors noted few charcoal particles in the sediments before 5,500 yrs B.P. but marked increase at 5,500-5,400 yrs B.P. The amount of charcoal particles never fell to the levels before 5500yrs B.P. and five major peaks in charcoal influxes were noted. These peaks were at ca. 5,350-5,150 yrs, 4,100 yrs, 3,750 yrs, 3,000-2,700 yrs and 1,700 yrs B.P. An unprecedented increase of agriculturally-less attractive opportunists such as ferns and *Alnus viridis* was also noted between 5,500 and 5,400 yrs B.P., and as inferred to be in response to the frequent occurrence of fire in the area, Furthermore at 5,500 yrs B.P., there was increase in the pollen of Poaceae (grasses). This vegetation change coincided with abundance in macroscopic and microscopic charcoal, and the appearance of single pollen of *Cerealia* and *Hordeum-Triticum*. The occurrence of abundant charcoal and pollen of agricultural crops were indications that there were increased anthropogenic activities and openings in the forest. The appearance of the pollen of *Cerealia* and *Hordeum-Triticum* were indications that the climate was warm, because these plants are naturally found in, and only grow well under warm temperate climates. This inference made about a warm climate is strengthened by the fact that the Ice man (Ötzi), which appeared to have been passing through the Alps at that time, was recovered buried under ice. This Ice man was dated to ca 5,300 yrs B.P. Gobet *et al.*, (2003) therefore stated that since the presence of the Ice man in the area coincided with when the climate was warm, this warm climate would have facilitated his movement on the mountains. The discovery of Ötzi was unequivocal evidence that humans used the Sub-Alpine and Alpine environment in the Swiss Alps ca. 5,500-5,000 yrs B.P. Therefore, the combined evidence of abundant charcoal, appearance of cultivated crops and concomitant reduction in forest trees was taken to indicate anthropogenic activities such as farming and the use of fire ca 5,500 yrs B.P. Although no archaeological evidence yet exists for human occupation of the Upper Engadine, the palynological and anthracological evidence is overwhelming. Gobet *et al.*, (2003:154) asserted that “only permanent and noticeable agricultural activities could explain the large-scale anthropogenic reshaping of the vegetation observed at Upper Engadine”.

Jensen (2004) studied the vegetation history of some coastal settlements in Norway at Kilden Normannsvik, Sundfjaera and Meland and are known to be of Stone and Iron-Ages. Based on the pollen and charcoal analyses, Jensen (2004) established, what was regarded as weak signals of anthropogenic impacts at 9,200 yrs B.P. At 6,200 yrs B P. There were indications of forest clearance signaled by increased values of charcoal and the presence of charred peat layers in the core studied. These were linked to continuous anthropogenic fire. According to Jensen (2004), natural fires are generally caused by lightning during summer and are less frequent in the coast than in the hinterland. Moreover, coastal vegetation is less likely to naturally burn extensively. Thus, the occurrence of such extensive fire as represented in the charcoal values were considered anthropogenic in nature. Large numbers of stones cracked by heat were also recovered from various levels from archaeological excavations of one of the sites—Sundfjeara. These stones were dated to 6,400-5,000 yrs, 4,900-4,500 yrs and 3,700 yrs B.P. These periods of cracking corresponded to periods of most intense anthropogenic impacts as revealed by the pollen records at Melkoya. Jensen (2004:277) suggested that "pollen influx of arboreal taxa is extremely low at coastal sites, even when the tree species are present in the vegetation". The reason is thought to be probably a combination of low pollen production and dispersal mechanism.

A period of low activity or local abandonment of the settlement site was recorded around 3,000-2,000 yrs B. P. at Kilden and 3,000-2,200 yrs B.P. at Norman (Jensen, 2004). At this time, high values of Poaceae and herb taxa usually indicative of grassy meadow were recorded. Furthermore, a combination of high values of Poaceae, *Ranunculus acris* type and *Rumex acetosa* type in Norway is usually characteristic of sites grazed by domestic animals and by extension presence of humans. However, the scarcity of charcoal which was noted during this time seems to indicate little or no settlement during this period. Jensen (2004) concluded that the scarcity of charcoal is difficult to interpret. In this study therefore, a combination of archaeological, pollen and anthracological evidence were used to establish the occurrence of fires and impacts of humans in the area.

During the mid-late Bronze Age of Great Britain and Ireland, *Qurecus* and *Betula* pollen were noted to decline. According to Lomas-Clarke and Barber (2007:423), this suggested "that some selective clearance was still being undertaken in the catchment." At the same time, there were increases in the values of silicon and titanium. During the Mid-Iron Age in Great Britian, ca. 400 B.C. increase in Poaceae and *Plantago lanceolata* percentages coincided with increase or rise in Si and Ti concentrations. From AD 1000 to AD 1600, low values of Poaceae and *Plantago lanceolata* were recorded, as well as low Si and Ti concentrations. These latter sets of evidences were taken to indicate occurrence of little local farming activity. The authors thus identified signals of human impact on the vegetation in Great Britian and Ireland during the Mid-Late Bronze age through the Middle ages (Tudor period) to the more recent past (historic past). This was achieved by complementing results from both palynology and geochemistry.

Since this work seeks to look into human-environment relationships especially in the lowland rainforest (LRF) with special attention on the mangrove swamp forest (MSF), attention will now be focused on the mangrove swamp forest vegetation (MSF) and human interactions with it, particularly in areas where it can be found today.

2.6 Palaeoecological studies of mangrove swamp forest vegetation (Outside Africa)

This review will place in proper perpective the vegetation history of the mangroves in the Holocene, their current situation and factors which have affected their distribution through time in these areas. Present-day studies of mangroves show that the red mangrove (*Rhizophora*) predominates when sea level is rising; while the white mangrove trees (*Avicennia* sp) are more abundant during stable or lowering sea levels and the black mangrove (*Laguncularia racemosa*) predominates during the formation of paludal basins. The distribution pattern of mangrove pollen and other pollen has been noted to be affected by transport processes and marine current. Studies on Caribbean mangroves indicate that they survive in a sea level rise rate of 8–9 cm/100 yrs but they cannot persist with rates over 12 cm/100 yrs. The survival of mangroves seems to depend upon the balance between sedimentation from land and rising sea level. In addition, Rull *et al.,* (1999) noted that when the pollen of herbs and ferns are under 5% of the pollen sum, or where herbaceous communities are less than 1% with high values of mangrove pollen, the mangrove vegetation is considered to be present and *vice versa*. It has been noted that during the early Holocene, the effect of the sea level rise resulted in the replacement of savanna by mangrove vegetation in Venezuela (Van der Hamman, 1998 In: Rull, 1999). In other words, an increase in sea level is favourable to the growth and expansion of mangroves especially *Rhizophora* species and *vice versa*.

In Playa Medina, Rull *et al.*, (1999) noted the total disappearance of *Avicennia* and *Laguncularia* in the Mid Holocene. The disappearance of *Avicennia* in Playa Medina was linked to human impact because palynological studies in the Playa Medina area indicated that mangroves, notably *Avicennia* and *Laguncularia,* have been widely used by humans since 5,000–6,000 yrs B.P. Furthermore, the low occurrence of *Avicennia* and *Laguncularia* and/or the disappearance of both species are indications of low salinities and human disturbances of the mangrove swamp forest vegetation in the area. At Lago Crispim, Brazil, the vegetation was dominated by rich, dense and tall Amazon forest and appreciable mangrove vegetation ca. 7,640-6,620 yrs B.P (Behling and Costa, 2001). At 7,000yrs B.P., although the Amazon rainforest was dense and diverse as indicated by the recovery of abundant pollen of rainforest species, there was a reduction in *Rhizophora* pollen, and was taken to be an indication of a lowered sea level. This was the first notable change in the vegetation of the study area. Low representations of mangroves were again noted at 6,620yrs B.P., which indicated a second lowering of sea level. The subsequent reduction in mangroves allowed for expansion of palm swamp dominated by *Mauritia*/*Mauritiella* from 6,620yrs B.P. to ca. 3,630yrs B.P. was the second change in the vegetation. A third change occurred ca. 3,630yrs B.P. when there was a sea transgression and mangrove swamp forest expanded. The palm swamp was replaced by Cyperaceae, and the Amazon forest was also replaced by salt marshes dominated by Poaceae and Cyperaceae; these vegetation changes coincided with an increased amount of charcoal particles. This drastic reduction in forest trees and the concomitant increase in charcoal particles indicated human impact (i.e felling of forest trees and bush burning) within the Amazon forest. From 1,840 yrs B.P., mangroves became significantly reduced due mainly to slightly lowered sea level and human impact.

Behling and Cohen (2004) carried out palynological studies of two cores (120 cm and 130 cm deep) recovered from the mangrove swamp forest at Barra Velha and Praia do Pesqueiro on the Eastern side of Marajo Island, Northern Brazil. The two sites are approximately 10 km apart. The results of the studies showed that mangroves occurred at 2750 yrs B.P. at Barra Velha and 650 yrs B.P. at Praia do Pesqueiro. The mangrove swamp forest was dominated by *Rhizophora* sp., although low values of

Avicennia and *Laguncularia* were recorded. At the lowest levels of the cores obtained from the two sites, mangroves were less abundant but towards the top, the mangroves replaced the Amazon rainforest, which was present at the earliest periods of the cores. The dominance of the mangroves was an indication of higher sea level. Although Behling and Cohen (2004) did not study microscopic charcoal particles, they did not find any evidence of early human impact in the pollen record. In other words, there was no significant increase in the pollen of Poaceae, neither was there occurrence of pollen associated with humans. However, the subsequent abundance of Cyperaceae pollen at the uppermost sections of the two cores was taken to indicate the occurrence of grazing cattle i.e. beginning of the practice of animal husbandry near the study area. About 230 yrs B.P. in Barra Velha, there was less frequent occurrence of coastal Amazonian forest, while the *Rhizophora*-dominated mangrove forest expanded. Similarly, at Praia do Pesqueiro, mangrove expansion occurred ca. 150 yrs B.P. These two evidences were indications that the highest sea levels in the study area were achieved ca. 250 yrs ago.

Species of the Rhizophoraceae were noted during the Early Holocene in Thale Noi (Crowley and Gagan, 1995). There was also an appearance and dominance of mangroves around 8,420–8,190 cal. yr B.P. From 7,880–7,680 cal. yrs B.P. the mangroves of Thale Noi became reduced and were replaced by fresh water swamps. This occurrence has been attributed to a decline in marine influence. Grass pollen was also noted to increase during this period. According to Crowley and Gagan, (1995), the grass pollen could have been derived from grass swamps growing behind the mangrove belt or from dry land vegetation. From 7,680 yrs B.P., the mangroves were re-established indicating the occurrence of higher sea levels. Subsequetly, the mangrove species were replaced by pollen indicative of fresh water conditions ca. 2435 ± 50 BP (2,720–2,350 yrs BP). This change in vegetation was an indication of sea regression. Crowley and Gagan (1995) noted that in regions of high rainfall, high freshwater input combined with lower rates of relative sea level prevent development of hyper-saline soils, and permit direct replacement of mangrove forest with non-halophytic communities. But extensive burning and disturbance of true peat swamp forest in the lagoonal system of Malay–Thai peninsula have been linked to human intervention.

In central India, sea transgression was said to have occurred between 6,650 ± 110 and 4,608 ± 122 yrs B.P. Similar sea transgression was indicated in straits of Malaca, Indonesia, between 8,000 yrs and 4,000 yrs BP when sea level rose from –13 m to +5 m. But drier periods occurred from ca. 4,500–3,000 yrs B.P. in Central India and in Rajasthan from 4,000–2,000 yrs B.P. This situation was linked to reduction of monsoon rainfall. The establishment of mangrove over extensive areas is usually limited to locations of optimal environmental conditions of calm water, a gently sloping sedimentary inter-tidal area and a relatively stable sea level. Holocene mangroves forest developed ca. 5,100 yrs B.P. due to rising relative sea level (Ellison and Stoddart, 1991). Between 5,100 yrs B.P. and 1,000 yrs B.P., relative sea level of the Bragança coastline, Northern Brazil, was probably never higher than 0.6m above the present level (Cohen, 2003). This led to the disappearance of mangroves from the plains as a result of relative sea level fall during that period and the replacement of mangrove swamp forest by herbaceous vegetation which comprised Cyperaceae and Poaceae.

2.7 Palaeoecological studies of mangrove swamp forest in Africa (excluding Nigeria)

Palynological analyses of three cores in south-eastern Bénin (Yèvié, Dogla-Alago and Goho) were carried out by Tossou *et al.*, (2008). The results indicated that the mangrove swamp forest was abundant from the mid Holocene, 7,500 yrs B.P. to early-late Holocene ca 3,000 yrs B.P. By 2,500 yrs B.P., completely disappeared and was replaced by fresh water swamp forest. A palynological study of a 14.50 m core obtained from Lac Sèlé located approximately 90km north of the coast of Bénin was carried out by Salzmann and Hoelzmann (2005). Although, the site is not located within the mangrove swamp forest zone of Bénin, the pollen record revealed the presence of mangroves in the area during the early-mid Holocene ca 8,200 yrs B.P. The abundance of mangroves continued from 8,200 yrs B.P. to ca. 7,100 yrs B.P. The presence of high amounts of mangrove pollen at the site during this period was an indication of sea transgression. The mangroves began to decline from 7,100 to 4,500 yrs B.P., and became drastically reduced from ca 4,500 to 1,100 yrs B.P. By 1,100yrs B.P., mangroves completely disappeared from the area. Caratini and Giresse (1979) noted a more reduced representation of *Rhizophora* after ca 3600yrs B.P. than at 5,000 yrs BP in the Congo. Reduction in mangrove pollen was also noted at Senego–Mauritania from 5,500yrs B.P onwards. Further reductions in mangrove occurred from ca. 2,800yrs B.P.–present with concomitant increase in *Elaeis guineensis* and *Uncaria africana*. The presence of the pollen of these two species was evidence of the occurrence of an open forest beginning from 2,800 yrs B.P. (Rossignol–Strick and Duzer, 1979).

The results of all these studies indicate that in the Carribean Islands, Venezuela, Brazil, India and West Africa, mangroves were more abundant during the Early-Mid Holocene. This was a period of high sea level and the sea transgressed farther inlands reaching at least 90 km north in Benin (Salzmann and Hoelzmann, 2005). This period is contemporaneous with the Nouakchottian sea transgression. The mangroves started to decline some time in the Mid-Late Holocene and were significantly reduced during the late Holocene which was marked by drier climate and lowered sea level

2.8 Humans and the Mangrove Swamp Forests in Southern Nigeria

The mangrove swamp forest is located along the coast of southern Nigeria. It stretches from Lagos to Calabar in the Niger Delta. The Niger Delta contains the largest distribution of mangroves in West Africa and is the third largest (4.7%) in the world (Ajonina *et al.,* 2008). Since the discovery of petroleum in the Niger Delta in 1956, numerous palynological studies have been carried out there. Most of these studies were based on offshore and terrestrial cores drilled from within the mangrove forest or very near it, and rock formations and outcrops within the southern Nigeria sedimentary basin. These studies, designed to satisfy the quest for crude oil by the oil companies located in the area, were primarily geological and biostratigraphic in nature. As a result, the focus was on palynofacies of the depositional environments and description of the palaeoenvironments of the past vegetations during the period when the sediments were deposited (e.g. Adegoke *et. al.,* 1978; Jan du Chene *et. al.,* 1978a; Jan du Chene *et. al.,* 1978b; Adeonipekun, 2006; Ige, 2009; Durugbo *et al.,* 2010; Adebayo, 2011). The results of some of these studies have been very useful in solving stratigraphic and palaeoenvironmental problems and age correlation, and have given insights into understanding the plant communities that once existed in the area. However, they have not addressed palaeoenvironmental changes in mangrove vegetations in relation to human-environment inter-relationships. This is understandable as these researches have very different aims and objectives. Besides, they were based on pre-Quaternary sediments, which are beyond the period during which modern humans are said to have evolved. Considering the importance of mangroves swamp forest to humans, as already outlined, studies on human occupation of the mangrove swamp forest are necessary as they border on the survival and continued existence of the human groups who have been part of the forest in the area for years. This will also provide information on how these humans have adequately adapted to this rather special environment in Nigeria.

2.9 Palynological studies of mangroves in Nigeria

The first palynological study, known to the author, carried out on the mangrove swamp forest in Nigeria, with the view to understanding early human history is that by Sowunmi (1981a & b). The study of a 36 m core drilled at Ofuabo creek, Niger Delta, revealed that mangrove swamp forest, represented by *Rhizophora,* was abundant and situated farther south than their present location before 35,000 yrs B.P. and the “freshwater swamp forest extended to the area now vegetated by *Rhizophora* salt water community” (Sowunmi, 1981a:469). Before 35,000 yrs B.P., mangroves expanded and occupied the present-day area which is located north of its pre-35,000 yrs period. This indicated a period of sea transgression. There was a hiatus in the core for the period between 35,000 and 8,000 yrs B.P. Although, some parts were missing, pollen evidence shows that mangroves and freshwater swamp forest were present. Between 7,600 and 6,800 yrs B.P., there were fluctuations within the mangrove swamp forest. From ca. 5,600 yrs B.P., high values for *Rhizophora* were noted, this indicated mangrove expansion as well as sea transgression. During this same period, there was a reduction in fresh water swamp species. Mangroves persisted from 2,800 yrs B.P. to the Present although their values were not a high as the mid-holocene period of 5,600 yrs B.P. (Sowunmi, 1981a). In another palynological study of an 11 m core from Ahanve, south western Nigeria, Sowunmi, (2004) showed that the mangroves were abundant and diverse from ca. 9,000 to 5,500 yrs B.P.. Reductions in the mangroves were noted at ca. 4,500 yrs B.P. while at 3,109 ±26 yrs B.P., the mangroves completely disappeared.

Increases in *Elaeis guineensis*, *Alchornea* and fresh water swamp forest taxa were noted around 3,109 ± 36yrs, and particularly after 3,000 yrs B.P. The mangroves were subsequently replaced by coastal savannas and secondary forest vegetation. Based on available evidence from Congo, Senegal, Mauritania, Côte d' Ivoire and southern Bénin, Sowunmi (2004) indicated that the reduction in, and the disappearance of mangroves was a regional phenomenon.

2.10 Mangroves and climate change

Mangrove species, like other forest taxa, are affected by climate change. The unique physiological characteristics of each mangrove species define its capacity for survival in the face of change. Mangroves respond rapidly to changes in temperature, rainfall, and sea level. For instance, because mangroves are characteristically restricted to elevations between mean sea level and highest tides, as sea level rises, their communities are displaced inland for survival. Since mangroves have narrow optimal temperature ranges, rising temperatures will cause their distributions to shift to areas north or south where temperature conditions are most suitable. Mangroves die off in areas where temperature and other climatic conditions are not suitable. Their success in making these shifts depends on their dispersal and re-establishment, and the availability of suitable space. Several of such changes have occurred throughout history; hence the current distribution of mangroves represents the survivors of all such past environmental changes.

2.11 Mangroves as indicators of sea level changes

Mangroves play an important role in preserving the imprint of sea level fluctuations related to climate, estuary or tectonic movement. Species of the Rhizophoraceae are known to occupy littoral zones, and thus provide a good understanding of the history of sea-level of the area. Therefore where an abundance of mangrove pollen is noted particularly in the pollen record, it means that sea level was high, and the area would have experienced good water run-off through tides, rivers and streams (Blasco *et al.*, 1992, Cohen, 2003). Such increased river competence favours the establishment and growth of mangroves. The reduction or absence of mangrove pollen has been noted in Holocene sites from Brazil (Behling and Costa, 2004; Behling *et al*., 2004), Venezuela (Rull *et al.*, 1999), Benin (Tossou *et al.*, 2008) and Nigeria (Sowunmi, 2004; Orijemie, 2005). The reduction in mangrove pollen indicated drastic decline of or destruction of mangroves, and lowered sea level. Furthermore, the absence of mangroves in an area shows highly disturbed sea level that lead to repeated desiccation not favourable to the development of mangroves. Thus repeated changes in sea level could lead to mass destruction of littoral forests. Kidson (1982) noted that one of the most reliable sea-level indicators is the presence of fossil mangrove plant remains recovered in-situ. For example, the fossilized remains of mangrove roots were recovered from sediments located above the present-day sea level in Malvan, Konkan, Indian west coast (Kumaran *et al.*, 2004). Based on this the authors stated that the past sea level must have been higher than that of the present day. Mangrove peat also represents the position of mean sea level. Qualitative and quantitative mangrove palynological records combined with radiocarbon (C14) dates provide accurate records of sea–level fluctuations. From the above review, it is obvious that there is evidence of significant human-environmental relationships, particularly human occupation of the forest zone at least in the Holocene. The degree and period of their impact vary in both time and space. However, when linking humans with environmental change, the evidence, particularly with support from archaeology, must be unequivocal.

CHAPTER THREE

3.0 Materials and Methods

The methods used in this research work are the following: (1) archaeological, (2) palynological, (3) lithological, (4) anthracological, (5) chemical and (6) standard radiocarbon (C14) and AMS dating methods. Presented below is a brief discussion on each of these methods except the last named.

1.1 Field Work

3.1.1 Archaeology

Excavations at Ahanve

Archaeological excavations were carried out at Ahanve. After due consultation with the Baale of Ahanve (Chief G.J. Toyon), Baale Orisa (Chief Dosu Toyon), Olori Ebi (Suru Toyon) and some elders of the village, two sites were chosen for excavation (Fig 8). The first site was a mound while the second, a smaller mound, was near the foot of the larger mound. The mounds are situated within a forest regrowth once considered to be an "Evil Forest". According to the Baale of Ahanve, domestic refuse and remains of animals and other materials were dumped there. This site was chosen on the basis of this ethnographic evidence, as it was expected to yield cultural materials. Moreover, some potsherds were already visible on the mound, probably exposed by a recent road construction. The second site was chosen close to a spot where a *Milicia excelsa* (*Iroko*) tree once stood. This spot, according to the villagers, was once used as a ritual place where sacrifices were offered to the local god. This location was also expected to yield cultural materials.

Fig 8: Discussing with Ahanve elders before archaeological reconnaissance

After the area was cleared and a datum point chosen, gridding was done. The exact location selected for Test Pit 1 was at N 06° 43138´ E 002° 77532´ and N 06° 43112´ E 002° 77534´ for Test Pit 2. We gridded 10m South and 10m East but a large area could not be gridded because it was close to a domestic area where palm oil was being produced. A test pit measuring 2 m by 1 m was sunk at each of the two sites. Both test pits were 12.6 m apart. The first pit was named AHF Test Pit 1 (TP I) while the second was AHF Test Pit 2 (TP II). The TP I was located to the north west of TP II. For both test pits, excavation was done at spit levels of 10 cm; sieving and collection of materials were done simultaneously. TPI was 210 cm while TP II was 110 cm in depth. Excavation was stopped when a sterile layer was reached at 205-210 cm of TPI. For TP II, there was a conspicious and sudden change in the colour of the sediment from dark brown to yellowish red at 60-70 cm first noticed at the western wall, and later apparent at the eastern wall at 70–80 cm. Sterile layer was 105-110 cm in this test pit. Stratigraphic layers for each test pit, based on colour changes, were determined. The boundry of each layer was marked out on each test pit, and represented on a diagram.

All the recovered materials were bagged and labelled. On getting back to the department, potsherds were washed while other materials were thoroughly cleaned. After washing, pottery was classified into rim and body parts and further divided based on decorative motifs. Analyses of the materials provided information used to determine the antiquity of humans at Ahanve, and reconstruct the past ways, material and non-material culture of the people. Analysis of the pottery began with classification, firstly into rims and sherds, and then into different categories based on the decorations on them. Body sherds were further classified into decorated, plain and indeterminate. Furthermore, sherds with similar characteristics were grouped together. The works of three Archaeologists—Allsworth-Jones and Wesler (1998) and Alabi (2002)—who had carried out excavations in the Badagry area were used as guide and for comparison. However, there are other decorations observed in Ahanve, which were not described by the three authors, and have thus been grouped or classified according to their most predominant characters. Rims were classified into pots and bowls. Pots and bowls were recognized in that the former have greater depth than width while the latter have greater width than depth. Rim morphology and a diameter chart were used in the reconstruction of vessels, and in arriving at the possible diameters of the re-constructed vessels. Percentage occurrences of the recovered artefacts (pottery inclusive) were calculated and plotted in graphs. Stratigraphic layers in the two test pits were delineated by visual observation of the changes in the colour and texture of the soil type. However, soil colour was determined using the Munsell colour chart.

3.2 Palynology

For this study, five sediment cores for pollen analysis were drilled in the lowland rainforest (LRF) and mangrove swamp forests (MSF) in the southwestern part of Nigeria using a Hiller sampler. In each case sub-samples were taken at 10 cm intervals and wrapped in well-labelled aluminium foil in the field for all the cores except those of Ikorigho I and Otolu, sub-samples of which were taken at 5 cm intervals.

Ogudu mangrove swamp forest site

The first field trip was to Ogudu mangrove swamp forest, Lagos State (Fig 2). This trip took place on July 23rd 2007. On that trip, a 6 m sediment core was obtained from the mangrove swamp forest.

Ahanve site, near Badagry, Lagos State

A 2 m sediment core was obtained from this village (Fig 2). The site was visited between April 15th and 19th, 2008. The vegetation consists of secondary and freshwater swamp forests.

Otolu rainforest and mangrove swamp forest, Ibeju-Lekki area, Lagos State

This area was visited between March 12th and 15th, 2009. The vegetation of the site consists of both rainforest and mangrove swamp forest. A sediment core, 45 cm in length, was obtained below a water depth of 75 cm (Fig 2). The corer could not penetrate beyond 50 cm because it struck sand at that point. Furthermore, level 0–5 cm was not available because this part of the sediment was not solid enough for the Hiller corer to grab.

Ikorigho, Mahin area Ilaje LGA Ondo State

The major vegetation in this site is the mangrove swamp forest (MSF) (Fig. 2). This site was first visited between March 16th and 17th, 2009. Within the mangrove swamp forest, a 2 m core was obtained. This core was named Ikorigho I. Since this 2 m core did not reach the bedrock, it was decided that the site be re-visited for the purpose of obtaining another core of greater length. This was necessary because the study of sediment samples from greater depths was expected to provide more information about the vegetation history of the mangroves in the area. Ikorigho was re-visited between 26th and 27th June, 2010 and an 8 m core was obtained. Coring was stopped when we were no longer able to push the corer further down because it had become unwieldy and very difficult to manipulate.

3.2.1 Laboratory analyses

Treatment of samples and microscope work

The sub-samples of the cores were processed using the method of Faegri and Iversen (1988). One gram of each sub-sample was weighed into a plastic beaker and of 60% Hydroflouric (HF) acid sufficient to completely cover the sub-sample was added and the mixture was kept in a fume cupboard overnight. This was done to digest the silica from the organic matter. The following day, the soaked sub-samples were transferred into plastic beakers. Water was added to the mixture in each beaker which was then thoroughly stirred. Then, the content of each beaker was carefully decanted into a plastic centrifuge tube, avoiding sand grains. The beaker was rinsed to retrieve as much of organic matter as possible. Before every centrifuging, stirring was done using an electrical whirlimixer. The content in the centrifuge tube was then centrifuged at 3000 revolutions/minute for 15minutes, and the supernatant was decanted while the residue was rinsed by adding water, centrifuging and decanting. This rinsing with water was done three times in order to completely remove the HF from the residue. The final residue of the plastic centrifuge tube was transferred into a plastic tube. This aqueous residue was then sieved using 120 micron sieve to remove coarse particles. The residue on the sieve was discarded while the filtrate was poured back into another plastic centrifuge tube, centrifuged and decanted. Cold 36% HCL was added to the residue and the mixture was warmed in a water bath. This was done to remove silicoflourides from the residue. After centrifuging, the supernatant was decanted while the residue was rinsed into the original centrifuge tube which contained the sieved residue. More-cold 36% HCL was added to this combined residue and centrifuging and decanting were done thrice.

Heavy liquid flotation

The sub-samples obtained from the treatment above were subjected to heavy liquid flotation treatment. This heavy liquid flotation process was done to free the pollen and spores from the remaining disaggregated or heavier silicates which might still be left from the pre-treatment process. A $ZnCl_2$/HCL solution, with a specific gravity of 2.0, was added to the residue obtained from the pre-treatment process above. The mixture, which had been poured into a centrifuge tube, was then stirred thoroughly in an electric whirlimixer. The heavy silicates sank to the bottom of the tube while the palynomorphs floated in the supernatant. This supernatant was then poured into another tube and centrifuged for ten minutes at 3000 revolutions/minute. After centrifuging, the supernatant was decanted into a tube and put aside while the residue containing the palynomorphs was put aside in a centrifuge tube. Some quantity of 0.5% HCL was added to this residue from the heavy liquid mixture and then centrifuged in order to free more palynomorphs still left in the residue. All the supernatants obtained from each of the successive centrifugations were added together and centrifuged to concentrate the recovered palynomorphs. Some water was added to the resulting residue and it was then added to the original which had been kept aside. This combined residue was then washed thrice with more HCL, centrifuged and rinsed with water thrice. The centrifuging and rinsing were done for three minutes at 3000 revolutions/minute.

Acetolysis (Acid Hydrolysis of Cellulose)

This process was carried out to remove cellulosic materials. This ensures a greater concentration of the palynomorphs and facilitates their identification. The final residue, obtained from the heavy liquid flotation outlined above, was dehydrated by adding glacial acetic acid and leaving for five minutes. This mixture was then centrifuged. The supernatant was not poured down the drainage pipe because it will corrode it. Rather it was decanted into a special bottle labeled “acetolysis waste”. This will be safely discarded after some time. Freshly prepared acetolysis mixture made of nine parts acetic anhydride and one part of Tetraoxosulphate VI acid (H_2SO_4) was added to the residue and heated in a hot water bath at 70ºC until boiling point (100ºC) was reached. Boiling was allowed for five minutes. This mixture was centrifuged and the supernatant decanted into the same bottle as above while the residue was retained. Rinsing was done thrice to ensure that the acetolysis mixture was completely got rid of. To this final residue was added 50% glycerol. The mixture was stirred in a whirlimixer and transferred into a calibrated centrifuge tube, ensuring that all was transferred. This mixture was left for 30 minutes after which it was centrifuged and the supernatant was decanted. A known volume of 100% glycerol was added to the residue in a ratio of 50:50 and this mixture was thoroughly stirred in a whirlimixer and then poured in a storage vial.

Mounting

When a portion of the stored mixture was to be mounted on slides, it was stirred thoroughly to ensure even distribution of palynomorphs. Two drops, each of 10µl, of the final glycerine mixture were transfered from the storage vial onto a microscope slide using a micropipette. A cover-slip was carefully placed on the slide to prevent the formation of air bubbles and the cover-slip was sealed onto the slide with translucent nail polish. All the samples from the five sediment cores were treated in the same way as described above. Two slides were prepared for each of the subsamples processed.

Thus, a total of 61 sub-samples were processed and 122 slides were prepared for the Ogudu core; twenty one sub-samples were recovered from the Ahanve core and a total of 42 slides were prepared. For the Otolu core, ten sub-samples were collected, and 20 slides were prepared. For the Ikorigho I core, a total of 41 sub-samples were obtained and 82 slides prepared while a total of 81 sub-samples were obtained and 162 slides were prepared for the Ikorigho II core.

3.2.2 Pollen identification and counting

The prepared slides were studied using an Olympus CH30 microscope with a camera attached. For the Ogudu core, microscope work was done between September 9th, 2007 and January 27th, 2008; for Ahanve it was between 23rd May and 26th November, 2008 and for Otolu, it was between 29th April and 6th May, 2009. For the Ikorigho I core microscope work was between 19th May and 19th September, 2009 while for Ikorigho II core, microscope work was between 22nd July and 6th December, 2010.

Palynomorphs were identified and counted using x40 and x100 objectives. Identifications were done to family, generic or species levels. For the lattermost, this was possible with pollen and spores which have very distinctive or characteristic features and/or belong to monospecific genera. The identifications were based on the 3600 reference slides collection, and photomicrograph albums in the Palynology Laboratory, Department of Archaeology and Anthropology, University of Ibadan, as well as the following publications: Erdtman (1966); Sowunmi, (1973, 1995a& b); Salard-Cheboldaeff, (1980, 1981, 1982 and 1983) and Van Campo *et al.*, (1974).

3.3.3 Pollen sum

Although all pollen and spores encountered were counted, only the major taxa having distinct morphological features and which belong to specific ecological zones were used in calculating the pollen sum. The pollen of *Rhizophora* and Poaceae were consistently excluded from the pollen sum because they were over-represented. However, the pollen of *Rhizophora* was not excluded from sub-samples between 40cm and 0 of the Ahanve samples because it occurred in very low quantities. In contrast the pollen of *Elaeis guineensis* and *Alchornea* were excluded from the pollen sum for this interval i.e. 40cm-0, because they were over-represented. Similarly, the pollen of *Typha australis*, being over-represented at 25cm, 35cm, 40cm-55cm, 65cm-75cm and 100cm in Ikorigho I core, and at 20cm, 40cm-60cm and 90cm in Ikorigho II core was excluded from the pollen sum. Also, *Avicennia* was excluded at 80cm and 90cm for the Ikorigho I core, and at 70cm-90cm and 120cm for Ikorigho II core. This was because it, too, was over-represented at those levels. The percentage occurrence of each pollen type was calculated based on the total pollen sum of respective levels, except otherwise stated.

3.2.4 Phyto-ecological groups and photomicrographs

The identified palynomorphs were grouped into phyto-ecological groups. This was based on the natural habitats of their presumed parent plants (Keay 1959; Hutchinson and Dalziel, 1958–1972). These phyto-ecological groupings reflect the major vegetation zones in Nigeria. Other palynomorphs belonging to ubiquitous species were grouped separately. Photographs of about 150 pollen and spores considered to be of greatest importance were taken. The exercise was carried out both at the Palynology Laboratory, Department of Archaeology and Anthropology, University of Ibadan and the Pollen Laboratory of the Faculty of Natural Sciences, University of Bergen, Norway. Most of the photographs were taken with oil immersion objective at magnifications of x1000. But large-sized palynomorphs were photographed using dry x40 objective lens which gave a magnification of x530.

3.2.5 Lithology

The sub-samples of the five sediment cores and samples from the stratigraphic layers from the excavations were classified according to their colour and soil types using the Munsell soil colour chart and grain-size analysis chart, respectively.

3.2.6 Pollen diagram

Pollen diagram of all the cores were produced using the 1.7.16 version of TILIA (Grimm, 2011). Pollen zones were fixed by visual study of the diagrams.

3.3 Anthracology

All slides were scanned for microscopic charcoal. This was done simultaneously with pollen and spore counts (Kangur, 2002). Identification and counting of microscopic charcoal particles of size class ranging from ≤12μm to 200μm were done. The results of the charcoal counts, expressed in charcoal concentrations particles/cm^3, were included in the pollen diagram.

3.4 Water Chemistry

Water samples were collected from all the four sites. One was collected from Ahanve swamp; two and three samples were obtained from mangrove swamp forest at Ogudu and Otolu respectively. Three samples were obtained from River Oluwa at Ikorigho mangrove swamp forest. The water samples were collected from different levels ranging from surface to different depths of 5-20cm. After collection, they were sent to the analytical laboratory, Department of Chemistry, University of Ibadan to ascertain their salinity.

The method used for determining the salinity levels of the water samples was the argentometric method (Mohr, 1979, in: Arnold *et al.*, 1985). 20mls of the water samples was measured into a conical flask and 1ml of Potassium Chromate was added as indicator, and was titrated against silver nitrate ($AgNO_3$) solution. The entire mixture was stirred continuously until the slightest perceptible reddish coloration was observed. A blank determination was carried out to make a correction in the titre value. The amount of chloride (salinity) in each sample was arrived at using the formula presented below.

$$\frac{\text{Vol of } AgNO_3 \text{ (ml)} \quad \text{x } 1000\text{mg/l}}{\text{Vol of water sample (ml)}}$$

This same method was used for all the nine water samples.

3.5 Radiocarbon dating

Six samples were sent to Beta Analytic Inc. Miami, USA for radiocarbon dating. The samples sent were in two categories namely:

1. Sub-samples from two sediment cores and
2. Charcoal and charred palm kernels recovered from archaeological excavations.

Sub-samples from sediment cores

Four samples from the Ogudu and Ikorigho cores namely levels 70-80 cm, 190 cm and 350 cm, and from 770-780 cm respectively were obtained for C^{14} dating.

Charcoal and charred palm kernels from excavations of TP I, Ahanve

Combinations of charcoal particles and charred palm kernels obtained from spit levels 180-190cm and from 130-140cm of TP I, after consulting Beta Analytic, were sent for dating. There were no recovery at 210cm depth; sufficient charcoal for dating was obtained at level 180-190cm.

CHAPTER FOUR

4.0 RESULTS

4.1 Archaeological Excavations at Ahanve

Two test pits were sunk and the details of the results from the excavations are given below (Figs 9-13). TP I and TP II were 210 cm and 110 cm deep respectively. Sterile layers were reached at 205-210 cm and 105-110 cm of TP I and TP II respectively. Materials recovered from TP I are: pottery, charcoal, smoking pipes (local and foreign), animal and fish bones, rusted nails (iron objects), iron slag, snail and bivalve shells, glass/broken bottles, hearth and palm kernel shells. Materials recovered from TP II included those from TPI except fish bones; spindle whorl and glass beads were only recovered from TPII (Tables 1-4). On the basis of the occurrence of foreign smoking pipes in the two trenches, two phases of human occupation were delineated. These are Phases I (120-210 cm in TPI and 70-110 cm in TPII) without foreign smoking pipes, and II (0-120 cm in TP I and 0-70 cm in TP II) with foreign smoking pipes.

Table 1: Percentage of materials recovered from Ahanve TPI

Table 2: Percentage of materials recovered from Ahanve TPII

Table 3: Pottery Inventory of Ahanve TPI

Table 4: Pottery Inventory of Ahanve TPII

Pollen analyses were not carried out on the soil samples recovered from the excavated pits because the soil is sandy and oxidised. Pollen and spores are not well preserved in such soils. Therefore, it was thought that such an attempt would be a waste of resources and time. Five stratigraphic layers (1-5) were recognised in the two test pits (Figs 14-15). Soil colours from the five stratigraphic layers ranged from light gray, dark gray to black (Table 5).

Table 5: Soil colours of stratigraphic layers delineated in TPI and TPII

Layer	**TPI**	**TPII**	**Soil**
1	Dark gray	Dark brown	Sand
2	Dark yellowish brown	Dark brown	Sand
3	Black	Light gray	Sand
4	Dark yellowish brown	Very dark brown	Sand
5	Dark Brown	Yellowish brown	Sand

4.1.1 Stratigraphic layers

Ahanve TP I

Layer 1 (205-210 cm): This is the sterile layer; the soil is very compact and contains only few number of pottery (ten) and large snail shells (*Archachatina marginata*; 23.1%) [12.2 x 7.7cm; length x width].

Layer 2 (150-205 cm): The soil is very hard and compact, with rootlets. Animal (4.4-33.1%) and fish bones (0.4-5.3%), bivalve (0.4%), iron slag (0.4-2.5%), charred palm kernels (0.8-9.8%) and charcoal (3.5-21.0%) were recovered from this layer. Pottery (44.8-84.5%) became abundant, and burnt bone appeared for the first time here.

Layer 3 (100-150 cm): The soil is loose and mottled, with rootlets. Fragments of local and imported bowls, and imported stems were recovered. Carved wood roulette (CWR) decor was abundant.

Layer 4 (30-100 cm): The soil is very hard and compact; is mottled with rootlets. Fish bones and bivalves disappear from this layer and from the rest of the test pit, while snail shells decreased (7.1-0.9%). Smoking pipes (0.4-2.3%) continued in this layer.

Layer 5 (0-30 cm): The soil is loose and contained recent European product such as nails (1.7%). It also contained abundant charcoal (16.1-83.3%) and palm kernels (3.5-20.8%). Smoking pipes and animal bones disappeared while pottery drastically decreased (5.6-5.2%) in this layer. Snail shells continued to occur but reduced in size (6.2 x2.5cm).

Ahanve TP II

Layer 1 (105-110 cm): This is the sterile layer. Soil is loose and fine grained. Pottery and a piece of unidentified wood were recovered from this layer

Layer 2 (78-105 cm): Very compact soil with charcoal specks. Animal and fish bones, bivalves, iron slag, charcoal and charred palm kernel were the major materials recovered from this layer.

Layer 3 (78-55 cm): Compact, whitish fine sandy soil. The soil contained pottery, snail shells, charcoal, stone and palm kernels.

Layer 4 (20-55 cm): Smoking pipes and glass beads were recovered from this layer. This was the last layer where animal bones were recovered.

Layer 5 (0-20 cm): The soil is loose and fine grained. Iron slag and iron object (nails) remained in this layer.

Fig 9: TPI mound before excavation was carried out

Fig 10: TPI at surface level

Fig 11: TP I at level 90-100cm

Fig 12: TPII at level 50-60cm

Fig 13: TPII at sterile layer (110cm)

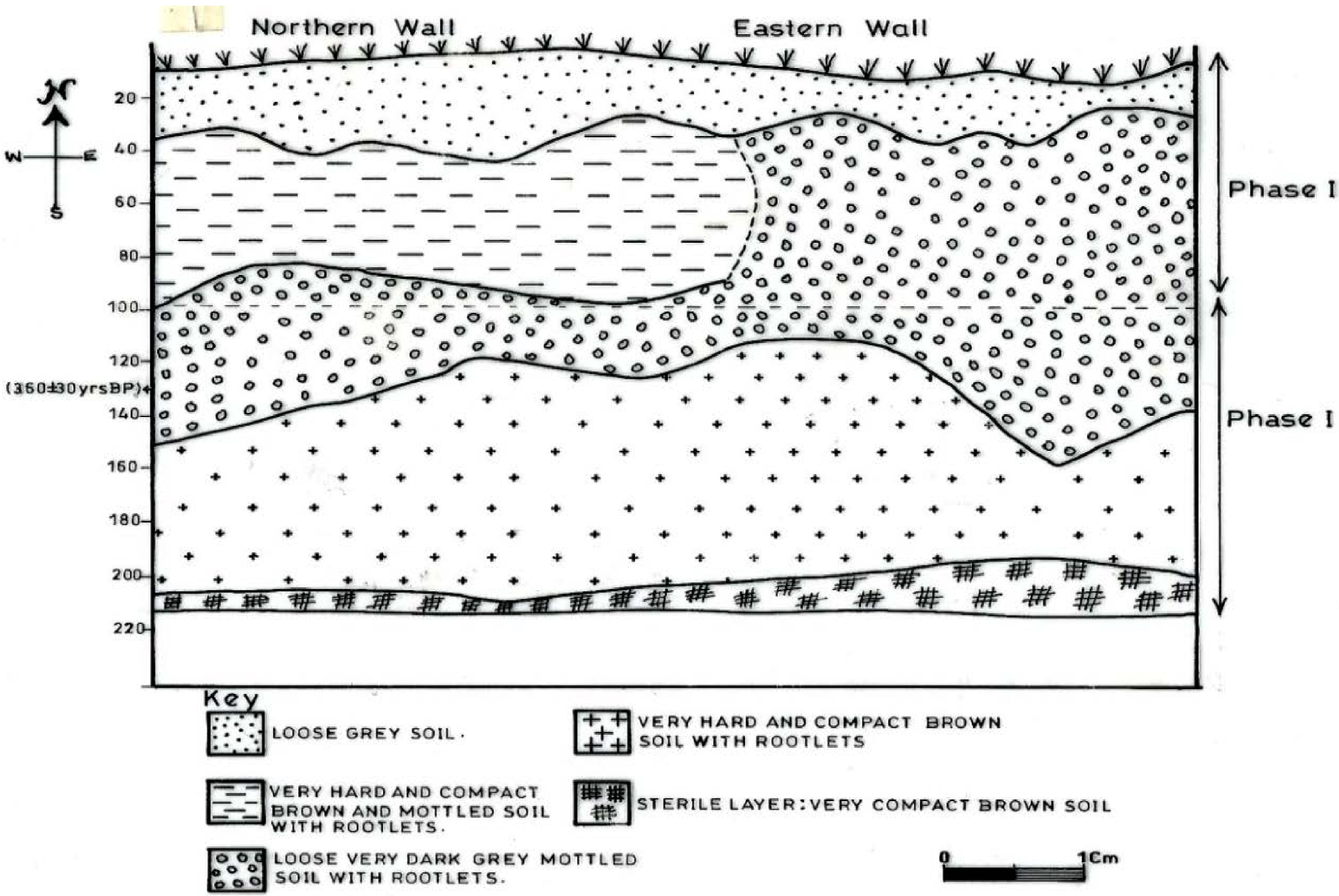


Fig 14: Stratigraphy of TPI excavated unit

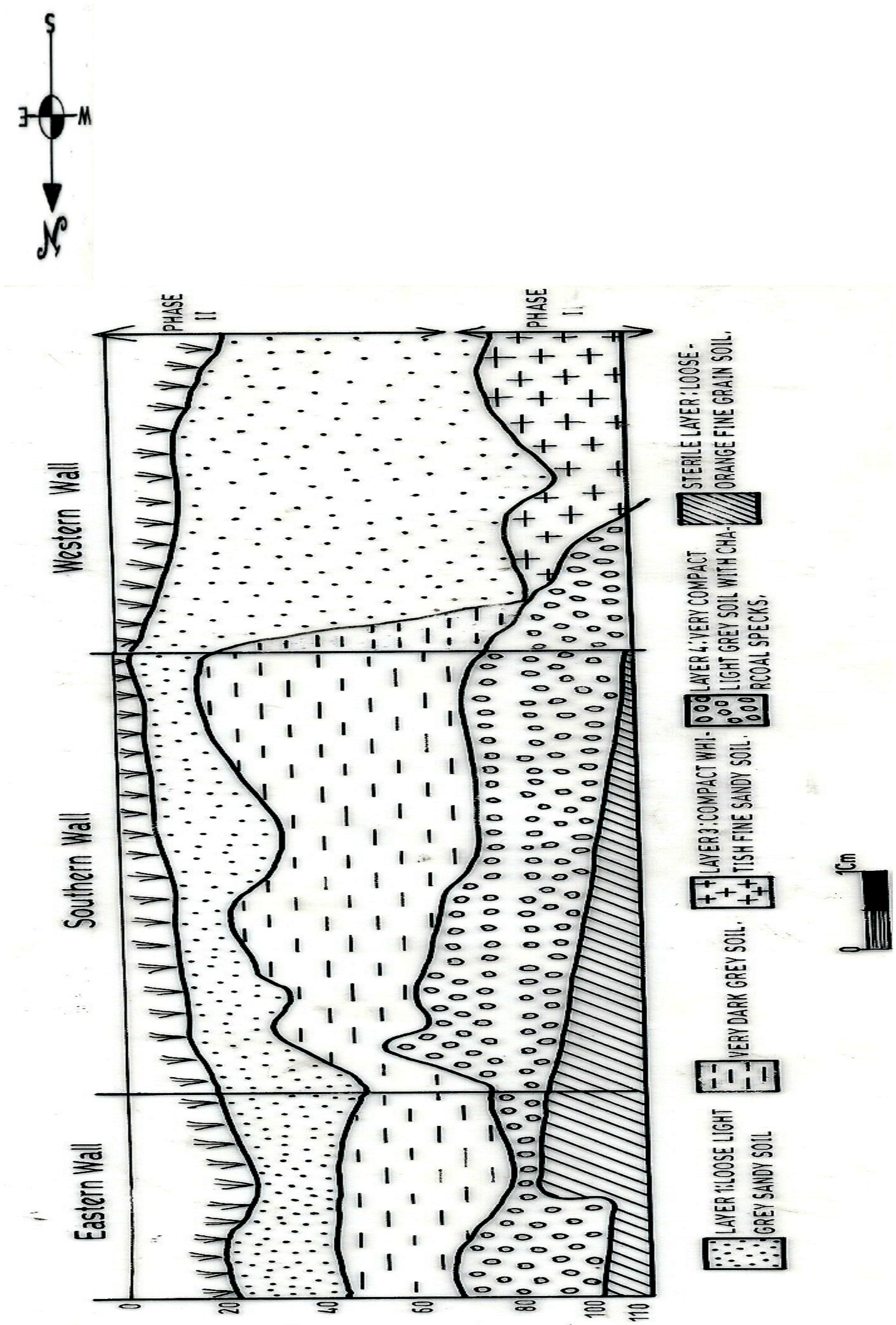


Fig 15: Stratigraphy of TPII excavated unit

Pottery was the most abundant artifact recovered from TP I and TP II. Decoration styles were common to the pottery recovered from both excavations and included the following: grooves, carved wood roulette, wavy lines, snail shell impressions, punctate, corn cob roulette, plain, burnished and plain, incisions, comb teeth impression, herringbone impression, burnished and incised, burnished and grooved, brush impressions, excision and brush, net/irregular cube impression, single-string cord roulette, finger impressions, grooved and incised, brush impression and deep incisions (tables 6-9). Photographs of some of these decoration types are shown in Figs. 16-17.

Table 6: Ahanve TPI: Decorative motifs on rim sherds

Table 6 contd

Table 7: Ahanve TPI: Decorative motifs on body sherds

Table 7 contd.

Table 8: Ahanve TPII: Decorative motifs on body sherds

Table 9: Ahanve TPII: Decorative motifs on rim sherds

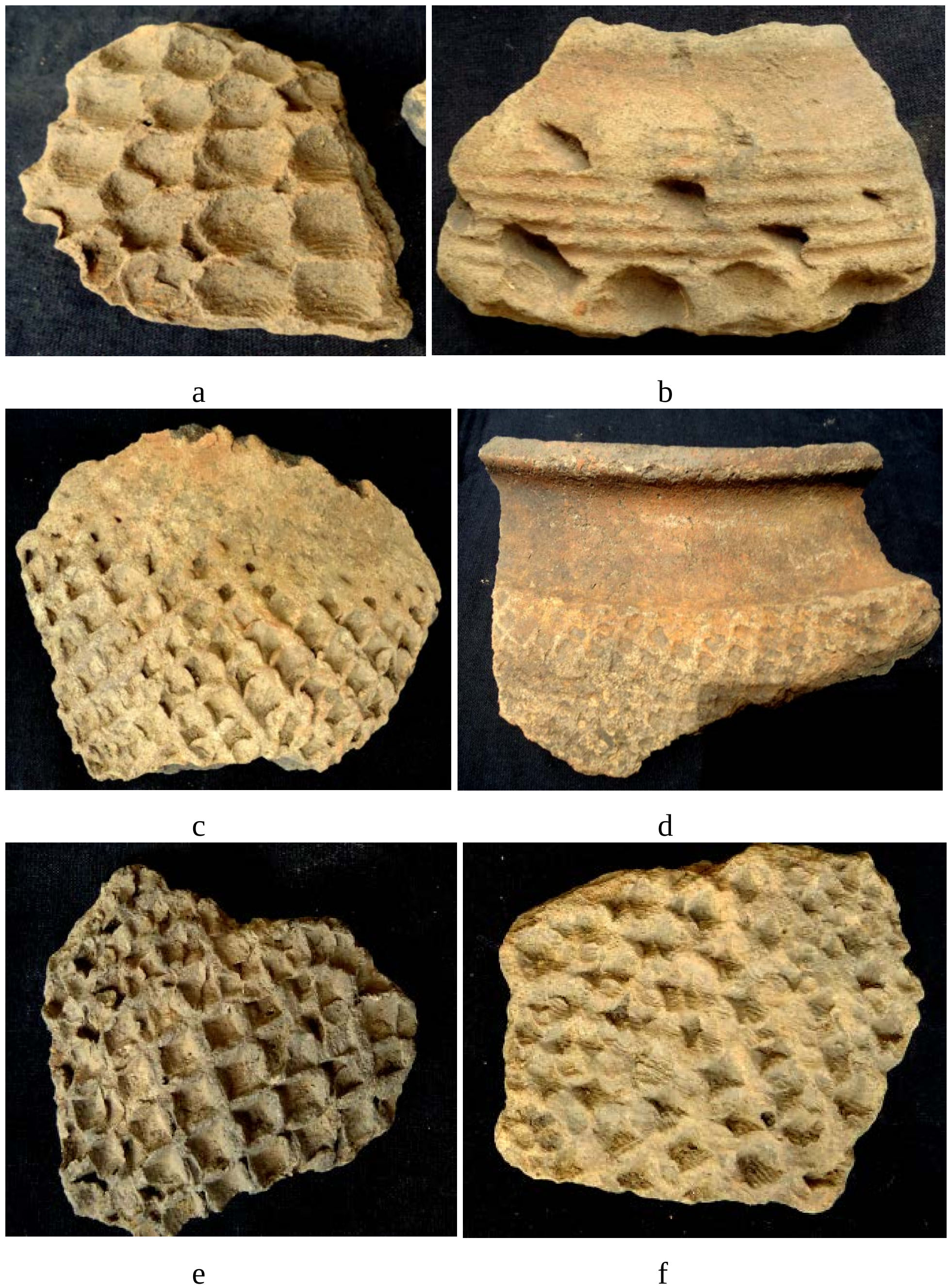


Fig 16: Decorative motifs on Ahanve potsherds I.

Legend: a. Snail shell impression, b. grooved& deep punctate. c-f. carved wood roulette

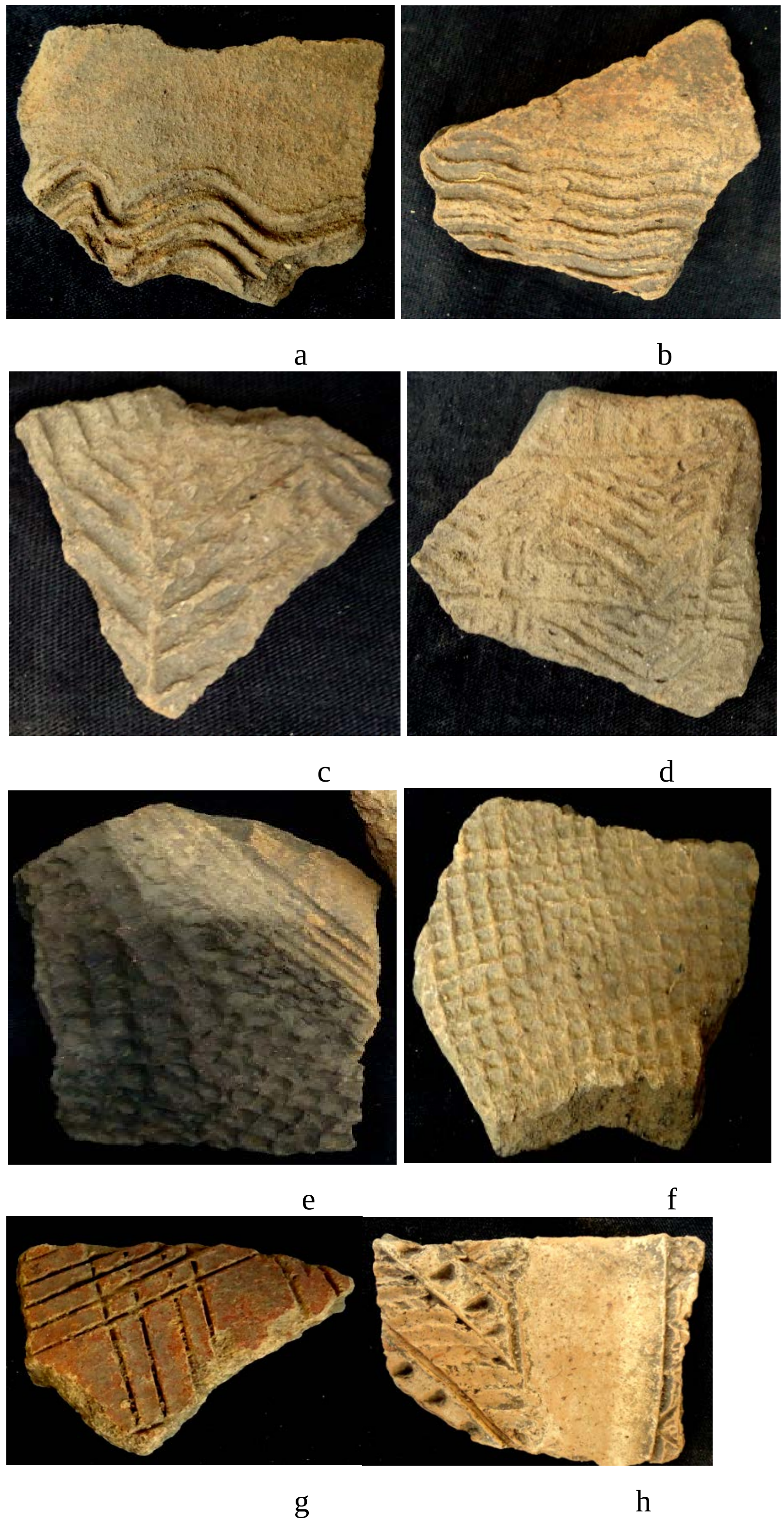


Fig 17: Decorative motifs on Ahanve Potsherds II.

Legend: a-b. Wavy lines, c-d. Herring bone, e-f. Carved wood roulette, g. deep incisions, h grooved and punctate.

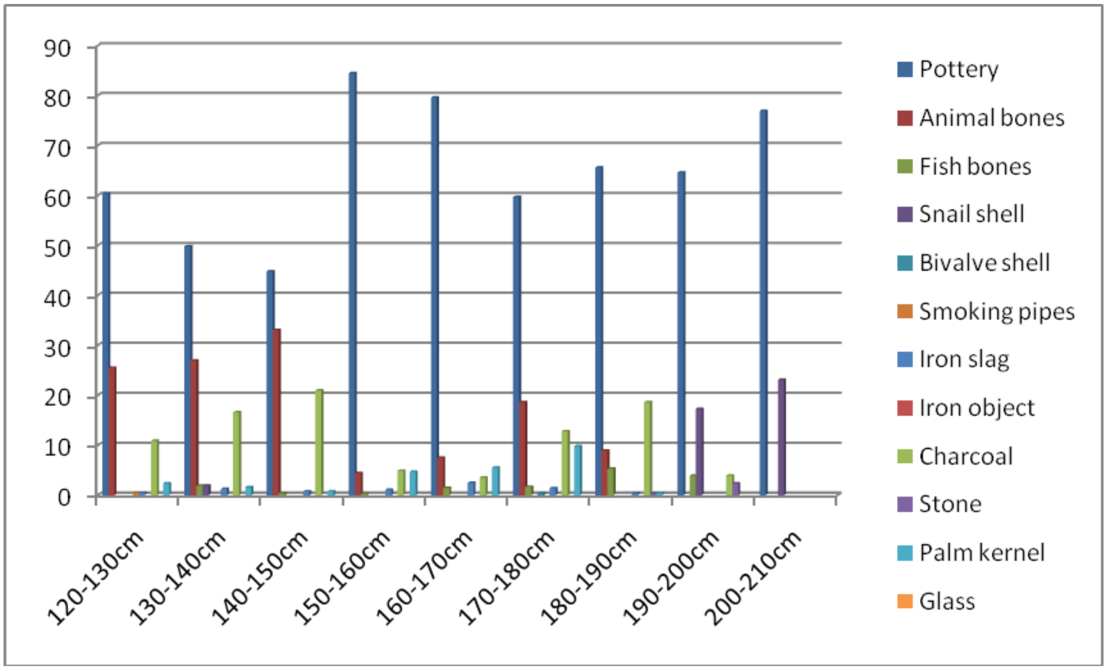


Fig 18: Amount of material culture (y axis) in Phase I plotted against depth (x axis) (TPI)

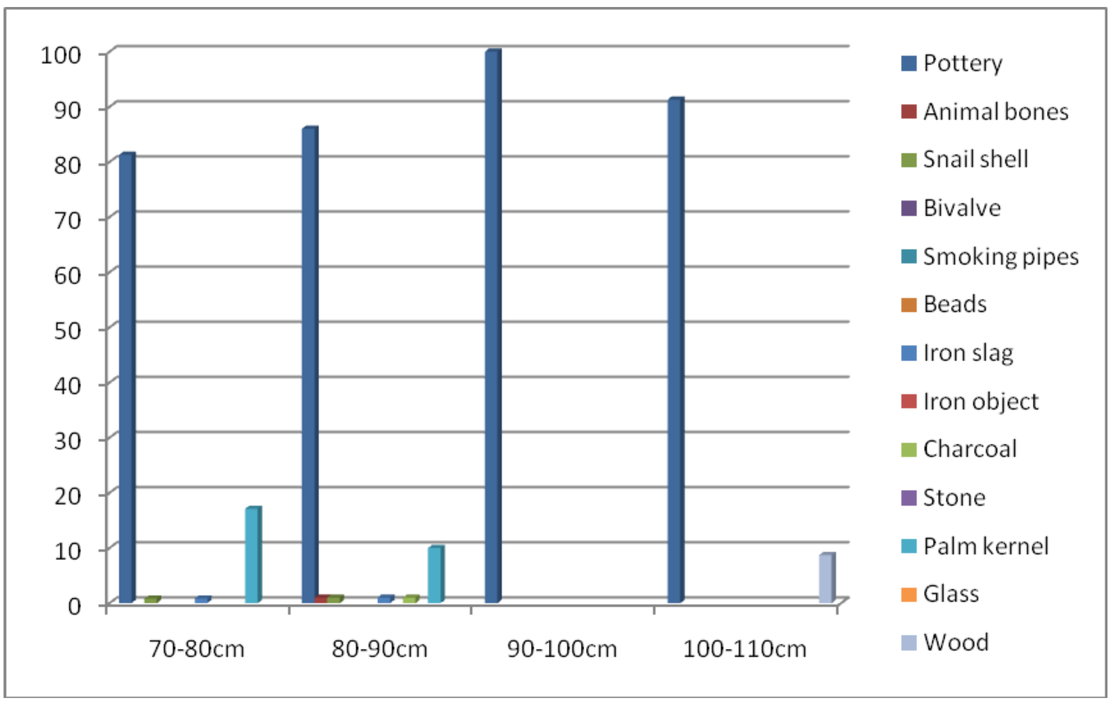


Fig 19: Amount of material culture (y axis) in Phase I plotted against depth (x axis) (TPII)

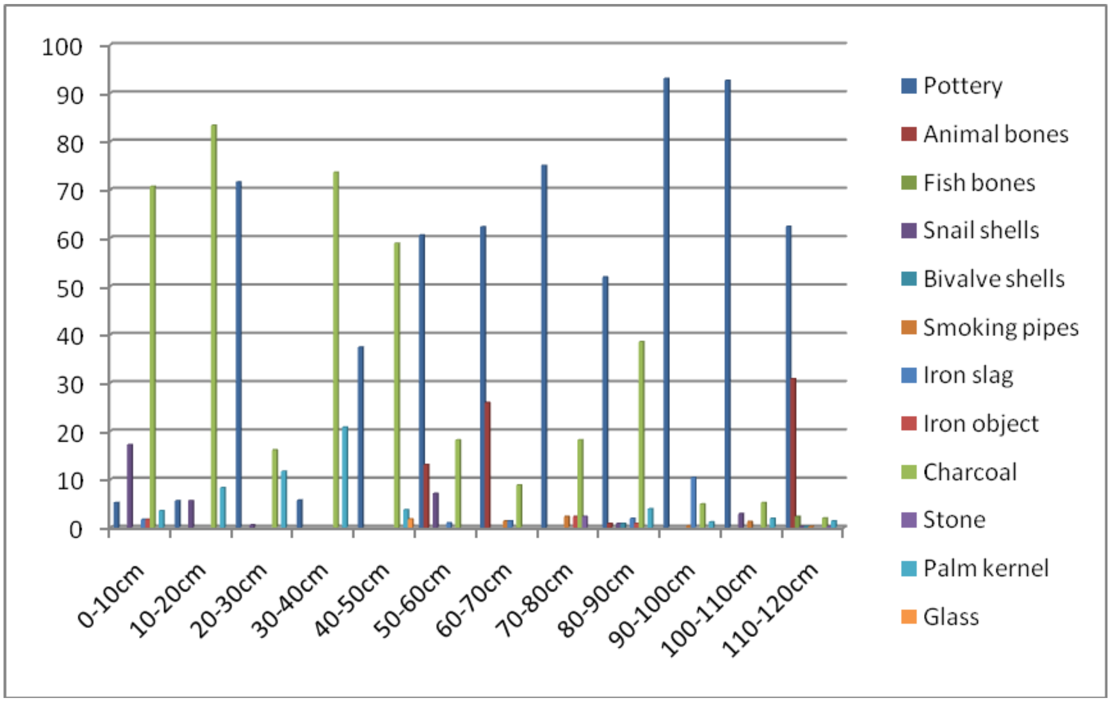


Fig 20: Amount of material culture (y axis) in Phase II plotted against depth (x axis) (TPI)

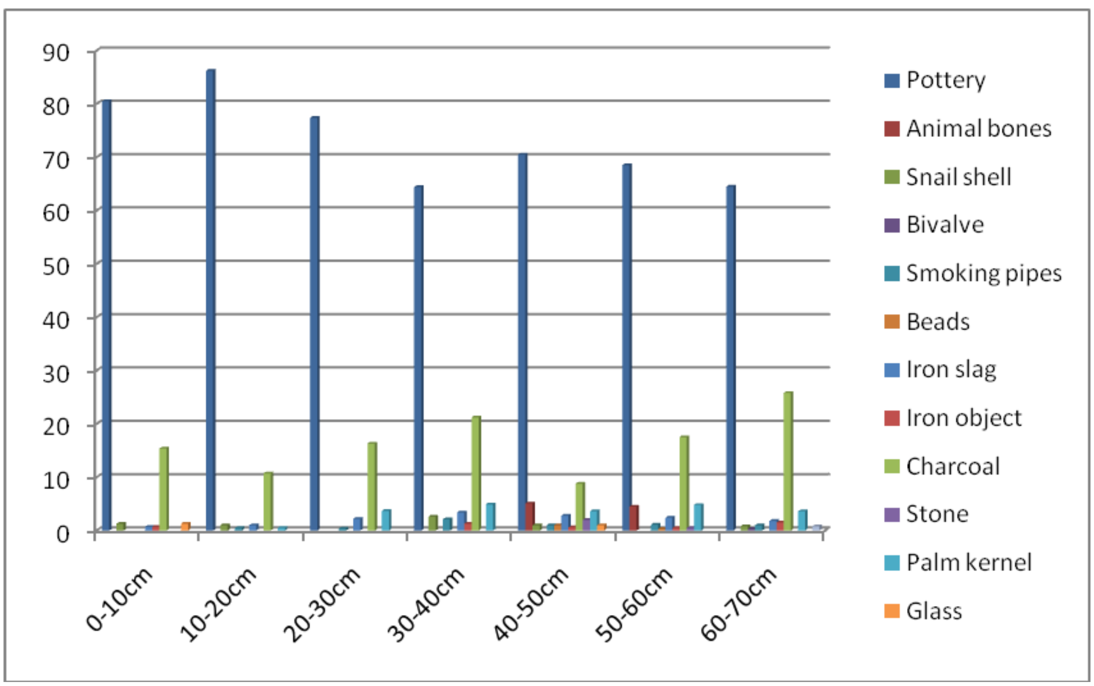


Fig 21: Amount of material culture (y axis) in Phase II plotted against depth (x axis) (TPII)

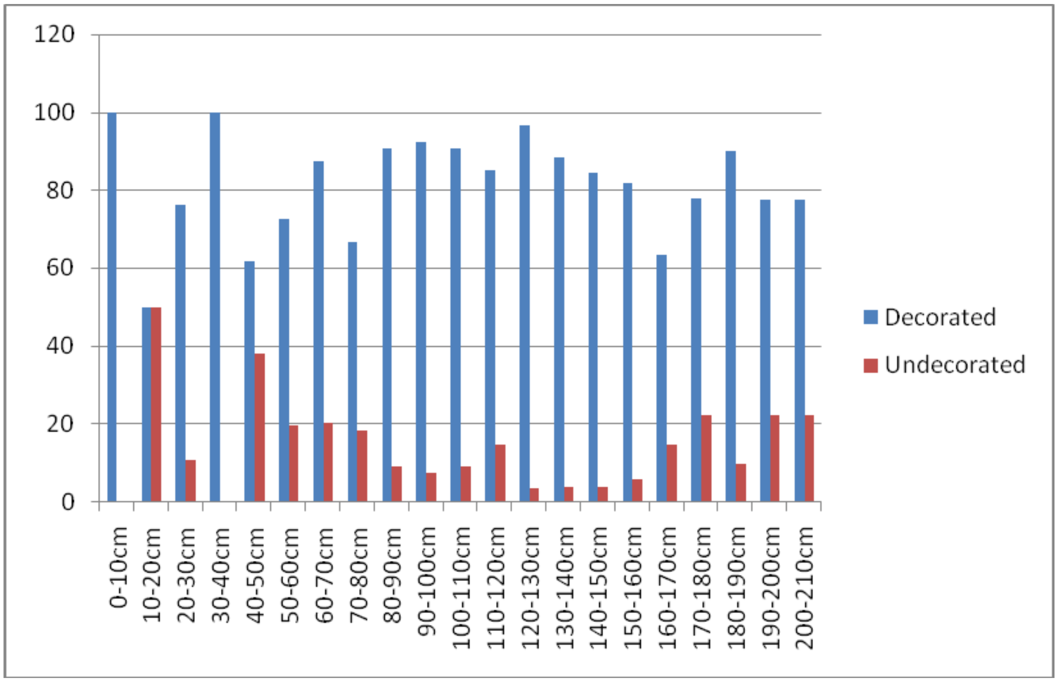


Fig 22: Number of decorated and undecorated pottery (y axis) plotted against depth (x axis) (TPI)

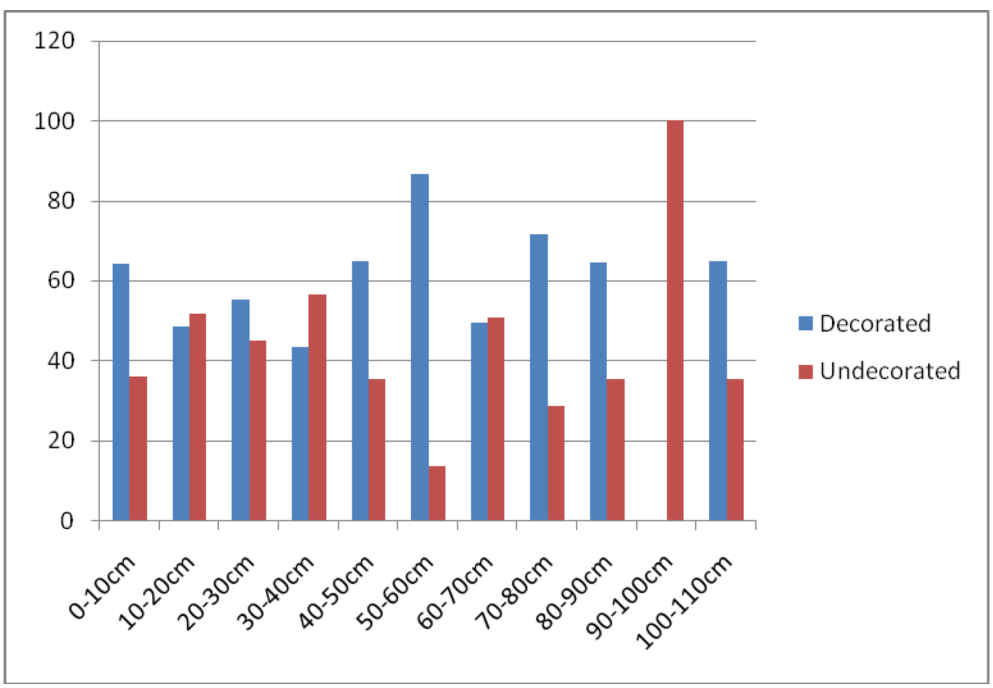


Fig 23: Number of decorated and undecorated pottery (y axis) against depth (x axis) (TPII)

4.1.2 Vessel forms

As stated in Chapter Three, under the archaeology (3.1.1), rim morphology is the method used in reconstructing the kinds of vessels forms (Fig. 24); tiny and indeterminate potsherds were excluded because most were too fragmented. The rim diameter obtained from the diameter chart gives an idea of how big the pot is. Therefore, rims with diameter in the category of 61-80 cm were considered 'large pots'; those with diameter of 35-55 cm were considered 'medium-sized pots' and those with diameter of 30 cm were grouped as 'small pots'. Those with rim diameter of between 10 cm and 20 cm were regarded as bowls. For this exercise, 55 rims, selected at random, were used. Of this number, large pots constituted 14.6%, medium-sized pots, 23.6%; small pots, 29.1% and bowls, 32.7%. There was also a lamp (Fig. 25).

Large-sized Pots (61-80 cm): These pots, which are mainly in the water storage and boiling category, have four broad forms named a, b, c and d.

Form a: Rim is thick (1.4 cm). Vessel is a little narrow at the neck but wider at the shoulders; from the rim to the shoulder, this vessel is plain. The other area of the body has punctate decoration particularly between the shoulder and the rest of the body. Body thickness is 0.7-0.8 cm (Fig. 24 i).

Form b: Rim is thick and in-turned with the round lip (1.5 cm). Body thickness is 0.8-0.85 cm. These vessels have no decoration, being entirely plain (Fig 20, ii).

Form c: The rim of this vessel, which is in-turned, has thick lips (1.9-2.0 cm); body thickness of vessel is 0.8-0.9 cm. This vessel form is large with deep incisions at the shoulders, followed by thin wavy lines. After the decorated area at the shoulder to the base, it is plain. Others, in this category, have the carved wood roulette decoration (Fig 24, iii).

Form d: The rim is not thick (0.9 cm); it has grooves, running west to east around the neck and shoulder of the vessel. The grooves are wider at the shoulder (0.2 cm) than at the neck (0.1 cm). Below the grooves are widely-spaced wavy lines. Rims are in-turned. Vessel is thick (1.5-1.6 cm) around the base where it is mainly plain (Fig 24, iv).

Medium-sized pots (35-55 cm): This catergory is used in cooking more than in the storage of liquids (water and oil). These vessels are similar to those in the above category except for some differences, which will be the focus here. There are two broad forms: (a) and (b).

Form a: It has long neck and out-turned rim; the neck is at an angle of about 25-30º to the main body. The vessel is 0.7-0.8 cm in thickness at the rim but 1.2cm in the body area. It is plain (Fig 24, ix).

Form b: This is similar to form (a) except that its neck is not as long and inclined at 45-60º. The rim is 0.85 cm thick at the lip; body thickness is 1.0 cm. It has six rows of grooves and two of zig-zag incision in between the last two rows of grooves around the neck and shoulder. These decorations form small ridges in that area. After these sets of decoration, it becomes plain from the shoulder to the base (Fig 24 x).

Small-sized pots (≤30 cm): There are three broad categories here; forms a, b and c.

Form a: Has thin rim (0.95 cm) at lip. Vessel thickness around shoulders is 1.45-1.5 cm. It has two columns of deep grooves on each side of the vessel (Fig 24 v).

Form b: Thick rim (1.65 cm) but body thickness is between 0.8 cm and 0.9 cm. This form is plain, and has a narrow base (Fig 24 vi).

Form c: This form has thick rim (1.4 cm) but body thickness is 0.5-0.6 cm. It has a broad base. It is also plain (Fig 24 viii).

Bowls (10-20 cm): These have in-turned; their rim measurements range from 0.7 cm to 0.8 cm; they are used in eating.

Form a: Vessels are with or without shallow and wide (flutes) grooves on the rims.

Form b: Vessel is thinner at the body and base (0.4 cm) than the rim (0.7-0.8 cm); the latter being generally flat (Fig 24 vii).

Lamp: Only one form of this was recovered from the two trenches. It was found almost whole, in level 90-100 cm of TPII. This cylindrical object is 13.3 cm in height, with base diameter of 8.5 cm and inner diameter of 5.5 cm. It is what is known as *Atupa* or *Fitila* among the Yoruba people (Fig. 25)

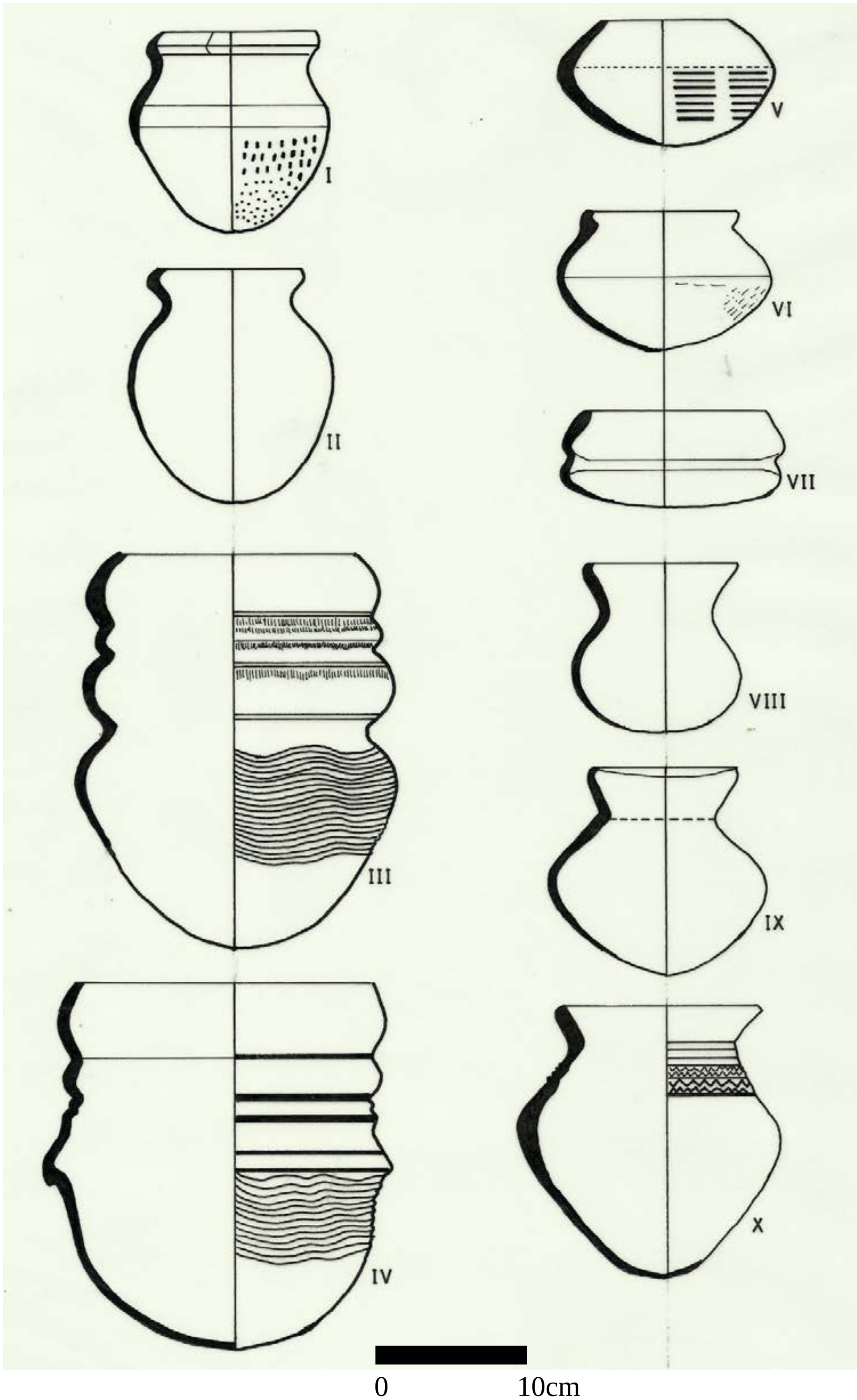


Fig 24: Reconstructed vessel forms recovered from the excavations

Fig. 25: Lamp recovered from Phase I of TPII (front and back views)

4.2 Salinity Analyses

Table 10: Salinity of all the cores

Site	Depth (cm)	Salinity (mg/L)
Ahanve	0	385
Ikorigho	0	590
Ogudu	0	580
Otolu	0	575
Ogudu	5	590
Otolu	5	580
Ikorigho	10	595
Ikorigho	20	600
Ogudu	10	585

Table 11: List of standard radiometric and AMS dates from the Study Area

Site	Lab number	Depth(cm)	C13/C12	C14 yr B.P.	Conventional radiocarbon Age	Calendar year
Ahanve TP1	Beta-296133	130-140cm	-24.6 o/oo	360 +/- 40 BP	370 +/- 40 BP	Cal AD 1440 to 1640 (Cal BP 510 to 310)
Ahanve TP1	Beta-296134	180-190cm	-26.3 o/oo	260 +/- 30 BP	240 +/- 30 BP	Cal AD 1640 to 1670 (Cal BP 310 to 280) , and Cal AD 1770 to 1800 (Cal BP 180 to 150) Cal AD 1940 to 1950 (Cal BP 10 to 0)
Ikorigho II	Beta-296135	770-780	-23.5 o/oo	1190±30yrs BP	1210 +/- 30 BP	Cal AD 710 to 750 (Cal BP 1240 to 1200)& Cal AD 760 to 890 (Cal BP 1190 to 1060)
Ogudu	Beta-296136	70-80	-25.9 o/oo	122.3+/-0.5 pMC	122.5+/-0.5 pMC	last 60 years
Ogudu	Beta-296137	190	-27.9 o/oo	100.4 +/- 0.4 pMC	101.0 +/- 0.4 pMC	last 60 years
Ogudu	Beta-296138	350	-25.4 o/oo	2620 +/- 30 BP	2610 +/- 30 BP	Cal BC 810 to 780 (Cal BP 2760 to 2730)

4.3 Palynology

4.3.1 Phytoecological groups and photomicrographs

The majority of the palynomorphs recovered from all the cores were well preserved and diverse. The identified palynomorphs were classified into phyto-ecological groups; the palynomorphs reflect the major vegetation zones in Nigeria. They are as follows: mangrove swamp forest, lowland rainforest, freshwater swamp forest, fresh water, coastal vegetation, secondary or open forest, montane forest and guinea savanna. Other palynomorphs, the parents of which are ubiquitous or which were identified mostly only to family level were grouped separately. These are (1) Poaceae (open vegetation) unidentified pteridophyte spores, (2) weeds and (3) miscellaneous. The components of each group are presented on pp 130-133.

1. Mangrove swamp forest

Acrostichum aureum

Avicennia africana

Laguncularia racemosa

Paspalum africanum

Rhizophora spp.

2. Lowland rain forest

Acanthus montanus

Adansonia digitata

Albizia zygia

Alstonia booenii

A. congensis

Anonidium cf. *mannii*

Anthocleista vogelli

Anthonotha macrophylla

Antidesma cf. *vogelianum*

Bauhinia cf. *pauletia*

Berlinia cf. *grandifolia*

Blighia sapida

Bosquiea angolense

Bombax sp.

Canthium hispidium

C. scrabrosum

C. setosum

C. subcordatum

C. venosum

Carapa procera

Ceiba pentandra

Celtis brownii

Clausena sp.

Combretodendron africanum

Daniellia ogea

Diospyros abyssinica

D. crassiflora

Dombeya buettneri

Entada gigas

Entandophragma utile

Funtumia elastica

Gaertnera paniculata

Gardenia imperialis

Hannoa klaineana

Hildegardia barteri

Holarrhena floribunda

Hymenocardia heudelotti

Hymenostegia afzelia

Irvingia gabonensis

Kigelia africana

Lannea cf. *welwitschii*

Lophira cf. *alata*

Lovoa trichiloides

Mansonia altissima

Mimusops warnecki

Morus cf. *mesozygia*

Nelsonia sp.

Nesogordonia papaverifera

Newbouldia laevis

Oncoba spinosa type

Parkia bicolor

Pavetta owariensis

Peltophorum pterocarpum

Pentaclethra macrophylla

Physedra eglandulosa
Piptadeniastrum africanum
Pterocarpus santalinoides
Pycnanthus angolensis
Raphia vinifera
Rauvolfia vomitoria
Sacoglottis gabonensis
Sapium sp.
Scaphopetalum parvifolium
Spathodea campanulata
Spondias mombin
Syzygium guineense
Tabernaemontana crassa
Tesmannia sp.
Tetrapleura tetraptera
Tetrorchidium didymostemon
Triplochiton scleroxylon

3. Fresh water swamp forest

Anthocleista liebrechtsiana
Cissus quadrangularis
Dalbergia ecastaphyllum
Leea guineensis
Macaranga sp.
Mitragyna ciliata
Nauclea diderrichii
Polygonum senegalensis
Raphia reclinata
R. vinifera
Spondianthus preussii
Symphonia globulifera
Uapaca sp.

4. Fresh water/ Aquatics

Ceratopteris cornuta
Cyperaceae
Eichhornia crassipes
Ludwigia repens
Koenigia sp.
Lygodium microphyllum
Otellia ulvifolia
Pandanus sp.
Pancratium sp.
Typha australis

5. Guinea Savanna

Borassus aethiopum
Bridelia cf. *ferruginea*
Daniellia oliveri
Dichrostachys cinera
Entada abyssinica
Grewia bicolor
G. mollis
Hymenocardia acida
Isoberlinia doka
Maytenus senegalensis
Parinari kerstingii
Phyllanthus discoideus
Tacazzea apiculata
Vitex doniana

6. Secondary/ Open forest

Alchornea sp.

Canthium setosum

Elaeis guineensis

Morelia senegalensis

Paullinia pinnata

7. Montane forest

Canthium guienzii

Cassine aethiopica

Ericaceae

Ilex mitis

Myrica arborea

Podocarpus milanjianus

8. Coastal vegetation

Chrysobalanus icaco

Drepanocarpus lunatus

Other palynomorphs

Poaceae (open vegetation)

Weeds

Ageratum conyzoides

Alternanthera repens

Aspilia africana

Chromolaena odorata

Euphorbia hirta

Ipomoea involucrata

Justicia flava

Oldenlandia corymbosa

Tridax procumbens

Pteridophyte Spores

?Asplenium sp.

Ceratopteris cornuta

Ceratopteris sp.

Ceratosporites morrincolus

Cyathea sp.

Cyclosorus sp.

Dryopteris cf. *pentheri*

Gemmate spore

Lycopodium cernuum

Monolete spores

Osmunda regalis

Polypodiaceae

Polypodium vulgare

Pteris cf. *togoensis*

Pteris sp

Selaginella cf. *flagellata*

Stenochlaena palustris

Trilete spores

Cultivars

Anacardium occidentale

Cocos nucifera

Mangifera indica

Vernonia amygdalina

Zea mays

Families

Amaranthaceae/Chenopodiaceae

Anarcadiaceae

Apocynaceae

Bombacaceae

Caesalpiniaceae

Combretaceae/Melastomataceae

Cucurbitaceae

Euphorbiaceae

Meliaceae

Rhamnaceae

Rubiaceae

Tiliaceae

Verbenaceae

Photographs of pollen and spores are shown in Figs 26-35

Legend for Fig 26

a, c. Pteridophyte spores

b. *Stenochlaena palustris*

d-e. *Lygodium microphyllum*

f. *Selaginella* cf. *flagellata*

g. Spore

h. *Sida acuta*

i. *Peltophlorum pterocarpum*

j. *Phyllanthus* sp.

k. *Newbouldia laevis*

Photomicrographs of some palynomorphs from the study area

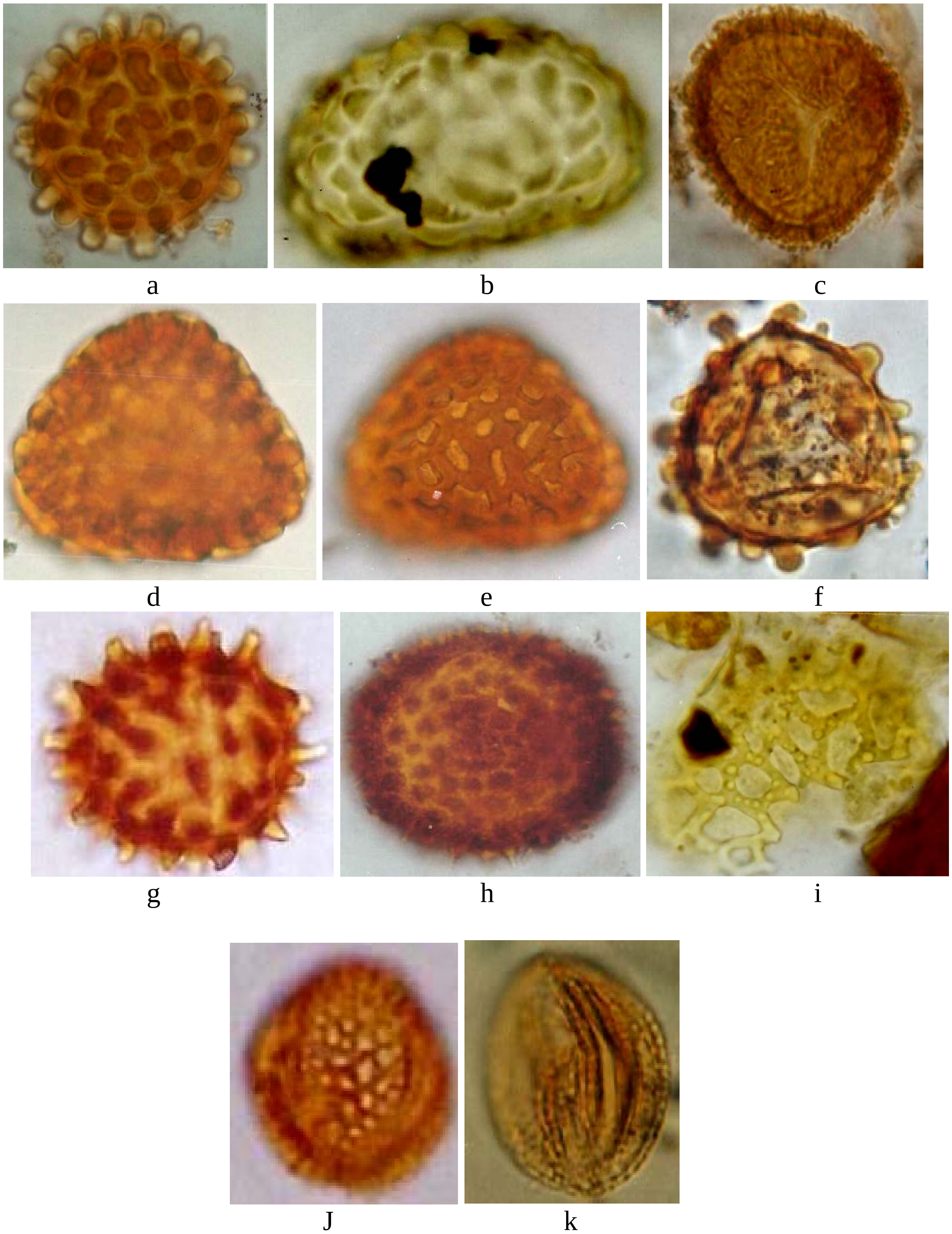


Fig 26. Fossil pollen and spores from the study area (Mag. x1000).

Legend for Fig 27

a-b. *Rhizophora* sp**.**

c. *Hymenocardia heudelotii*

d. *Lannea* cf. *welwithchii*

e-f. *Alchornea* cf. *cordifolia*

g-h. *Phyllanthus* type

i. *Santiria trimera*

j. ?*Asplenium* sp.

k-l. *Polypodium vulgare*

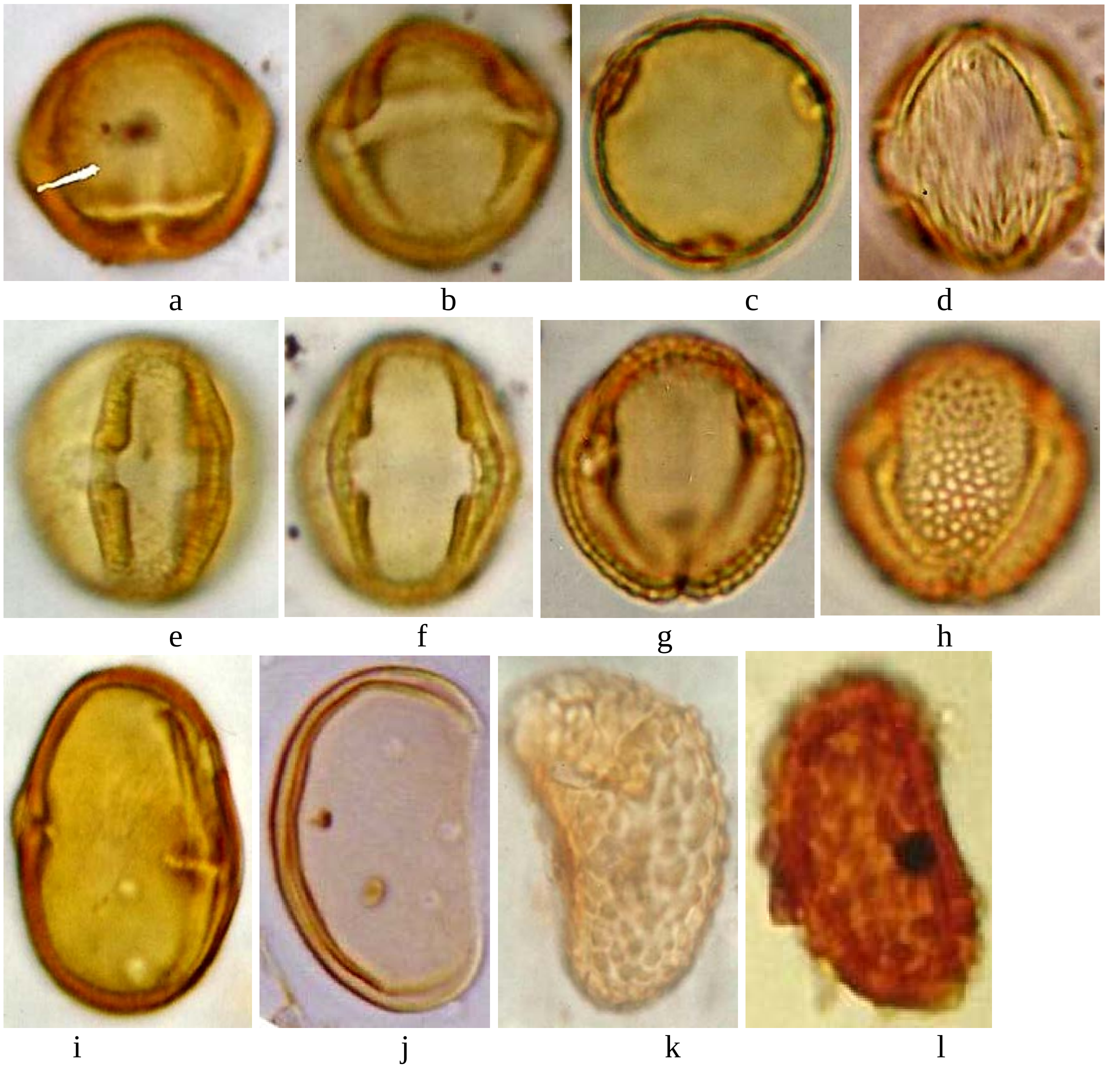


Fig 27. Fossil pollen and spores from the study area (Mag. x1000).

Legend for Fig 28

a-b. *Chromolaena odorata*

c. *Ageratum conyzoides*

d-f. *Spondias mombin*

g. *Justicia flava*

h. *Mimusops warneckei*

i. *Phoenix dactylfera*

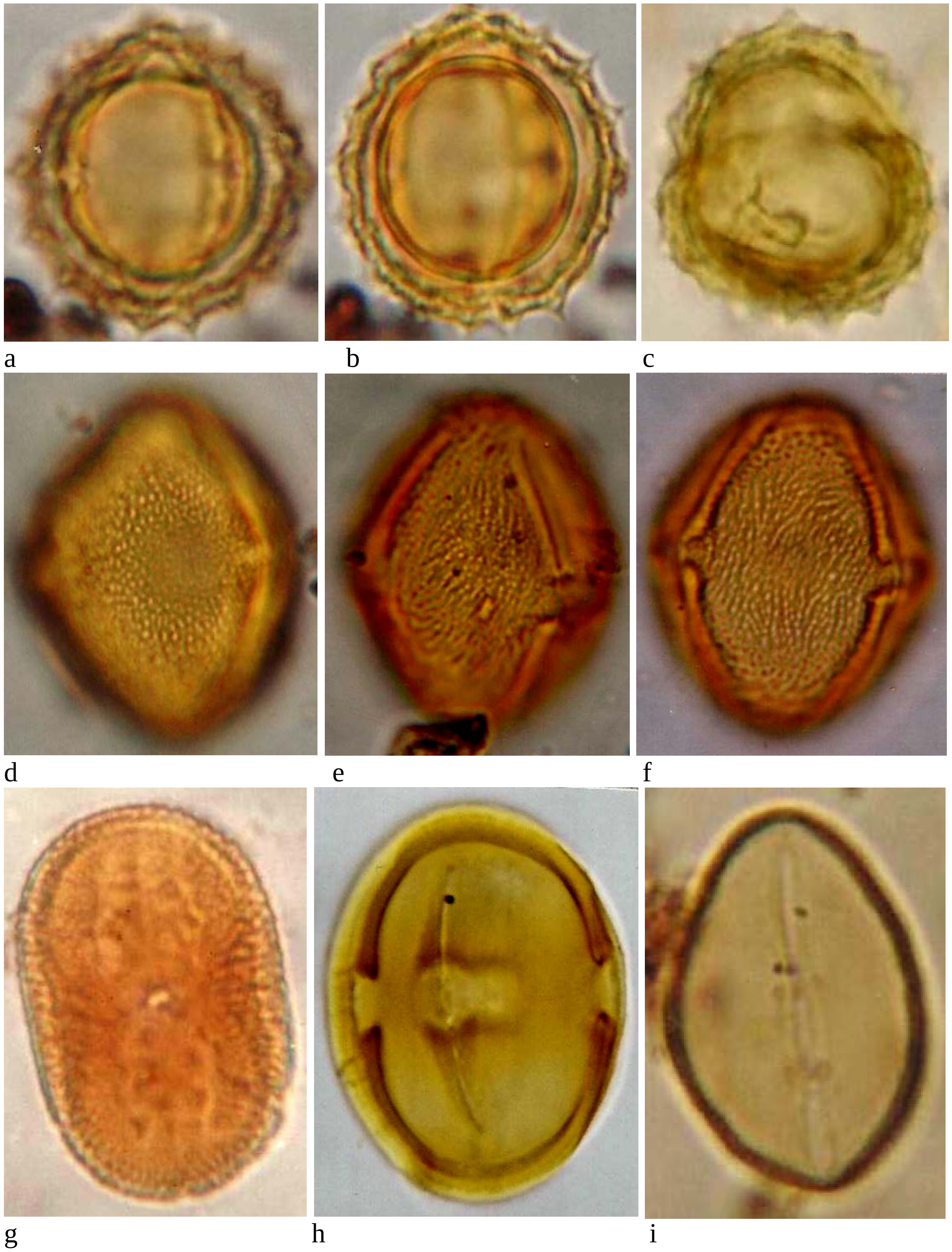


Fig 28. Fossil pollen from the study area (Mag. x1000)

Legend for Fig 29

a-b. *Rhizophora* sp.

c-d. *Mitragyna ciliata*

e, f. *Alstonia booeni*

g. *Morus* cf. *mesozygia*

h. *Celosia* sp.

i-j *Psychotria* sp.

k. Loranthaceae

l. *Nymphaea lotus*

m. *Bosqueia angolensis*

n. *Paullinia pinnata*

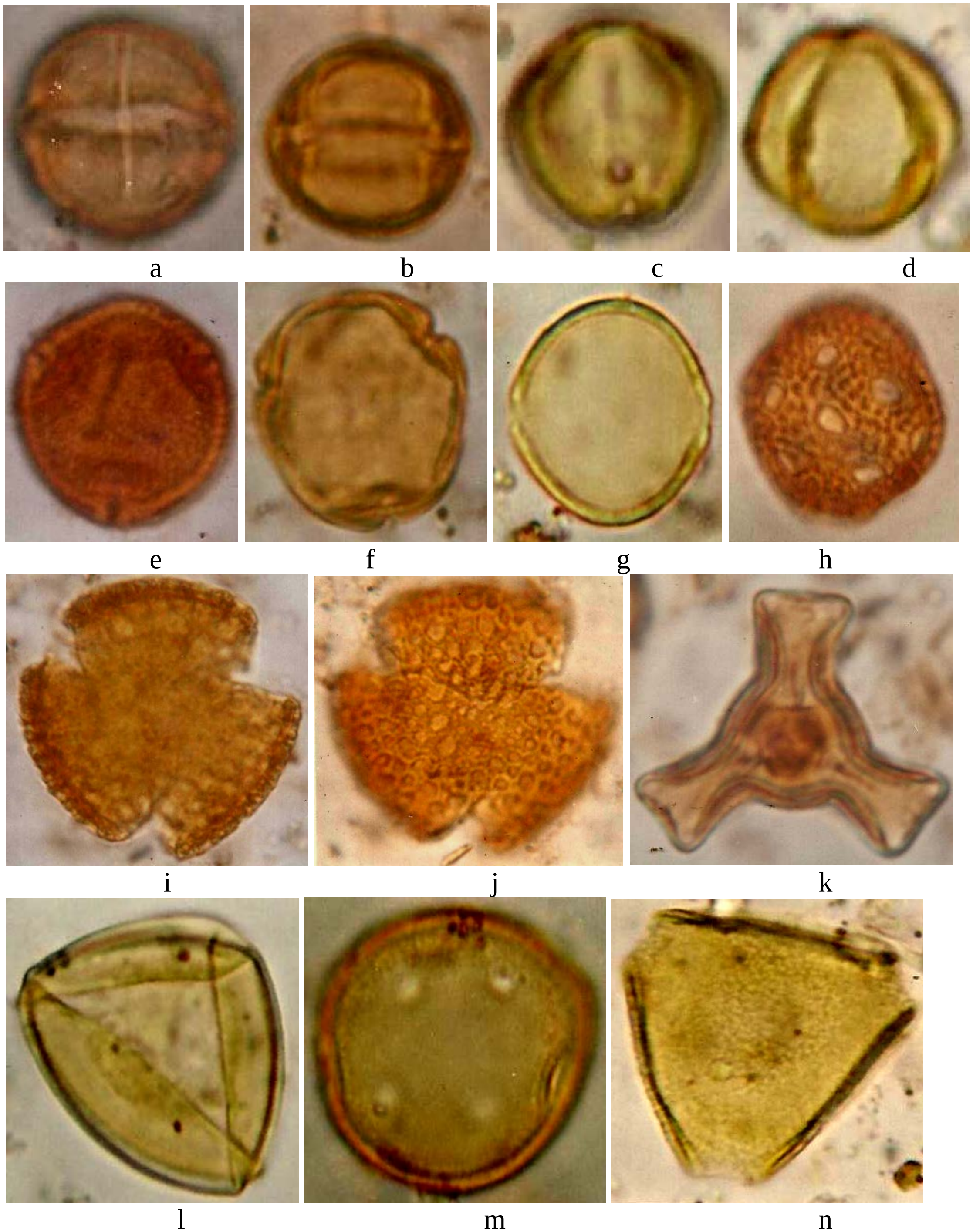


Fig 29. Fossil pollen from the study area (Mag. x1000)

Legend for Fig 30

a-b. *Leea guineensis*

c,o. Cyperaceae

d. *Pentachlethra microphylla*

e-f. *Blighia sapida*

g-h. *Hymenostegia afzeli*

i-j. *Typha australis*

k. *Bridelia ferruginea*

l. *Mansonia altissima*

m-n. Umbelliferae

p. *Cissus quadrangularis*

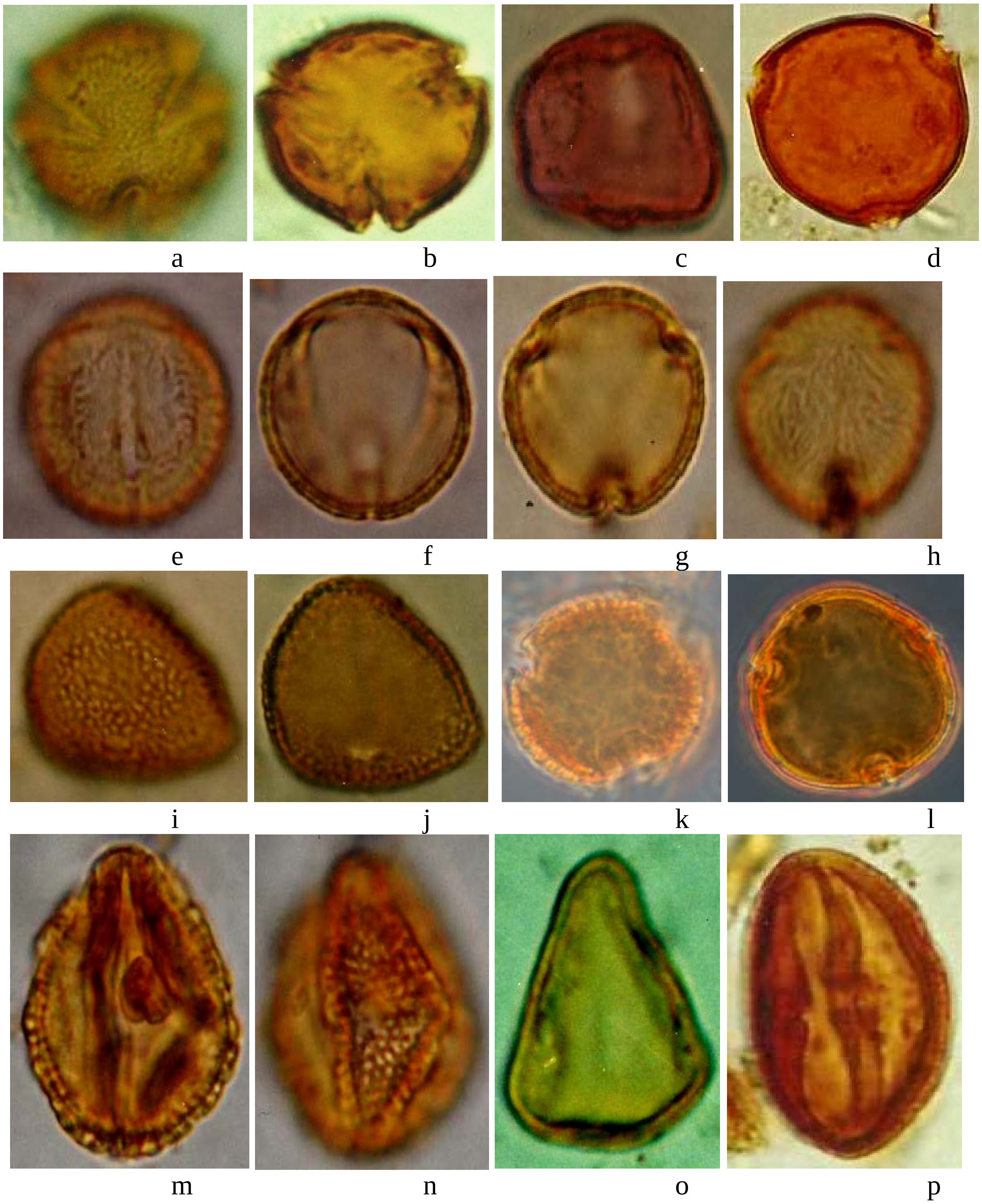


Fig 30. Fossil pollen from the study area (Mag. x1000)

Legend for Fig 31

a-b. *Ceiba pentandra*

c. *Alternanthera repens*

d *Combretodendron africanum*

e. *Acanthus montanus*

f. *Hymenostegia afzeli*

g. *Physedra englandulosa*

h. Unidentified

i. *Tabernaemontana crassus*

j-k. *Spondias mombin*

l-m. *Podocarpus milanjianus*

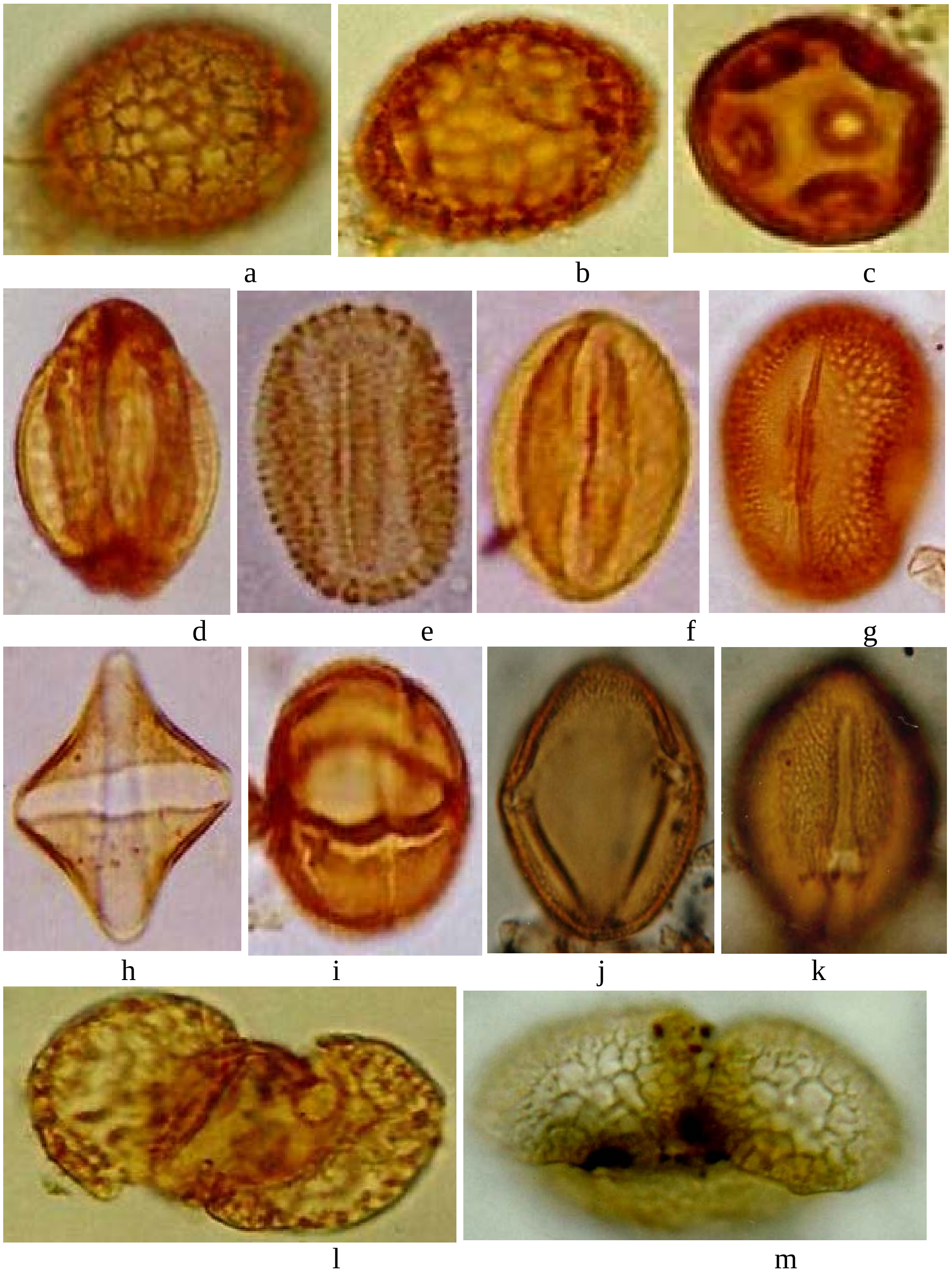


Fig 31. Fossil pollen from the study area (x530)

Legend for Fig 32

a. *Hyphaene thebaica*

b. *Albizia zygia*

c. *Parkia bicolor* (x530)

d. *Gaertnera paniculata*

e-f. *Ceratopteris* sp.

f. *C. cornuta*

g. *Parinari* cf. *kerstingii*

h. *Elaeis guineensis*

i. *Canthium* sp.

j. *Canthium setosum*

k. *Diospyros abyssinica*

l. *Ludwigia repens*

m-n. *Grewia mollis*

o-p. *Uapaca acuminata*

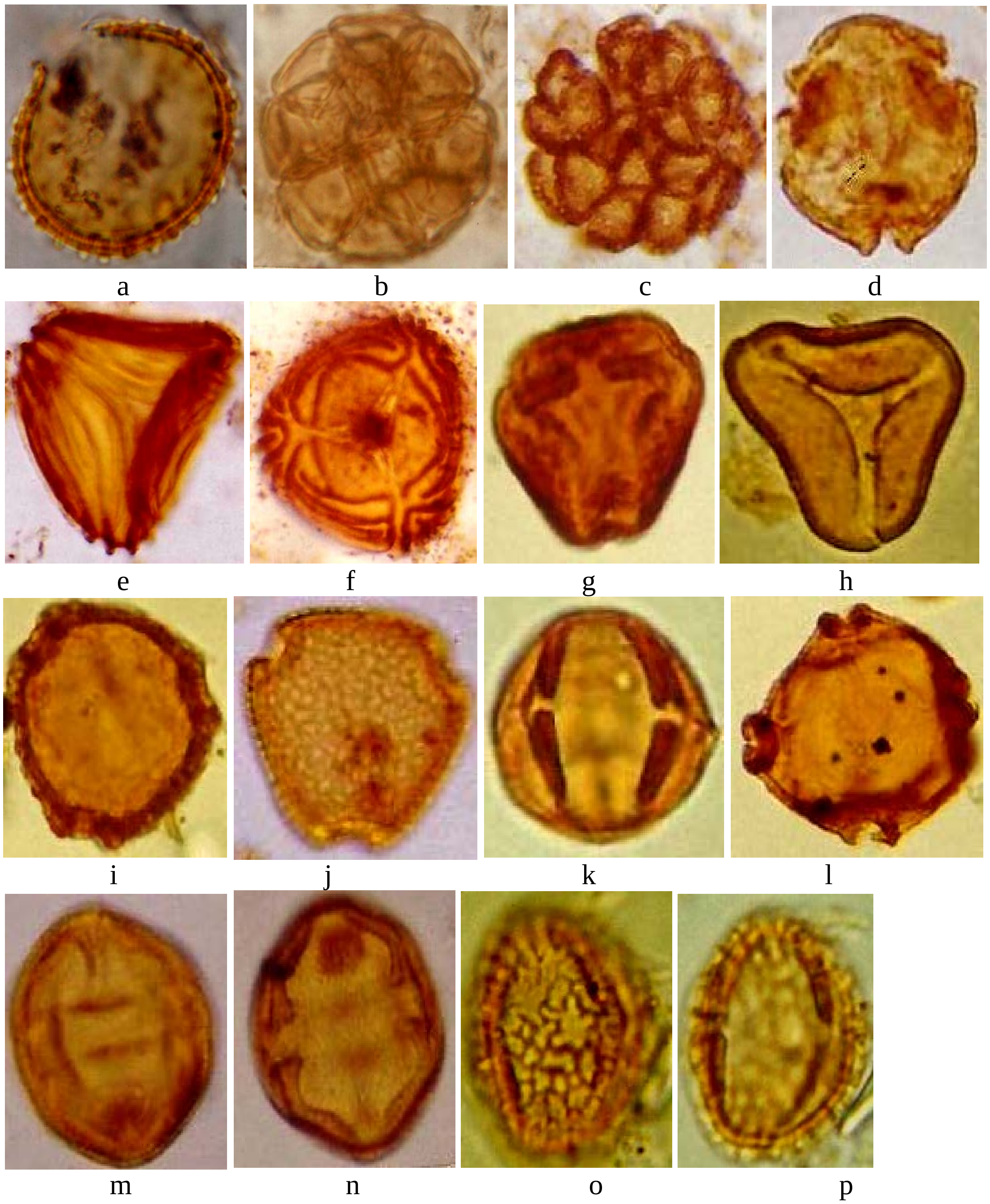


Fig 32: Fossil pollen and spores from the study area (x1000).

Legend for Fig 33

a. *Flabellaria paniculata*

b-c. *Oldenlandia corymbosa*

d. *Irvingia gabonensis*

e. *Tacazzea apiculata*

f. *Gardenia sokotoensis*

g, l. *Tetrorchidium didymostemon*

h. *Myrica arborea*

i-j. *Avicennia africana*

k. *Psychotria* sp.

m-n. *Symphonia globulifera*

o. *Tridax procumbens*

p. *Grewia mollis*

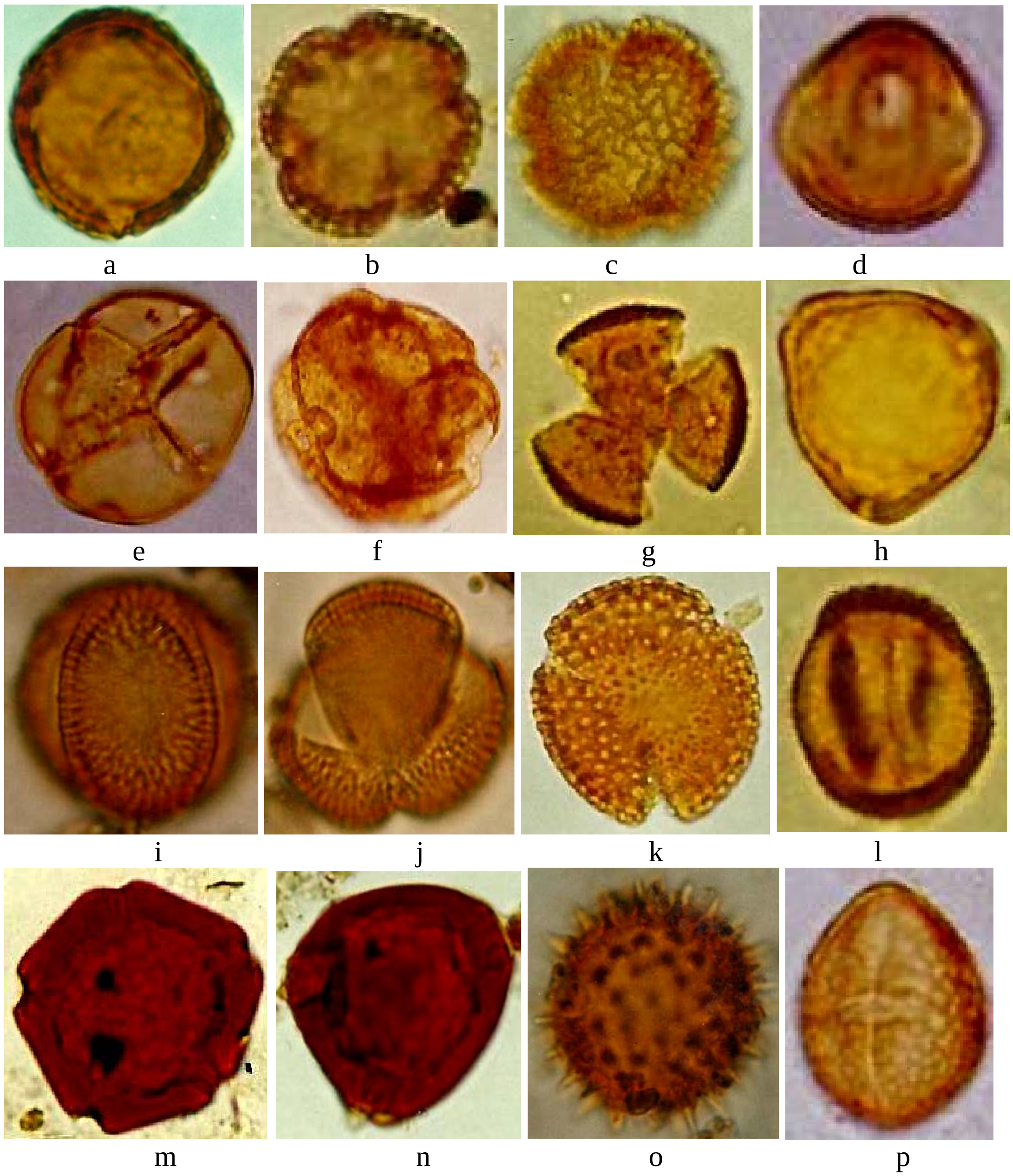


Fig 33: Fossil pollen from the study area (x1000).

Legend for Fig 34

a *Drepanocarpus lunatus*

b. *Anthocleista liebrechtsiana*

c. *Calamus deeratus*

d. *Mimusops warneckei*

e-f. *Rhizophora* sp.

g. *Protea* sp.

h. *Psychotria* sp.

i-k. Poaceae

l. *Canthium scabrosum*

m-n. *Triplochiton scleroxylon*

o. *Myrica arborea*

p. *Paullinia pinnata*

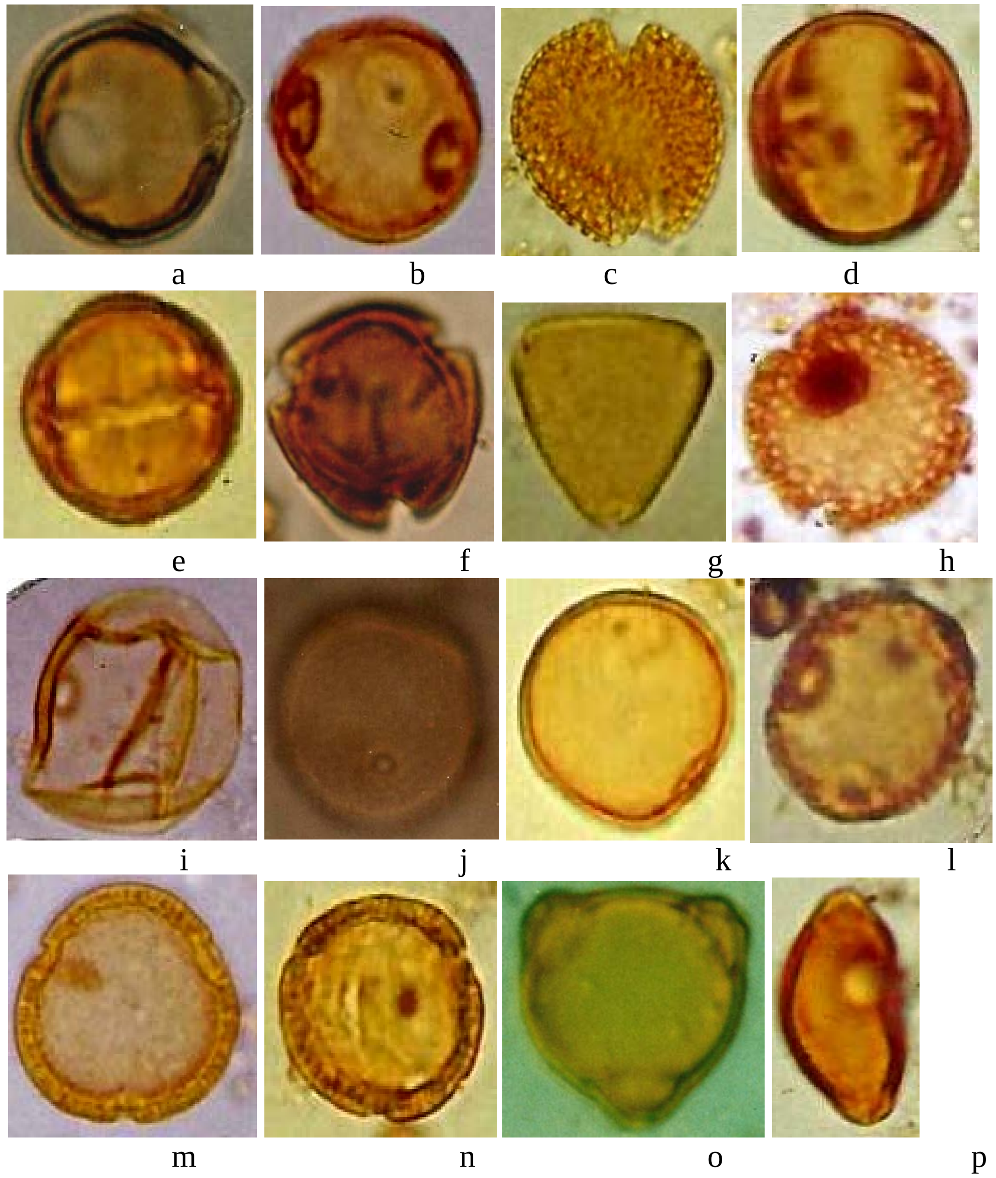


Fig 34. Fossil pollen from the study area (x530)

Legend for Fig 35

a-b *Maytenus senegalensis*

c. Unidentified

d. *Polygonum senegalensis*

e. *Alchornea* sp.

f. *Rhizophora* sp.

g. *Elaeis guineensis*

h. *Grewia* sp.

i. Combretaceae/Melastomataceae

j. *Canthium venosum*

k. *Pteris* cf. *togoensis*

l. *Lygodium microphyllum*

m. *Parkia bicolor*

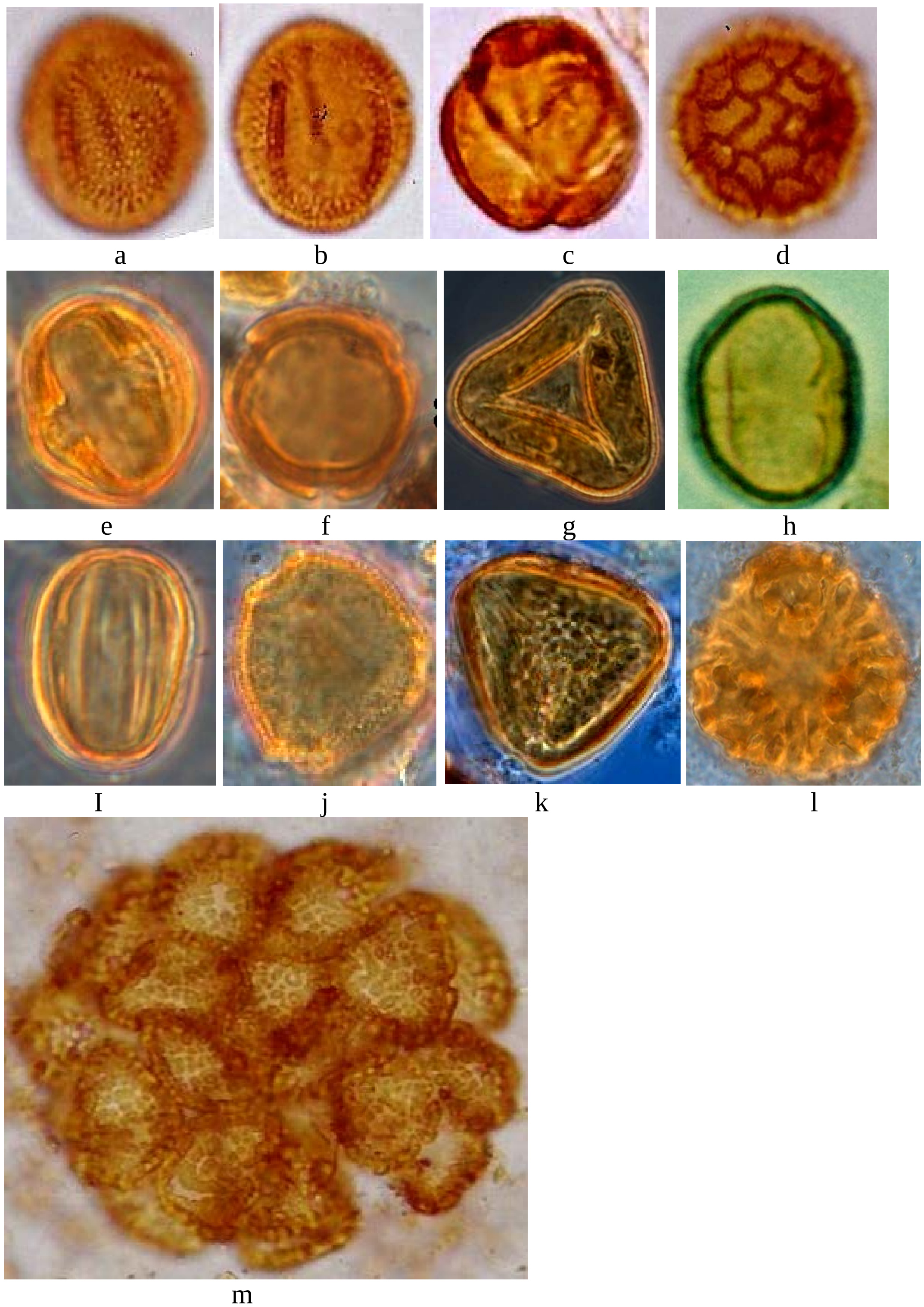


Fig. 35 Fossil pollen and spores from the study area (x530); *Parkia bicolor*, x1000.

Table 12: Lithology of Ogudu Core

Depth (cm)	Soil colour	Soil type
0-80	Very dark gray	Peat
80-180	Very dark brown	Peat
180-430	Very dark gray	Peat
430-450	Dark brown	Peat
450-480	Dark gray	Peat
480-500	Dark grayish brown	Peat
500-600	Dark gray	Peat

4.3.2 Pollen diagrams and zones

The pollen diagrams have been divided into zones based on changes in the abundance of the pollen and spores, charcoal particles, as well as in the lithology of the sediment cores.

4.4 Palynology of Ogudu core, Lagos (600 cm)

From this core, a total of 250 palynomorph types were observed. Out of these, 213 types were identified, while 37 were unidentified. Identification to species level was difficult because of similarities among several pollen of same family or genus. Examples include Caesalpiniaceae, Euphorbiaceae, Rubiaceae, Sapotaceae, Solanaceae, *Uapaca* and *Rhizophora*.

Phyto-Ecological groups

Eight phyto-ecological groups were recognized for Ogudu core as presented below in table 13.

Table 13: Phyto-ecological groups for Ogudu core

No	Phyto-ecological group	Pollen and Spores
1	Mangrove swamp forest	*Rhizophora* spp., *Avicennia africana, Acrostichum auruem, Laguncularia racemosa*
2	Fresh Water Swamp Forest	*Polypodium senegalense, Anthocleista liebrechtsiana, Mitragyna ciliata, Spondianthus preussii, Uapaca* sp., *Leea guineensis, Symphonia globulifera, Nauclea diderrichii, Dalbergia ecastaphyllum.*
3	Fresh water/Aquatics	Cyperaceae, *Lygodium microphyllum, Ceratopteris cornuta, Eichhornia crassipes, Typha australis, Pancratium* sp., *Koenigia* sp.
4	Secondary/Open forest	*Elaeis guineensis, Alchornea* sp, *Paullinia pinnata, Morelia senegalensis, Canthium setosum, Tacazzea apiculata*
5	Guinea Savanna	*Acacia* sp., *Grewia mollis, G. bicolor, Entada abyssinica, Bridelia* cf. *ferruginea, Phyllanthus discoideus, Vitex doniana, Borassus aethiopum, Dichrostachys cinera, Parkia biglobosa, Hymenocardia acida, Isoberlinia doka, Parinari kerstingii*
6	Montane forest	*Ilex mitis,* Ericaceae, *Podocarpus milanjianus, Myrica arborea*
7	Coastal vegetation	*Drepanocarpus lunatus, Cocos nucifera, Parinari* sp.
8	Lowland rainforest	*Acanthus montanus, Afzelia africana, Alstonia booenii, A. congensis, Anthocleista vogelli, Anthonotha microphylla, Antidesma* sp. *Berlinia* cf. *grandifolia, Blighia sapida, Bombax* sp., *Bosquiea angolense, Canthium hispidium, C. scrabrosum, C. subcordatum, C. venosum, Carapa procera, Ceiba pentandra, Celtis brownii, Clausena* sp. *Combretodendron africanum, Daniellia ogea, Diospyros crassiflora, D. abyssinica, Dombeya buettneri, Entada gigas, Entandophragma utile, Erythrina* sp., *Flabellaria paniculata,*

		Funtumia elastica, Gaertnera paniculata, Gardenia imperialis, Hannoa klaineana, Hildegardia barteri, Holarrhena floribunda, Hymenostegia afzeli, Irvingia gabonensis, Kigelia africana, Lannea welwitschii, Lophira cf. *alata, Lovoa trichiloides, Macaranga* sp., *Mansonia altissima, Mimusops warnecki, Morus mesozygia, Oncoba spinosa* type, *Nelsonia* sp, *Nesogordonia papaverifera, Newbouldia laevis, Ormocarpum sennoides, Parkia bicolor, Pentaclethra macrophylla, Physedra eglangulosa, Piptadeniastrum africanum, Pterocarpus santalinoides, Pycnanthus angolensis, Sacoglottis gabonensis, Scaphopetalum parvifolium, Syzygium guineense, Tabernaemontana crassa, Tetrapleura tetraptera, Tetrorchidium didymostemon, Triplochiton scleroxylon,*

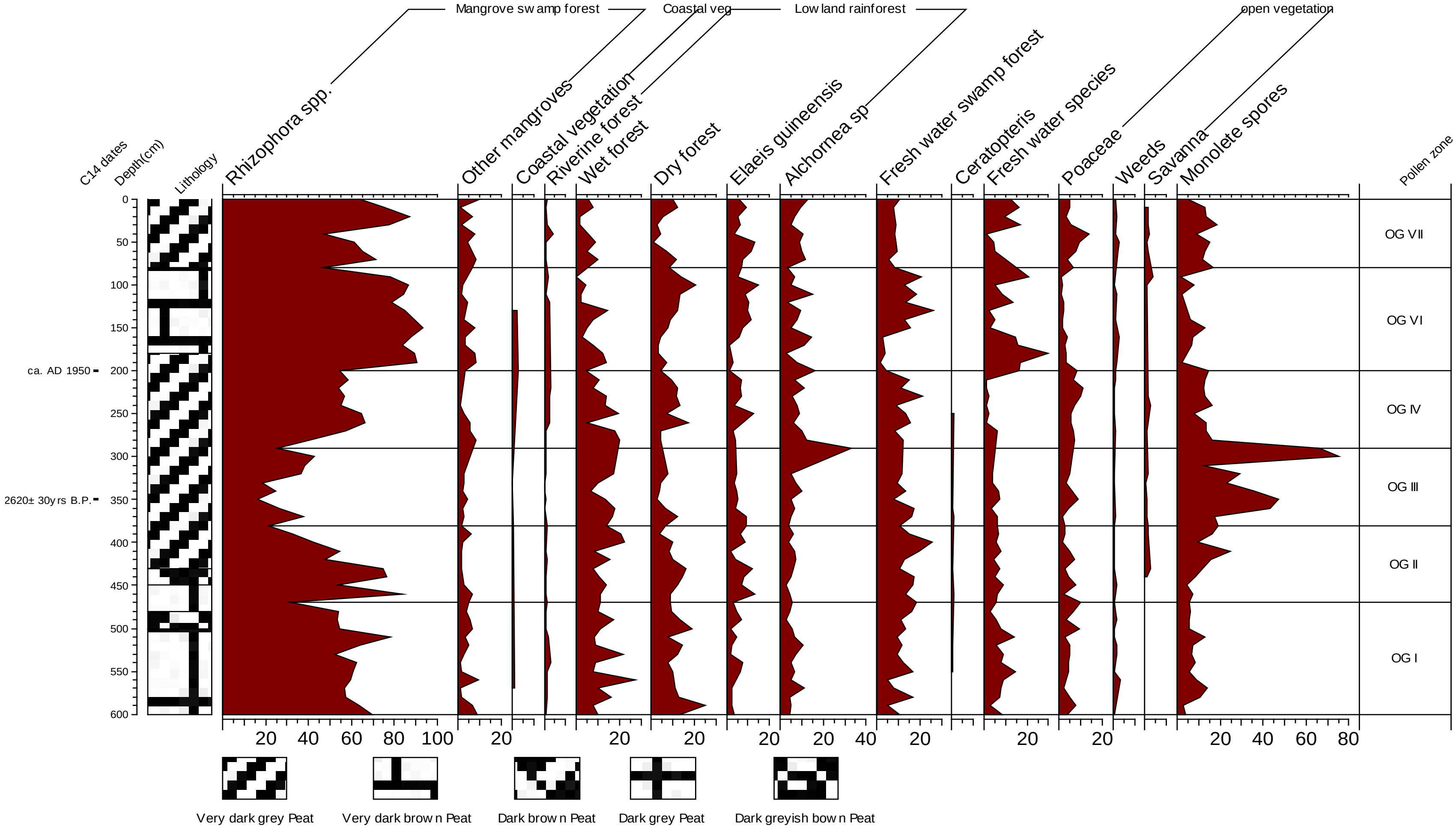


Fig 36: Pollen diagram of Ogudu core, Lagos Nigeria (N 06. 56537, E 003. 40086, 12m asl)

The Ogudu core was classified into pollen zones I-VI (Fig. 36). The zones are presented below:

Zone I: 600–470 cm

The Mangroves swamp forest (MSF) was well represented. *Rhizophora* was 69.5 % at the initial phase of the zone but decreased slightly to 63.6 % at 590 cm. *Avicennia* (2.5-7.5 %) and *Acrostichum aureum* (2.9-3.8 %) were also present. At this time forest (LRF) taxa, which was 24.1% (600 cm) to 32.5 % (590 cm); the LRF was dominated by taxa characteristic of drier forests such as *Celtis* and *Syzygium*. Freshwater swamp forest (FWSF) fluctuated at the beginning but it later increased continuously from 5 % through 11.4 % to 18.5 % at the end. It was represented by *Nauclea, Spondianthus preussii, Symphonia globulifera, Mitragyna ciliata, Macaranga* and *Uapaca*. Secondary forest taxa such as *Alchornea* sp. (6.7-8 %) and *Elaeis guineensis* (2-7.3 %) were present. Towards the end of the zone, the MSF represented by *Rhizophora* fluctuated between 53.3 % and 78.3 % (600 cm and 560 cm) but decreased at the end to 31.6 % (470 cm). At the end of the zone, the LRF increased from 20.9 % to 30.9 % and became dominated by pollen characteristic of wet forests such as *Daniellia ogea, Hannoa, Piptadeniastrum africanum, Bosquiea angolensis* and *Alstonia booenii*. In contrast, values of Poaceae (open vegetation) which were in the ranges of 3.9 % and 7.7 % reduced to between 2.3 % and 4.4 %; they later fluctuated at the end of the zone.

Zone II: 470-380 cm

The MSF fluctuated; *Rhizophora* increased sharply from 31.6 % to 83.5 % at 460 cm; it later decreased until it reached 21.2 % at 380 cm. *Avicennia* and *Acrostichum* also had low values. Values of FWSF ranged from 6.7 % to 16.7 %; LRF was between 16.8 % and 32.4 %. The values of secondary forest were stable being in the range of between 9.9 % and 22.2 %. Poaceae (open vegetation) fluctuated during this period with values ranging from 1 % to 2.2 %. Monolete spores which were between 7.3 % and 8.3 % (470-440 cm) increased to between 11.6 % and 24.7 %. Pollen of guinea savanna plants such as *Parkia biglobosa, Morelia senegalensis, Bridelia* cf. *ferruginea, Parinari* cf. *ferruginea, Phyllanthus discoideus, Lannea microcarpa, Psychotria* and *Acacia* sp. were recovered from level 380 cm.

Zone III: 380-290 cm

The zone was characterized by a very significant reduction in the mangrove swamp forest (MSF) particularly *Rhizophora* and marked increase in monolete spores. *Rhizophora* decreased until it was 16.1 % at 350 cm—the lowest value recorded for *Rhizophora* throughout the core. But it gradually increased until it reached 42.8 % at 300 cm. Similarly, *Avicennia* (0.5-0.7 %) and *Acrostichum* (1.1-3.5 %) had low representations; they were not recovered between 310 cm and 290 cm. In contrast, monolete spores were abundant; they increased from 17.2 % (370 cm) through 47.4 % (350 cm) and reached a peak of 66.6 % % at 290 cm. Poaceae (open vegetation) increased from 4.3 % at 360 cm to 9.0 % at 350 cm and then to 4.7 % at 320 cm. The secondary forest characterized by *Elaeis guineensis* and *Alchornea* had no significant increases at the beginning of the zone; its values ranged between 8.2 % and 11.7 % respectively. However, *Alchornea* increased sharply from 4.7 % (320 cm) to 33.3 % at 290 cm. LRF was quite abundant (29.2 %) at the beginning of the zone, it decreased to 16.6 % (350 cm), 11.1 % at 340cm and then to 10.2 % at 330 cm. LRF pollen recovered from 350-320 cm included *Pycnanthus angolensis*, *Celtis* sp., *Bosquiea angolensis, Gaertnera paniculata, Canthium setosum* and *Tetrorchidium didymostemon*. Soon after, between 320 cm and 290 cm, its values were between 25.6 % and 29.2 %. Values of FWSF were between 9.2 % and 17.4%. Few palynomorphs were recovered between 310 cm and 290 cm.

Zone IV: 290-200 cm

This zone was dominated by LRF, FWSF, Poaceae (open vegetation) and secondary forest (*Alchornea* sp.), though there were fluctuations at certain levels. *Rhizophora* increased from 42.8 % at 290 cm to a maximum of 54.6 % at 200 cm. The LRF was between 22.7 % and 29.5 % but it became significantly reduced to 8.8 % at 200 cm. FWSF increased from 8.2 % (270 cm) through 13.4 % (250 cm) to 15.1 % (210 cm); they too were reduced to 4.4 % at 200 cm. Poaceae (open vegetation) and secondary forest (*Alchornea*) dominated and reached their maximum values at 200 cm with 8.0 % and 16.2 % respectively. *Elaeis guineensis* fluctuated but became significantly reduced at 200 cm with value of 1.5 %

Zone V: 200-80 cm

This zone was characterized by a dominance of the mangrove swamp forest for most of the zone. *Rhizophora* had a minimum of 78 % and maximum of 90.3 % while values of *Avicennia* were 0.6-2.9 %. Forest taxa were 11.0-40.5 % with a majority of the forest pollen being those of the wet type; FWSF taxa were also well represented (3.2-12.6 %). In contrast, Poaceae (open vegetation) decreased from 8 % at 200 cm to 1.5% at 140cm until the end of the zone. Secondary forest taxa such as *Elaeis guineensis* increased from 3.2% at 190 cm to 12% at 140 cm while *Alchornea* was 13%. At the top of this zone, the MSF represented by *Rhizophora* decreased from 89.2% to 54.8%, LRF also decreased markedly from 40.5 % to 8.3 % particularly those belonging to the wet forest type; FWSF (18.7-4.8 %) taxa decreased. Secondary forest represented by *Elaeis guineensis* (2.4-7.1 %) and *Alchornea* (4.8-7.1 %) was well represented. Poaceae (open vegetation) which was between 1.2 % and 1.8 % increased to 6.8 % at 80 cm.

Zone VI: 80-0 cm

The MSF represented by *Rhizophora* continued to decrease from 80 cm to 40 cm, reaching 47.2 % at 40 cm. In contrast, Poaceae (open vegetation), which had decreased slightly at 70 cm, increased from 60 cm and maintained this increase until it had a peak of 14.4 % at 40 cm. The secondary forest (*Elaeis guineensis* and *Alchornea*) was also well represented although *Elaeis guineensis* decreased from 13.3-3.3 % between 50 cm and 40 cm. The LRF decreased from 22.5 % at 70 cm until it reached 13.2 % at 40 cm and then to 6.7 % at the end of this zone. It became dominated by pollen characteristic of open forest (*Celtis* sp., *Ceiba pentamdra, Paullinia pinnata* and *Syzygium guineense*). FWSF increased and was represented mainly by *Symphonia globulifera*, *Uapaca* and *Macaranga*. Subsequently, *Rhizophora* (MSF) recovered from its previously low value and became the dominant species at the end of this zone; its values were between 64.3 % and 87.0 %. Though it remained the dominant taxon in the zone, it decreased from 87.0 % to 75.3 % between 20 cm and 0 cm. Guinea savanna taxa (*Phyllanthus discoideus, Bridelia* sp., *Protea* sp., *Borassus aethiopum* and *Vitex doniana.*) appeared (1.3-1.7 %) at the end of this zone.

Table 14: Lithology of Ahanve core

Depth (cm)	Soil Colour	Soil Type
0-50	Black-dark gray	Peat
50-70	Dark reddish gray	Peat
70-140	Dark brown/black	Peat
140-150	Dark brown	Peat
150-200	Black	Peat

4.5 Palynology of Ahanve core near Badagry (200 cm)

From the 2 m deep Ahanve core, 21 sub-samples were analysed. One hundred and forty palynomorphs were observed. Of this number, 128 were identified while twelve could not be identified. The identified pollen and spores were classified into eight phyto-ecological groups as shown in table 15.

Table 15: Phyto-ecological groups for Ahanve core

No	Phyto-ecological group	Pollen and Spores
1	Mangrove swamp forest	*Rhizophora* spp., *Avicennia africana, Acrostichum auruem, Laguncularia racemosa*
2	Fresh Water Swamp Forest	*Polypodium senegalense, Mitragyna ciliata, Spondianthus preussii, Uapaca* sp., *Leea guineensis, Symphonia globulifera, Nauclea diderrichii, Dalbergia ecastaphyllum.*
3	Fresh water/Aquatics	*Cyperaceae, Lygodium microphyllum, Eichhornia crassipes, Typha australis, Pancratium* sp.
4	Secondary/Open forest	*Elaeis guineensis, Alchornea* sp., *Paullinia pinnata, Morellia senegalensis, Canthium setosum*
5	Savanna	*Grewia mollis, G. bicolor, Entada abyssinica, Bridelia cf. ferruginea, Phyllanthus discoideus, Vitex doniana, Borassus aethiopum, Dichrostachys cinera, Hymenocardia acida, Isoberlinia doka, Parinari kerstingii,*
6	Montane forest	*Canthium guienzii, Ilex mitis,* Ericaceae, *Podocarpus milanjianus, Myrica arborea, Cassine aethiopica*
7	Coastal vegetation	*Drepanocarpus lunatus, Cocos nucifera, Parinari* sp.
8	Lowland rainforest	*Tetrorchidium didymostemon, Macaranga* sp. *Polypodium vulgare, Hymenostegia afzeli, Pycnanthus angolense, Lovoa trichiloides, Irvingia gabonensis, Berlinia* cf. *grandifolia, Acanthus montanus, Morus mesozygia, Ceiba pentandra, Triplochiton scleroxylon, Gaertnera paniculata, Lannea welwitschii, Newbouldia laevis, Mimusops warnecki, Piptadeniastrum africanum, Sacoglottis gabonensis, Tacazzea apiculata, Daniellia ogea, Anthocleista vogelli, Pentaclethra macrophylla, Canthium subcordatum, Celtis brownii, Diospyros abyssinica, D. crassiflora, Hannoa klaineana, Carapa procera, Pterocarpus santalinoides, Hildegardia barteri, Syzygium guineense, Tabernaemontana crassa, Pteris* cf. *togoensis, Bosquiea angolense, Canthium hispidium, Parkia bicolor.*

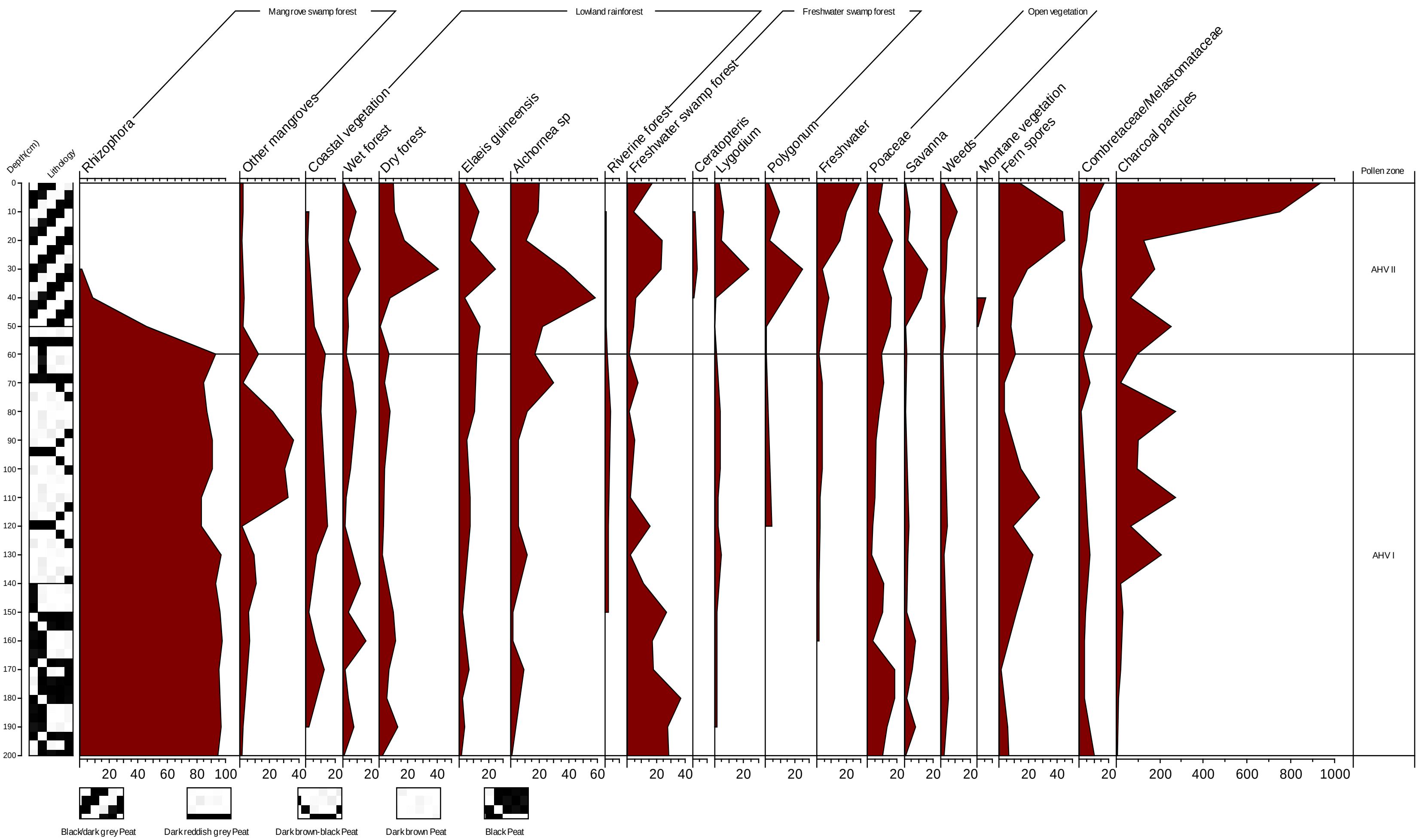


Fig 37: Pollen diagrm of Ahanve core, near Badagry, Lados Nigeria (N 060. 43195 E0020. 77475, 0.5m asl

The pollen diagram (Fig 37) has been divided into two zones: zone I and II.

Zone I: 200-50 cm

The MSF dominated this zone: *Rhizophora* spp. values range between 94.4 % and 47.2 %. Other mangrove species—*Avicennia* (1.3-3.3 %), *Acrostichum aureum* (1.1-11.1 %) and *Laguncularia racemosa* (0.4-3.9 %) were also present although they were not as abundant as *Rhizophora*. However, between 110 cm and 90 cm, *Acrostichum aureum* became abundant; its values were between 30.2 % and 36.8 %. Freshwater swamp forest (FWSF) species were initially abundant with values at 29.6 % at 180 cm and 23.5 % at 150 cm but eventually became reduced to 2.3 % at 130 cm. They decreased continually reaching a very low representation until the end of the zone. Poaceae was 18.2 % at 170 cm while lowland forest species were 33.3 % at l60 cm. Poaceae was well represented between 200 cm and 170 cm but it soon fluctuated between levels 160 cm and 110 cm (2.3-5.0%). At 100 cm, all species except *Rhizophora* (90.7 %) decreased significantly. Secondary forest species (*Elaeis guineensis* [1.9-11.7%] and *Alchornea* sp [1.9-17.2%]) were present but their occurrence was irregular. A significant but gradual change in vegetation occurred at 50 cm. MSF taxa such as *Rhizophora* spp. decreased to 47.2 % while *Acrostichum* was reduced from 5.5 % at 60 cm to 1.3 %. Notable increases in secondary forest species such as *Elaeis guineensis* and *Alchornea*, and FWSF *(Uapaca*, *Mitragyna* and *Nauclea)*, *Lygodium microphyllum* and *Eichhornia crassipes* occurred at 60 cm. Charcoal, though moderate (6-273 particles/ cm^3), fluctuated throughout this zone.

Ahanve Zone II: 50-0 cm

The mangrove swamp forest decreased: *Rhizophora* became reduced from 47.2 % at 50 cm to 8.7 % at 40 cm and then disappeared at 30-0 cm; *Laguncularia racemosa* and *Avicennia* which had been present from 200-50 cm (1.3-36.8 %) disappeared at 20 cm and 40 cm respectively. The first appearance of *Myrica arborea*—a montane taxon was noted at 50 cm. Montane forest taxa eventually increased to 6.1 % at 40 cm; these taxa are *Ilex mitis, Myrica arborea, Canthium guienzii, Podocarpus milanjianus* and Ericaceae. *Acrostichum aureum* remained in the vegetation to the top of the zone though with very small values (1.1-2.1 %). Secondary forest species were highly represented in this zone: *Elaeis guineensis* had values of 3.9-24.6 % while *Alchornea* values were between 10.9 % and 58.6 % in this zone. Freshwater/aquatics species *Typha australis* and *Lygodium microphyllum* also increased beginning from 40 cm. Poaceae i.e. the open vegetation (7-15.6 %) was abundant but the LRF fluctuated (5-53.3%) and was characterised mainly by those of dry/open type. *Ceratopteris cornuta* made its first appearance at 40 cm; it increased slightly and decreased but remained till the top of the zone. *Polypodium senegalense*, which hitherto, had a very low value (1.8 %) increased at 30cm reaching the very high level of 25.0 %. It subsequently decreased to 2.5 % and then to 1.8 % at the top of the core. Charcoal increased continuously from 66 particles/ cm^3 (40 cm) through 128 particles/ cm^3 (20 cm) to 933 particles/ cm^3 (0 cm)

Table 16: Lithology of Otolu core

Depth(cm)	Soil color	Soil Type	Remark
5-15	Dark reddish brown	Silt and clay	Rootlets present
15-48	Dark reddish brown	Mainly silt and clay	Small rootlets present
48-50	Grayish-brown	Sand	

4.6 Palynology of the 45 cm-core from Otolu core, near Ibeju Lekki, Lagos (45cm deep)

Ten sub-samples were obtained from the 45 cm-deep core. The length of the core was from 50-5 cm drilled below 45 cm column of water. The topmost layer (i.e. 0-5 cm) could not be sampled because it was not solid enough to be taken by the corer. Pollen and spores were observed from all ten sub-samples. The palynomorphs were fairly well preserved and diverse. A total of 64 palynomorphs were encountered; 54 were identified while ten were not identified. The total number of palynomorphs counted ranged from 821 (35 cm) to 67 (50 cm). The identified pollen and spores were classified into eight phyto-ecological groups as shown in Table 16.

Table 17: Phyto-ecological groups of Otolu core

	Phyto-ecological group	Pollen and Spores
1	Mangrove swamp forest	*Rhizophora* spp., *Avicennia africana, Acrostichum auruem, Laguncularia racemosa.*
2	Freshwater swamp forest	*Macaranga* sp., *Mitragyna ciliata, Uapaca* sp., *Leea guineensis, Cissus quadrangularis*
3	Fresh water	Cyperaceae, *Eichhornia crassipes, Pancratium* sp., *Otellia ulvifolia*
4	Secondary/Open forest	*Elaeis guineensis, Alchornea* sp, *Canthium setosum*
5	Guinea Savanna	*Boswellia* sp, *Daniellia oliverii, Parinari* sp.
6	Montane forest	*Ilex mitis*
7	Coastal vegetation	*Drepanocarpus lunatus, Cocos nucifera, Parinari* sp., *Chrysobalanus* sp.
8	Lowland rainforest	*Pterocarpus santalinoides, Mangifera indica, Mimusops warneckei, Sapotaceae, Tesmannia* sp, *Anonidium* sp, *Irvingia gabonensis, Spondias mombin, Morus mesozygia, Daniellia ogea, Gaertnera paniculata, Diospyros crassiflora, Syzygium guineense, Bauhinia* cf. *pauletia, Polypodium vulgare*, Polypodiaceae, *Pteris* cf. *togoensis*.

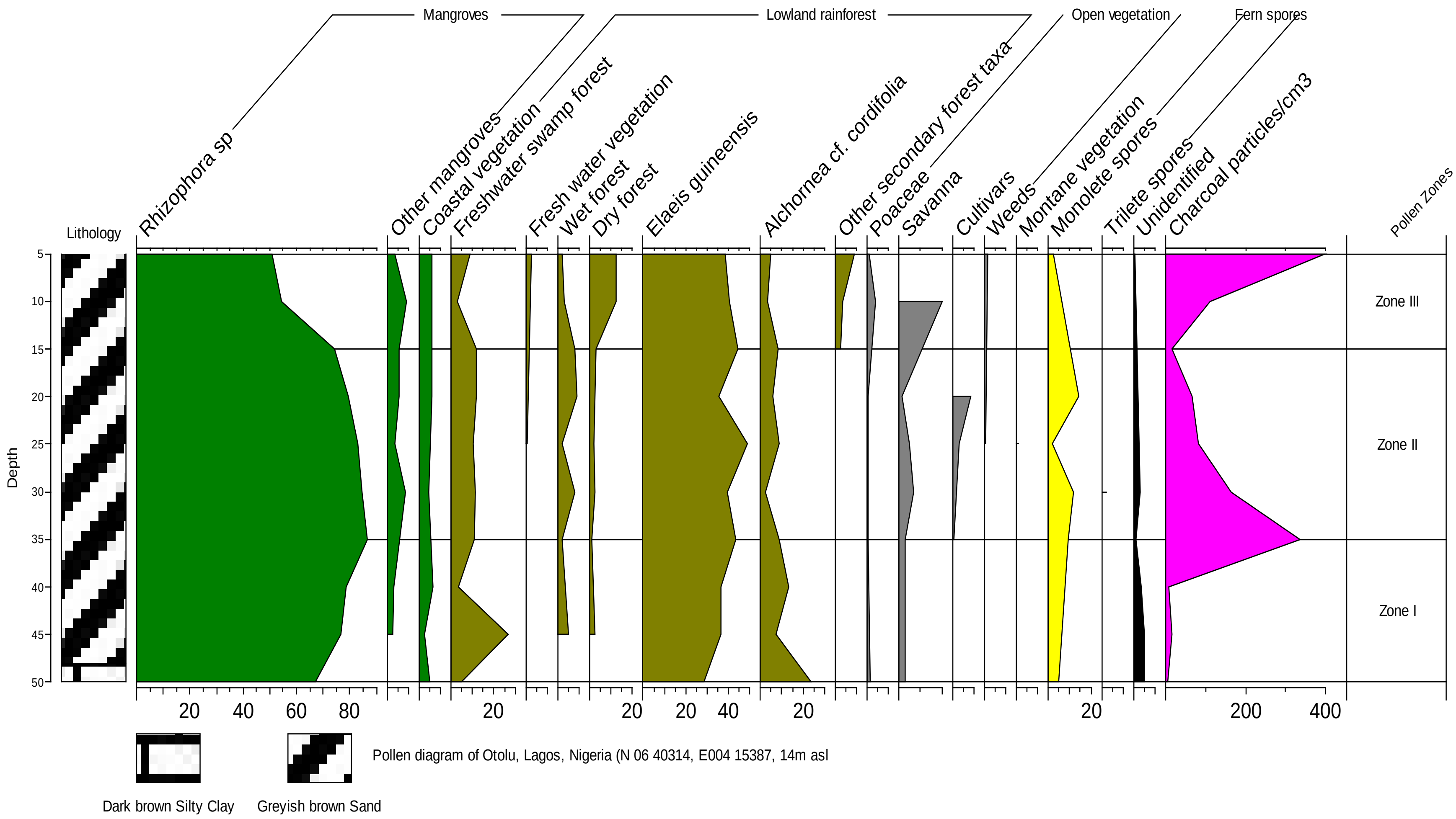


Fig 38: Pollen diagram of Otolu core, Lagos, Nigeria (N 06. 40314 E 004. 15387, 14m asl)

Three pollen zones (Fig. 38) were recognized, namely: Zones I, II and III.

Zone 1 (50-35 cm)

The mangroves swamp forest tree, *Rhizophora* (67.2-86.7 %), secondary forest (*Elaeis guineensis*) [28.7-43.6 %], and the forest species (*Syzygium guineense*, 13.6 %) dominated at the beginning of this zone. Another MSF species, *Avicennia africana* (2.4-4.5 %), was also present. *Rhizophora* and *Elaeis guineensis* increased from their initial value of 67.2 % and 28.7 % at 50 cm to 76.6 % and 36.6 % respectively. They both peaked at 86.9 % (35 cm) and 43.6% at 50 cm respectively. *Alchornea* became reduced from 23.8 % (50 cm) to 7.3 % (45cm); it decreased to 8.7 % at the end of the zone to 8.7%. LRF species increased from 13.6 % (50 cm) through 17.1 % (45 cm) to 20.6 % (40 cm) but later decreased sharply to 4.7 % at 35 cm. Poaceae (open vegetation) which was 1.5% at the beginning (50 cm) was not recovered from 45-40 cm but was 0.6 % at 35 cm. Fresh water swamp forest increased from 4.5 % to 27 % but decreased to 11.2 % at the end of the zone. Guinea savanna (2.7 %) and freshwater/aquatics taxa (10.7%) were present towards the end of the zone. Other mangrove species (*Avicennia* and *Acrostichum aureum*) fluctuated but were each 3.7 % at the end of the zone. Spores (monolete) appeared at 50 cm (4.5%) and then at 40 cm (3.4 %) increasing only slightly to 3.7 % at 35 cm. The spores subsequently increased to 9.3 % at 35 cm. The increase noted in the spores corresponded with increase in the FWSF (3.4-11.7 %). LRF was 7.2 % at 45cm but decreased to 2.7 % at 35 cm. A pollen of *Mangifera indica* (cultivar) [1.9 %] occurred at 35 cm. Charcoal particles were in the range of 3/ cm^3 and 153/ cm^3, the latter being the value at 35 cm.

Zone II (35-15 cm)

Rhizophora spp. experienced a gradual decrease from the peak at 86.9% to 75.8% at the end of this zone (15 cm). The secondary forest (both *Elaeis guineensis* and *Alchornea*) exhibited similar patterns in this zone. There were alternations in the rise and fall exhibited by these two species. *Elaeis guineensis* decreased from the previous 43.6 % to 39.5 %; it later increased to 48.7 % (25 cm) and decreased slightly to 44.4 % (15 cm) at the end of this zone. *Alchornea* was 8.7 % at 35 cm, decreased to 2.3 % at 30 cm and increased to 8.7 % at 25 cm decreasing to 8.3 % at 15 cm. Other mangrove species fluctuated during this period attaining a maximum of 6.6% and minimum of 3.5%. Poaceae (open vegetation) was poorly represented 0.6-0.7%; it was not recorded at 15 cm. Savanna and fresh water species both continually decreased. Freshwater/aquatics decreased from their previous 3.7% at 35 cm to 1.7% and disappeared at 20 cm. The guinea savanna species (*Parinari kerstingii*) increased to 5.9 % at the end of the zone, other savanna elements such as *Daniellia oliverii* did not recover from the previous occurrence. Forest species increased to 10.1 % (30 cm) but decreased to 3.6 % at 25 cm; they then increased to 8.6 % (20 cm) and further to 20.6 % at 15 cm. Cultivars (*Anacardium occidentale* [0.8%] and *Zea mays* [3.2%]) were recovered from this zone. Pteridophytie spores increased from the previous 9.3 % to 11.1 % and subsequently decreased slightly to 9.6 % at 25 cm. They increased to 14.5 % at 20 cm and then finally disappeared at 15 cm i.e. at the end of this zone. Charcoal particles were between 6/ cm^3 and 153/ cm^3.

Zone III (15-5 cm)

Rhizophora (MSF) continued to decrease from the previous 75.2 % at 15 cm through 54.5 % (10 cm) and to 50.6 % at 5 cm. Other mangrove species increased from 5.9 % at 15 cm to 8.6 % at 10 cm but decreased to 2.6 % at 5 cm. *Acrostichum aureum* was not recovered from this zone. Secondary forest decreased from 52.7 % (15 cm) to 43.2 % at the end of the zone (5 cm). Forest (LRF) elements initially decreased from 20.6 % to 17.1 % but increased to 19.7 % at 5 cm. Poaceae (open vegetation) was 3.9 % (10 cm) but it subsequently decreased to 0.9 % at 5 cm. Guinea savanna elements increased from 5.4 % at 15 cm to 9.9 % at 10 cm, while freshwater/aquatics was 2.6 %. FWSF increased at the beginning of the zone from 0% (15 cm) through 2.8 % (10 cm) to 8.5 % (5 cm) at the end of the zone. Values of pteridophyte spores decreased from 5.7 % at 10cm to 3.9 % at 5 cm. In contrast, charcoal had a sharp increase from 15 particles/ cm^3 to 396 particles/ cm^3 in this zone.

Table 18: Lithology of Ikorigho I core

Depth (cm)	**Soil Colour**	**Soil Type**	**Remark**
0-5	Dark brown	Peat	Abundant Rootlets present
5-10	Gray and dark brown	Peat	Abundant Rootlets present
10-15	Dark brown	Peat	Rootlets present
15-140	Dark gray	Peat	Rootlets present
140-145	Dark grayish brown	Peat	
145-165	Dark gray	Peat	
165-170	Dark grayish brown	Peat	
170-195	Dark gray	Peat	
195	Dark grayish brown	Peat	
195-200	Dark brown	Peat	

4.7 Palynology of Ikorigho I core (200 cm deep)

One hundred and sixty three palynomorphs were observed: 145 were identified while 18 could not be identified. Six phyto-ecological groups were recognized as shown in table 19.

Table 19: Phyto-ecological groups of Ikorigho I core

Phyto-ecological group	**Pollen and Spores**
Mangrove swamp forest	*Rhizophora* spp., *Avicennia africana*, *Acrostichum auruem*, *Laguncularia racemosa*
Freshwater swamp forest	*Macaranga* sp., *Polypodium senegalense, Mitragyna ciliata, Spondianthus preussii, Uapaca* sp., *Leea guineensis, Symphonia globulifera, Nauclea diderrichii, Dalbergia ecastaphyllum, Pandanus* sp.
Fresh water	Cyperaceae, *Lygodium microphyllum*, *Eichhornia crassipes, Pandanus* sp., *Typha australis, Pancratium* sp.
Montane forest	*Podocarpus milanjiaus, Myrica arborea*
Coastal vegetation	*Drepanocarpus lunatus, Cocos nucifera, Parinari* sp.
Lowland rainforest	*Blighia sapida, Ceiba pentandra, Bacilicum* spp, Moraceae, *Morus mesozygia, Hymenocardia heudelotti, Pycnanthus angolensis, Daniellia ogea, Irvingia gabunensis, Syzygium guineense, Nelsonia* spp., *Spathodea campanulata, Ormocarpum sennoides, Berlinia grandifolia, Lannea* spp., *Mimusops crassifolia, Piptadeniastrum africanum, Dombeya buettneri, Newbouldia laevis, Calamus deerratus, Triplochiton scleroxylon, Bosquiea angolensis, Flabellaria paniculata, Synsepalum* sp., *Rauvolfia vomitoria, Pentaclethra microphylla, Adansonia digitata, Bombax buonopozense, Pterocarpus santalinoides, Tabernaemontana crassus, Tetrorchidium didymostemon, Hannoa klaineana, Anthonotha macrophylla*

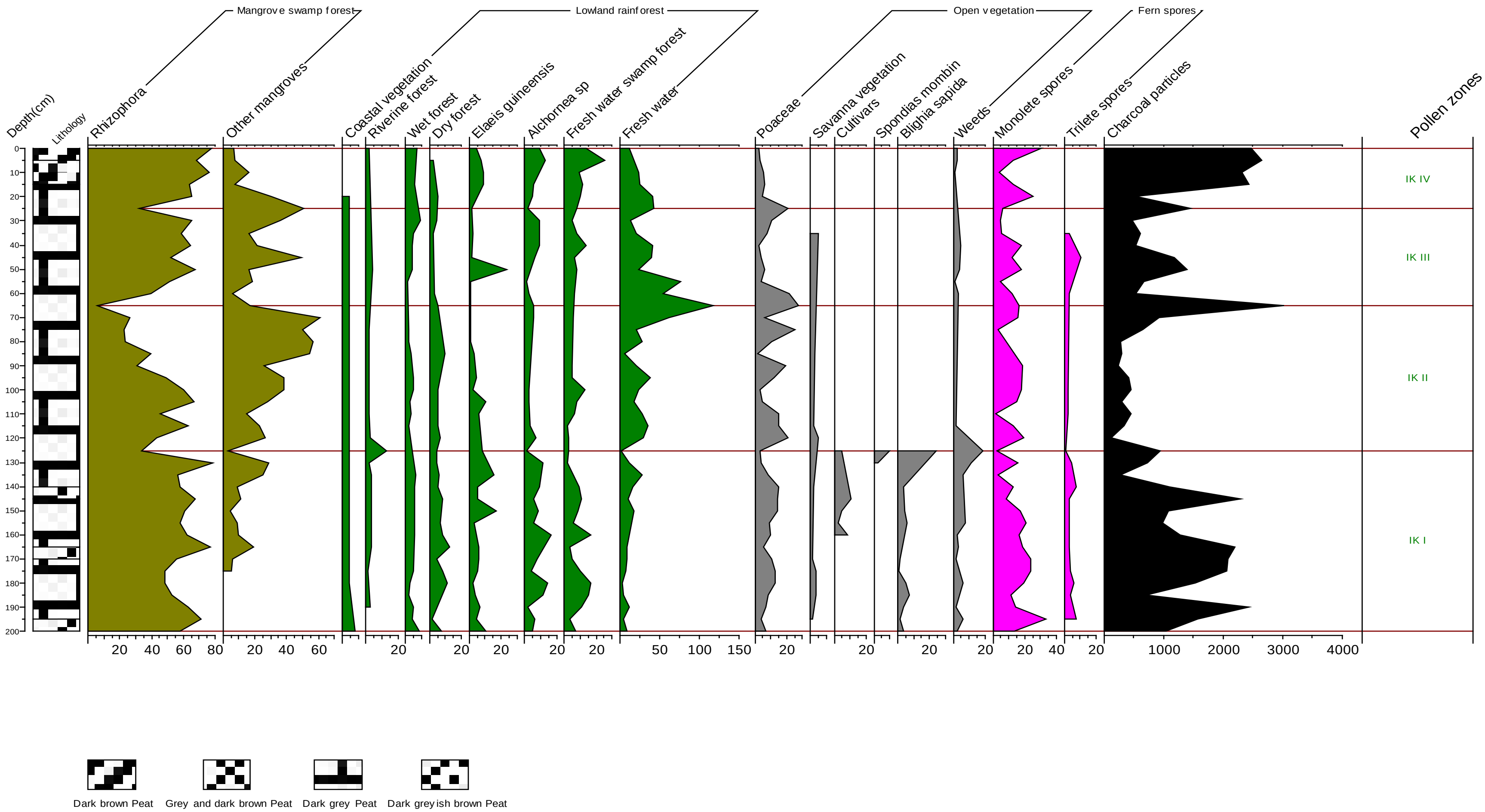


Fig 39: Pollen diagram of Ikorigho I core, Ondo State, Nigeria (N 05. 95726 E004. 93099); 2m asl

Four pollen zones (Fig. 39) were recognized as presented below.

IK I, Zone I (200-125 cm)

This zone was marked by high values of the mangrove swamp forest: *Rhizophora* (33.3-78.4 %) and *Avicennia* (1.2-13.3 %) were well represented; *Uapaca* (0.5-8.8 %), as well as some LR forest species. *Rhizophora* was 58.2% at the beginning, it increased to 71.5 % at 195 cm, and fluctuated until 165 cm. *Avicennia* also fluctuated (2-13.3 %) initially but increased steadily till 165 cm. *Acrostichum auruem* fluctuated at the beginning but increased steadily from 180 cm to 125 cm. Fresh water swamp forest (FWSF) taxa (2.3-16.9 %)—*Mitragyna ciliata* and *Uapaca*–were present but decreased between 185 cm and 170 cm; *Symphonia globulifera* appeared at 170 cm and increased thereafter until 165 cm. Poaceae (open vegetation) was in moderate quantities at the beginning of the zone (4-13.1 %); increased to 8.7-15 % and fluctuated; decreasing slightly at the end of the zone (3.1-3.9 %). Values of secondary forest (*Elaeis guineensis* and *Alchornea* sp.) ranged between 3.8 % and 25.1 %. *Rhizophora* spp. decreased from 78.4 % 130cm to 33.3% at 125 cm; *Acrostichum* from 13.3 % to 1.2 % and *Avicennia* from 13.3-1.4 %. Poaceae (open vegetation) also decreased from 14.5 % (140 cm) to 3.1 % at 125 cm. Freshwater swamp forest species were present especially *Mitragyna* (4.4-7.3 %) and *Uapaca* (4.4 %) although *Symphonia* disappeared at 160 cm. Weeds (*Chromolaena odorata* and *Ageratum conyzoides*, 2.9 %) were present but no freshwater swamp species was represented between 135 cm and 130 cm. Protected plants such as *Spondias mombin* (9.6 %) and *Blighia sapida* (24.1 %) were well represented; weeds 9.2%, (*Aspillia africana* 2.9 %, *Ageratum conyzoides* 2.0 %, *Chromolaena odorata* 7.0 %, *Rauvolfia vomitora* 0.2 %, and *Vernonia cinera*, 0.2 % appeared at the end of this zone.

IK I, Zone II: 125-65 cm

Rhizophora (MSF) fluctuated at the beginning of this zone. It was between 5.6 % and 66.7 % with lowest value at 65 cm (5.6 %). *Avicennia* (MSF) experienced similar fluctuations at the beginning (1.4-28 %) but it became stable from 105 cm and increased onwards (23.1-55.5 %). Although *Avicennia* (MSF) reduced at 100 cm (18.9-14.9 %), it increased until it peaked at 70 cm (ca. 55.5 %). *Acrostichum* was present but was reduced from 15.4 % to 12.8 % (125-90 cm) and then to 3.9% at 80 cm. The mangrove swamp forest was thus an *Avicennia*-dominated forest at this time. During this same period, *Typha australis*, Poaceae (3-27.7 %), monolete spores (2.7-18.4 %), *Polypodium vulgare*, and Polypodiaceae increased. FWSF (*Mitragyna ciliata*, *Uapaca* sp., *Symphonia globulifera* and *Pandanus*) increased from 2.0 % to 12.7 % but values of *Alchornea* (1.4-5.6 %) and *Elaeis guineensis* (0.9-8.4 %) were moderate. The charcoal counts were also moderate (53-426 particles/ cm^3) in the beginning but increased markedly towards the end of the zone (298-1370 particles/ cm^3).

IK I, Zone III: 65-25 cm

Rhizophora (MSF) remained stable at the initial period (40.2-65.4 %), but decreased to 32.6 % at 25 cm. *Acrostichum aureum* followed the same pattern as *Rhizophora*: It peaked at 65 cm (16.7 %), fluctuated between 16.8 % and 13.6 % from 55 cm to 30 cm, and became reduced to 2 % at 25 cm. *Avicennia* was well represented in this zone and peaked at 25 cm (1.9-48.8 %). Secondary forest (*Alchornea* and *Elaeis guineensis*) fluctuated throughout this zone (1.8-14.1 %) and (0.9-5.0 %) respectively. Poaceae (open vegetation) was quite abundant; its values ranged from 13.8 % to 21.4 % at 25 cm. Freshwater/aquatics (*Typha*) was very abundant (94.6 %) at 65 cm but it decreased thereafter until it was between 8.6 % and 19.5% [30-40 cm]; it then increased steadily to 36.4 % (20 cm). FWSF (*Mitragyna ciliata*, *Uapaca* sp., *Symphonia globulifera*) was between 4.5 % and 13.6 %. LRF taxa [0.9-13.6 %] such as *Celtis* sp. *Flabellaria paniculata*, *Syzygium guineense*, *Tetrorchidium didystemon* were present. Charcoal particles were high at 65 cm (1370 particles/ cm^3) but decreased to between 217 particles/ cm^3 and 660 particles/ cm^3.

IK I, Zone IV: 25- 0 cm

Rhizophora spp. increased at the beginning from 65.3 % to 78.0 % at the end of the zone. The increase in *Rhizophora* shows that the MSF was now dominated by *Rhizophora* sp. *Acrostichum* was also well represented (6.0-48.8 %) at the beginning but *Avicennia* decreased continuously from 48.8 % at 25 cm to 7.4 % at 15 cm and to

2.8 % at 5 cm but had a small relative increase to 3.9 % at 0cm. *Alchornea* sp. (2.0-12.8 %) and *Elaeis guineensis* (2.0-9.3 %) increased but while the former decreased at 0 cm (4.7 %), the latter increased to 9.4 %. Poaceae (20-2.3 %) and *Typha* (30.6-4.7 %) decreased while FWSF increased (8-25.7 %). LRF taxa became significantly reduced from 2.6 % to 6.9 % at 20 cm. During this period, *Flabellaria*, *Celtis* sp. *Diospyros* sp., *Hymenocardia heudelottii* and *Hymenostegia afzeli* all disappeared. Only *Tetrorchidium didymostemon* (5 %) and *Syzygium guineense* (2.6 %) were recovered at 20 cm and 5 cm respectively. In contrast, charcoal particles which were between 660/ cm^3 and 244/ cm^3 increased continuously from 2319/ cm^3 to a peak of 2649/ cm^3 (20-0 cm).

Table 20: Lithology of Ikorigho II core

Depth(cm)	Soil colour	Soil type
0-10	Gray and dark brown	Peat
10-150	Drak gray	Peat
160-200	Gray with mixture of dark brown	Peat and clay
210-250	Gray	Peat
260	Dark gray	Peat
270-620	Gray	Peat
630-650	Grayish brown	Peat
660-800	Gray	Peat

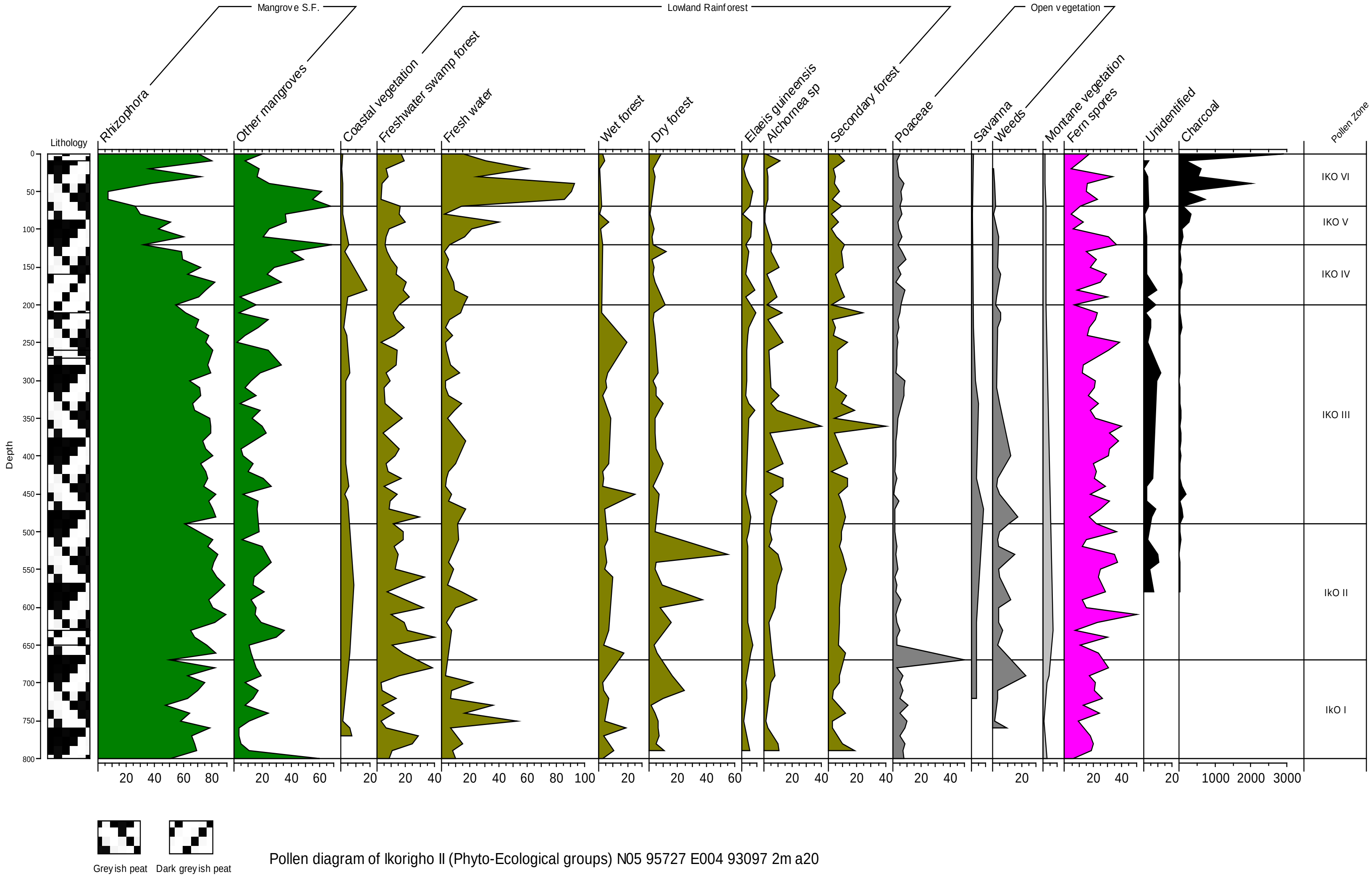
4.8 Palynology of Ikorigho II (800-0 cm)

From the palynological analysis of this second core from Ikorigho, 195 palynomorphs were observed. Of this number, 175 were identified while 20 could not be identified. The identified palynomorphs have been grouped into eight phyto-ecological groups. The eight phyto-ecological groupd are presented below in table 21.

Table 21: Phyto-ecological groups of Ikorigho II core

	Phyto-ecological group	Pollen and Spores
1	Mangrove swamp forest	*Rhizophora* spp., *Avicennia africana, Acrostichum auruem, Laguncularia racemosa, Ipomoea*.
2	Freshwater swamp forest	*Macaranga* sp., *Mitragyna ciliata, Spondianthus preussii, Uapaca* sp., *Leea guineensis, Symphonia globulifera, Nauclea diderrichii, Paullinia pinnata, Dalbergia ecastaphyllum, Lycopodium microphyllum.*
3	Fresh water	Cyperaceae, *Lygodium* sp., *Eichhornia crassipes, Typha australis, Ludwigia repens*.
4	Secondary/Open forest	*Elaeis guineensis, Alchornea* sp., *Paullinia pinnata, Ceratopteris cornuta, Morelia senegalensis, Protea* sp.
5	Savanna	*Entada abyssinica, Bridelia* cf. *ferruginea, Phyllanthus discoideus, Vitex doniana, Borassus aethiopum, Hymenocardia acida, Parinari kerstingii.*
6	Montane forest	*Podocarpus milanjiaus, Myrica arborea*
7	Coastal vegetation	*Drepanocarpus lunatus, Parinari* sp., *Chrysobalanus* sp.,
8	Lowland rainforest	*Alstonia booneii, Newbouldia laevis, Tabernaemontana crassus, Entada gigas, Flabellaria paniculata, Dombeya buettneri, Nesogordonia parpavifera, Adansonia digitata, Spondias mombin, Tetrorchidium didysmotemon, Hymenostegia afzeli, Pycnanthus angolense, Irvingia gabonensis, Berlinia* cf. *grandifolia, Acanthus montanus, Morus mesozygia, Ceiba pentandra,*

		Triplochiton seleroxylon, Gaetnera paniculata, Lannea welwitschii, Raphia vinifera, Calamus deerratus, Mimusops warnecki, Piptadeniastrum africanum, Sacoglottis gabonensis, Canthium setosum, Daniellia ogea, Anthocleista vogelli, Pentaclethra macrophylla, Canthium subcordatum, Celtis brownii, Diospyros abyssinica, D. crassiflora, Carapa procera, Pterocarpus santalinoides, Hildegardia barteri, Hannoa klaindaena, Bosquiea angolense, Polypodium vulgare, Stenochlaena palustris, Lycopodium cernum, , Cyclosorus sp., monolete spores, *Pteris* sp..



Pollen diagram of Ikorigho II (Phyto-Ecological groups) N05 95727 E004 93097 2m a20

Fig 40: Pollen diagram of Ikorigho II core (N 05. 95727 E004. 93097; 2m asl)

The pollen diagram of Ikorigho II core (Fig 40) was divided into six zones, they are as follows:

IK II, Zone I: 800–670 cm

The dominant taxa include *Rhizophora* (51.2-82.2 %), *Acrostichum aureum* (0.3-11.5 %) and monolete spores (3.4-24 %). Other mangrove species such as *Avicennia* (2.6-7.7 %) and *Laguncularia* (7.7 %) were present. Poaceae (3.3-9.7 %), *Elaeis guineensis* (0.9-2.7%) and *Alchornea* (1.9-7.7 %) were represented. The freshwater/aquatics—*Typha australis* (3.6-47.1 %) and Cyperaceae (3.4-10 %)—and FWSF species (15.5-25.7 %) were well represented but eventually decreased to 21.6 %, 2.7 % and 7.7 % respectively towards the end of the zone. LRF ranged between 1.3% and 28.0%. *Typha*'s increase to 47.1 % at 750 cm was phenomenal. Trilete spores were also present (2.7-3.6 %). *Rhizophora* and *Acrostichum aureum* decreased from 82.2% to 50 %, and 11.5% to 7% respectively, but monolete spores, Poaceae (open vegetation) and *Avicennia africana* increased to (10.8-23.2 %), (5-44.5 %) and (2.6-7.7 %) respectively at the end of the zone. Charcoal particles were absent from this zone.

IK II, Zone II: 670-490 cm

This zone was also dominated by mangroves swamp forest taxa (*Rhizophora*, *Avicennia* and *Acrostichum*). The FWSF species are also well represented (7.1-38.5 %), secondary forest species (*Alchornea* and *Elaeis guineensis*) had moderate values of between 7.6 % and 19.7 % but were absent from some levels. These levels included 680-670 cm, 640-630 cm, and 590-580 cm. Poaceae (open vegetation) had generally low values (1.4-1.9%) throughout this zone except for a significantly high value at the beginning ie at 670 cm (44.5 %). At 590 cm, freshwater/aquatics (Cyperaceae and *Typha australis*) experienced significant upsurges to 25 % (590 cm) and 14.3 % (580 cm). Monolete spores had good representations (9.9-36.3 %). Towards the top of this zone, the vegetation became dominated by the MSF. All the MSF species (*Rhizophora*, *Avicennia* and *Acrocstichum aureum*) were well represented. *Rhizophora* maintained a high percentage (60.8-89.2 %) and was regular in occurrence during the zone but *Avicennia* was not regular in occurrence (4.5-10.5 %). Few LRF pollen (*Acanthus* *montanus, Flabellaria paniculata, Ceiba pentandra, Lophira* cf. *alata*) were recovered; they fluctuated towards the end of the zone (4.0-17.7 %). Poaceae (open vegetation) had low values ranging between 1.3 % and 6.9 % except at 670 cm where it was 50 %. Charcoal particles ranged between three and 34/ cm^3

IK II, Zone III 490-200 cm

The dominance of the MSF continued here i.e. at the beginning of the zone. Values of *Rhizophora* (60.7-82.8 %), *Avicennia* (3.4-9.1 %) and *Acrostichum* (2.3-20 %) were quite high. Among the FWSF taxa, *Uapaca* was well represented (2.5-10.5 %), but decreased towards the end of the zone. At 360 cm, when most taxa and phyto-ecological groups were significantly reduced, *Alchornea* had an upsurge from 4.5 % (370 cm) to 40 %. Poaceae, *Typha* and *Elaeis guineensis* were well represented at 300 cm reaching 8.9 %, 9.4 % and 3.1 % respectively. Secondary forest taxa (*Elaeis guineensis* [3.1-9.1 %] and *Alchornea* [3.5-13.8 %]), FWSF (9.2-29.3 %), FW (*Typha*, 9.1-16.7 %; Cyperaceae 4.5-9.9 %) fluctuated. At 340 cm *Rhizophora* was 67.6 % at 340 cm but fluctuated and was 64 % at 300 cm. Other important taxa during this period included *Acrostichum* (3.1-26.6 %), Poaceae (3.1-8.9 %), *Elaeis guineensis* (2.6-9.1 %) and *Alchornea* (4.8-13.8 %). At the beginning of the zone, LRF had moderate values of 0-25.3 %; LRF taxa included *Pycnanthus angolensis*, *Celtis* cf. *brownii*, *Albizia zygia*, *Holoptela grandis* type and *Flabellaria paniculata* were represented. Subsequently between 300 cm and 200 cm, only few LRF taxa such as *Flabellaria paniculata, Acanthus montanus, Celtis* and *Pycnanthus angolensis* were recovered. Towards the end of the zone, *Rhizophora* (80.6-54.3 %), *Avicennia* (6.9-4.4 %), *Acrostichum aureum* (19.4 %) and *Uapaca* (2.7-7.9 %) became the dominant species. *Alchornea* sp. appeared at 260 cm (3.4 %) increased up till 250 cm but fluctuated between then and 200 cm. Cyperaceae (5.5-6.6 %), Poaceae (4.9-5.9 %) and *Typha* (8.8-14.8 %) increased towards the end of the zone. Charcoal particles fluctuated between 13/ cm^3 and 104/ cm^3.

IK II Zone IV: 200-120 cm.

Fluctuations were noted in the MSF represented in *Rhizophora* (54.3-75.4 %) and *Avicennia* (0-10 %). The values of secondary forest represented by *Alchornea* and *Elaeis guineensis* also fluctuated but were in low quantities, being always less than 10 %. But there was a steady rise in Poaceae particularly towards the end of the zone (max ≤10 %) and in *Acrostichum aurem* (2-12 %). FWSF taxa (*Mitragyna ciliata, Uapaca* and *Symphonia globulifera)* ranged between 7.6 % and 35.9 %. Other taxa included Cyperaceae (2.2-18.2 %), Poaceae (2.7-9.2 %), Sapotaceae (2.8-18.2 %) and *Chrysobalanus* (2.3 %).

IK II Zone V: 120-60 cm

The vegetation was characterized by a reduction in mangroves at the beginning of the zone and fluctuations subsequently; values of *Rhizophora* were between 7.1 % and 60.3 %, those of *Avicennia* were between 1.1 % and 48.7 %, and *Acrostichum aureum*'s representation was between 2.6 % and 53.8 %. Other pollen recovered included *Elaeis guineensis* (0.7-3.2 %), *Alchornea* (0.7-5.6 %) and few LRF taxa (1.4-6.6 %). There were marked reductions in *Rhizophora* from the highest value of 60.3 % to 30.2 % and *Acrostichum aureum* from 53.8 to 2.0 % between 100 cm and 80 cm while *Avicennia* increased to 22.2 % and 33.4 %. There were high values of FWSF taxa [*Mitragyna ciliata, Uapaca* and *Symphonia globulifera*] (14.1 %); freshwater/aquatics [*Typha* and Cyperaceae] was 2.4 % and Poaceae was 6.5 %. Charcoal particles were between 39 and 713/ cm^3.

IK II Zone VI: 60-0 cm

The MSF was well represented in this zone. *Rhizophora* values ranged from 7.7 % to 80 %); *Avicennia* from 1.1 % to 9.6 %) and *Acrostichum aureum* from 9.5 % to 4.8 %. Between 60 cm and 40 cm and at 20 cm, freshwater/aquatics (*Typha australis*) was over-represented with values of 73.2-90.5% and 60% respectively. Charcoal particles continuously increased from 119/cm^3 to 1120/cm^3 towards the top of the zone. Similarly, *Rhizophora* became abundant and dominated the MSF from 50 cm upwards; it increased from 36.4 % to 80 %. This became particularly evident towards the top of the zone (20-0 cm). Poaceae was quite low with value of 3.6 % while FWSF taxa (*Uapaca*, *Mitragyna*, *Anthocleista*, and *Spondianthus*) [3.2-17.1 %] while freshwater/aquatics (Cyperaceae, *Eichhornia* and *Typha*) [25.6-91.1 %] were well represented. Few LRF taxa and secondary forest—*Elaeis guineensis* (1.1 %) and *Alchornea* sp (2.5 %)—were present. The pollen of *Podocarpus milanjianus,* (1.2 %) a montane forest tree, was noted at the top of the zone.

CHAPTER FIVE

5.0 DISCUSSION I (PALYNOLOGY)

5.1 Palynology of Ogudu

Zone I: 600-470 cm

The abundance of LRF and freshwater swamp forest taxa indicated that the vegetation at 600 cm was characterized by abundant rainforest and mangroves species. The lowland rainforest species recovered from this level included *Hannoa klaineana, Celtis, Mimusops, Piptadeniastrum africanum, Hildegardia barteri, Pycnanthus angolensis, Bosquiea angolensis, Acanthus montanus, Tetrorchidium didymostemon, Alstonia booenii, Bombax buonopozense* and *Syzygium.* The majority of the parents of these pollen being naturally found in wet forest reflected the prevailence of wet and warm climate. Rossignol-Strick and Duzer (1979) noted that there were humid/wet climatic conditions between 12,500 and 5,500 yrs B.P. in Senego-Mauritania area. In the Niger delta area, wet conditions were noted before 7,600 yrs B.P. (Sowunmi, 1981a). Similar wet and humid climatic conditions also prevailed in Dogonboulo, Niger, the Sahara region ca. 7000yrs B.P. (Neumann and Schulz, 1987); between 7,000 and 6,500 yrs B.P. in Abu Ballas, Southern Egypt (Neumann, 1991) and at 5,700 yrs B.P. in Wadi Shaw, Northern Sudan (Neumann, 1991). Salzmann *et al.,* (2002) also noted marked increases in the pollen of wooded Guinea savanna taxa in the pollen record of a core drilled in Lake Tilla situated on the Biu plateau, North East Nigeria. The increase in the pollen of Guinea savanna, in an otherwise Sahel savanna region, according to the authors, reflected the occurrence of a dense wooded Guinea savanna which could only have thrived under a humid and wet climate. The levels representing this period in the Lake Tilla core, N.E. Nigeria were dated to between 8,600 yrs and 7,000 yrs B.P. This period falls within the early part of the Mid Holocene, which was generally wet in Nigeria (Sowunmi, 1981a& b; Sowunmi, 1985; Sowunmi, 2004), as well as in the West African region (Maley, 1997; Salzmann and Hoelzmann, 2005; Tossou *et al.,* 2008). From the above, it is clear that wet/humid conditions prevailed in West Africa in the Northern-most regions ca. 8,600-7,000 yrs B.P., and later around the southern and coastal areas between 7,600 yrs and 5,750 yrs or 5,500 yrs B.P. Therefore, the period when level 600 cm being characterized by abundant mangroves and LRF pollen and wet and warm climate, probably falls within the mid-Holocene. Subsequently the LRF became characterised by abundant pollen of drier type of forest, as these forms (*Celtis* and *Syzygium*) while those of wet forest decreased. The abundance of the pollen of drier forest along with those of secondary forest (*Elaeis guineensis* and *Alchornea*) indicated that vegetation was open. At 560cm, the occurrence of few palynomorphs indicated the existence of a brief unfavourable environmental condition. Favourable environmental conditions returned afterwards with increases in the MSF and LRF (*Mimusops warneckei, Funtumia elastica, Entada gigas, Ceiba pentandra, Tetrorchidium didymostemon, Irvingia gabonensis, Canthium setosum, Celtis sp., Lophira* cf. *alata, Malacantha* type, *Pycnanthus angolensis* and *Nesogordonia parpaverifera*). Coastal vegetation and fresh water swamp forest (*Spondianthus preussii, Uapaca* sp*, Mitragyna ciliata, Cissus quadrangularis* and *Nauclea*) (Fig. 36) were also well represented: Thus the occurrence of abundant LRF and FWSF species shows that the lowland rainforest flourished during this period, although there would have been some openings within it as evidenced by the occurrence of *Elaeis guineensis* and *Alchornea cordifolia*. Furthermore, one pollen form representative of savanna vegetation i.e. *Daniellia oliveri* was recovered; its low occurrence indicated that the savanna was far from Ogudu and/or was located further north than is the case today (Sowunmi, 1981a). The presence of freshwater/aquatics (Cyperaceae and *Ludwigia repens*) and *Podocarpus milanjianus* indicated high competence of rivers around the site of deposition. Although *Podocarpus milanjianus* is usually transported by wind on account of its air sacs, its presence (only one pollen) here might not indicate a wind transport, neither does its occurrence indicate a cooling in temperature. Rather, it was probably transported by river until it found its way into the Lagos-Ogudu area where it was finally deposited. Based on pollen evidence, the vegetation was dominated by abundant LRF and MSF taxa. Similar periods of forest and mangrove regrowth, establishment and expansion as well as increased river competence due to higher/increased rainfall have been found in other areas in West Africa dated to the Mid Holocene period (Sowunmi 1981a&b, 2004; Tossou, 2008). Sowunmi (1981a) noted high amounts of *Rhizophora* pollen at levels dated to 5600ys B.P., which represented a period of sea transgression in the Niger Delta. In Northern Sudan, Neumann (1991) noted the occurrence of a humid climate around 5,700 yrs B.P. when Sahel savanna vegetation (*Acacia* sp., *Balanites aegyptiaca*, *Ziziphus* sp., cf. *Grewia tenax*, *Grewia* type *villosa/bicolor* and *Acacia nilotica*) were found 300 km from their present location into the desert areas of Wadi Shaw. Similarly, Sowunmi (2004) recovered high amounts of *Rhizophora* in sediments dated to ca. 6,640-5,780 yrs B.P. in the Ahanve core. This period of abundance of *Rhizophora* in Ahanve occurred immediately after the period when few pollen was recovered. A similar occurrence, which has been discussed above, took place at level 550 cm of the Ogudu core. Based on dates from both the Niger Delta (Sowunmi, 1981a) and Ahanve cores (Sowunmi, 2004), this period under which the MSF and LRF flourished in Ogudu may have been some time between ca. 6,600 yrs and 5,600 yrs B.P. Therefore, the period, being characterized by abundant pollen of LRF and MSF, indicated a return from a somewhat dry period to favourably wet and humid conditions. There was an abundance of monolete spores over trilete spores and such a development has been linked to increased wetness and closed forest canopy (Fall, 2005). This provides further evidence which supports the fact that the LRF was extensive. Furthermore, pollen of freshwater species (*Lygodium* and *Ceratopteris*) was also recovered lending credence to the inferred wet period. During this same time, *Rhizophora* had maximum increase suggesting rise in sea level but in contrast the LRF slightly decreased. These events indicate very rapid transgression of the sea and expansion of mangroves which encroached over much of the LRF area.

Subsequently, new LRF taxa such as *Alstonia booenii, Triplochiton scleroxylon, Hymenostegia afzeli, Pterocarpus santalinoides, Carapa procera, Acanthus montanus, Canthium scabrosum, Syzygium guineense, Paullinia pinnata* and *Bosquiea angolensis* were noted in this zone. Palms such as *Raphia reclinata* and *Calamus deerattus* were recovered. The occurrence of the palms suggests that climate was warm. Presence of freshwater/aquatics taxa (*Nymphaea lotus*, Cyperaceae and *Typha*) is an indication of continued high river competence. FWSF species were also well represented (*Anthocliesta liebrechtsiana*, *Nauclea*, *Mitragyna*, *Cissus quadrangularis*, *Uapaca* and *Symphonia globulifera*. The abundance of these species was an indication of a maximum extension of the tropical forest. The slight increase noted in Poaceae (open vegetation) and secondary forest species indicated that there were spaces or openings within the forest vegetation. The occurrence of smooth monolete spores and *Polypodium* in the ratio of 8.7:1.5 suggests the occurrence of a wet climate. The occurrence of pollen indicative of disturbances in the vegetation was significant. The species included *Ageratum conyzoides*, *Borerria* sp., *Talinum triangulare*, Asteraceae, and Amaranthaceae/Chenopodiaceae. In addition, the pollen of Guinea savanna species, *Bridelia* sp., *Cassia* and *Vitex doniana*, were also recovered. The appearance of pollen of Guinea savanna and those of herbaceous plants associated with disturbance of vegetation indicated that there was some environmental disturbance within the vegetation. Presumably, the environmental disturbance led to reduction in wet forest species and created some openings in the LRF. The predominance of pollen of drier forest taxa: *Clausena* cf. *anisota, Celtis* sp., and *Paullinia pinnata* over those of wet forest taxa and the subsequent appearance of Guinea savanna pollen (*Bridelia* sp, *Vitex doniana* and *Cassia*) at this time are indications that though the climate would have been generally wet, it experienced some periods of dry seasons.

Indeed the MSF represented by *Rhizophora* gradually decreased drastically at 470 cm. According to Sowunmi (1981), a percentage occurrence of *Rhizophora* below 40 % is regarded as indicative of significantly reduced mangrove vegetation or that the location of mangroves was very far from the coring site. Similarly, *Acrostichum* decreased during this same level. But *Avicennia* had marginal increase indicating that the location of the mangroves was further from the coast. This phenomenon could be linked to a lower relative sea level. *Avicennia* was possibly not affected by the reduction in sea level because it naturally occupies elevated areas behind the *Rhizophora* zone (Vedel *et al.*, 2006). At the same time, there was an increase in Poaceae. Therefore, Poaceae pollen were most probably derived from grasses located within the LRF but not from the savanna. Today grasses are found in almost all habitats or all vegetation types including mangrove swamp forest (e.g. *Paspalum vaginatum*). Grasses and sedges are known to colonise open or exposed swampy areas. Indeed Cyperaceae was quite abundant during this period. In other words, the environment though open was also characterized by some swamp conditions. Subsequently, the LRF decreased while

Poaceae increased. During this same period, pollen of savanna vegetation were recovered. These included *Vitex doniana, Parinari* cf. *kerstingii, Lannea* sp*., Psychotria* sp., as well as weeds such as *Alternanthera repens* and *Euphorbia hirta*. The occurrence of these pollen types, as well as a sharp increase in Poaceae concomitantly with reductions in the MSF and LRF indicated the onset of drier conditions.

Zone II: 470-380 cm

Rhizophora experienced an upsurge which shows recovery and re-establishment of the mangrove. *Avicennia* and *Acrostichum* were well represented indicating that the MSF was extensive, and that the sea would have transgressed into the plains. Rainforest taxa were abundant suggesting that while mangroves were abundant along the lower areas and coastal land and the LRF was fairly extensive. The high values of smooth monolete spores and *Polypodium vulgare* signified the abundance of pteridophytes within the LRF. The occurrence of these diverse sopecies indicated a wet and warm climate.

On account of the high amounts of *Rhizophora*, LRF and FWSF, climate is inferred to have been generally wet. Sowunmi (2004) noted the occurrence of wet conditions some time after 5,682 ± 32 yrs B.P. but before 3,109 ± 62 yrs B.P. at Ahanve, and this coincided with the Nouakchottian marine transgression of 5,500-4,000 yrs. More importantly, this wet period in Ahanve described above occurred immediately after a dry phase. In a similar way, the inferred wet phase during in this zone also occurred immediately after a dry phase (530 cm-470 cm, dated by correlation to ca. 5,600-5,000 yrs B.P.). A point to note is that while the MSF decreased pollen of montane vegetation such as (*Myrica arborea, Ilex mitis* and *Podocarpus milanjianus*) occurred. The occurrence of these montane species in a coastal location was an indication of cooler climate and occurrence of a nearby mountain or that the montane pollen grains were transportation from it. This will be discussed in more detail shortly. In addition the MSF decreased with a concomitant increased occurrence of pollen of guinea savanna vegetation (*Parkia biglobosa, Acacia* sp*., Morelia senegalensis, Bridelia* cf. *ferruginea, Parinari* sp., *Phyllanthus discoideus, Lannea microcarpa* and *Psychotria*). Their occurrence of these savanna taxa along with the appearance of montane pollen with concomitant reduction in MSF indicated that conditions were drier, and perhaps there was a sea regression. Furthermore, the occurrence of the pollen of *Acacia* sp. and *Parkia biglobosa* at 380 cm is of some environmental importance and is discussed in the following section.

The pollen of *Acacia* sp. and *Parkia biglobosa* are polyads, i.e. they occur in units containing 16, and between 24 and 32 grains *Parkia* respectively. The parent plants of these pollen are naturally found in savanna regions. Since they were recovered as polyads, it means that they were transported whole from their original location, perhaps some where in the southern Guinea savanna to Ogudu. Polyads are heavier than single grains; as a result, they are seldom dispersed over great distances from their parent plants. Sometimes, single grains of *Acacia* and *Parkia* can be found especially when carried over long distances, but this is rare. For instance, pollen analyses of several honey samples obtained from savanna regions of Northern Nigeria carried out in the Palynology Laboratory, Department of Archaeology and Anthropology, University of Ibadan by the author revealed that majority of the grains of *Parkia biglobosa* and *Acacia* sp. found in these honey samples appear as polyads. Single grains are rarely found. This may not be unconnected with the fact that since these honey samples were produced in the southern Guinea savanna region, the pollen grains were carried over short distances. Thus, they remain intact in the honey. In addition, a large proportion of the pollen in honey is, deliberately or unconsciously, included by honey bees, whose maximum flight range is 3 km (Crane, 1980). This shows that the shorter the distance a pollen travels, the more the chances that they, in this case, of *Acacia* sp. and *Parkia biglobosa,* would be deposited as polyads rather than as single, individual grains. Therefore, the occurrence of the polyads of *Acacia* sp. and *Parkia biglobosa* in level 380 cm shows that they were transported over short distances, indicating that their sources were nearer Ogudu at that time i.e when level 380 cm was deposited. This suggests that the Guinea savanna vegetation might have been closer south than its present location during this period.

On the occurrence of montane pollen, since there is no montane vegetation presently in the Lagos area, the Cameroon Mountains and the Vogel Peak are possible areas from where the pollen of these montane plants may have been derived. The pollen of these plants would have been initially transported by strong wind. By this medium, the pollen would have been deposited first on the River Benue, which joins the Niger at Lokoja. From the Niger, the *P. milanjianus* pollen would have been carried by it or its tributaries to the Niger Delta, and finally reaching Lagos from there. However, it is difficult to conceive of a situation where the pollen would have been carried from the Niger Delta upstream to Lagos. This is because rivers naturally run downstream; the Niger Delta is the watershed of the drainage or river systems in southern Nigeria. It seems rather unlikely that these montane pollen, particularly *P. milanjianus* was transported from the Cameroon mountain range.

The other likely areas are Jos plateau (1,200-1,500 m above sea level) and the areas covering Apata and Kukuruku Hills (300-500 m asl) in Ekiti and Ondo States. Jos plateau is approximately 1,000 km from Ahanve while the area surrounding the Apata and Kukuruku hills is 250-300km from Ahanve. In addition, if it is possible that these areas were higher in the past than now, temperatures would have been cooler. Thus if temperatures during the period of the occurrence of montane pollen in Ogudu were at least 5° C lower, then montane plants may have thrived at Jos plateau and Ekiti-Ondo Uplands, although they may not be there today. Considering the distance, the latter i.e. Ekiti-Ondo Uplands are the closest location from where the montane pollen may have come. Besides, there are rivers around the Uplands which may have carried the pollen to Ahanve. These rivers—Shasha, Oni and Oshun—take their source from Apata and Kukuruku Hills and connect the Lagos lagoon (Fig 3). Although there have been no palynological studies of these Uplands to refute or confirm the above inference, these areas appear to be the most plausible locations where the montane pollen may have been derived from some 3,000 yrs B.P.

This inference is strengthened by the recovery of substantial amount of the pollen of *Podocarpus milanjianus* and *Myrica arborea* (Fig 41) honey samples from areas around the Ekiti uplands recently studied by this author. These areas included Ado Ekiti and Are-Ekiti. Although, the exact location(s) from where these montane pollen found their way into the honey samples is not yet known, their presence is quite significant. Because pollen are carried by wind, it might not be far-fetched to infer that their parent plants might be somewhere in these highlands. Therefore, if *P. milanjianus* and *M. arborea* did exist in these uplands in the past, and probably at a time when climate was colder and drier, they probably would have reached Ogudu from there. The present-day average temperature of the Apata and Kukuruku hills ranges between 22° C and 24° C. Therefore, if *P. milanjianus* and *M. arborea* thrived on Apata and Kukuruku hills in the past, temperature in these areas, would have been between 17° C and 19° C, i.e. 5° C lower than present day temperatures. It appears that these areas are lifted such that they sustain temperatures of 5° C lower than at sea level as is obtained in the Cameroon Highlands.

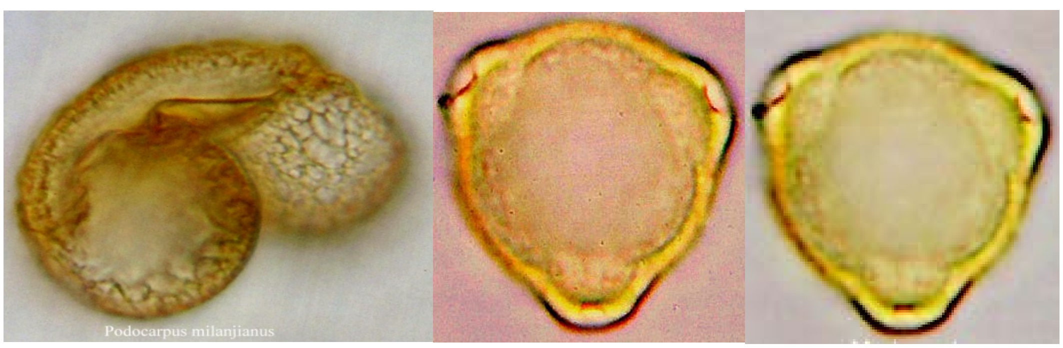


Fig 41: *Podocarpus milanjianus* and *Myrica arborea* from Ekiti honey samples

Finally, the presence of these relatively abundant and diverse savanna pollen, as well as those of montane taxa reveal the continuation of the dry and cold climate which prevailed during that period. Since the reduction in LRF and MSF in Ogudu was noted immediately after a wet phase, it probably shows that the pollen record reflected the early stages of the late Holocene dry phase. Salzmann *et al.,* (2002) stated that the late Holocene dry phase in NE Nigeria started at about 7,000 yrs B.P. when there was a decline in pollen of woody climbers and those of Guinea savanna tree taxa. By 3,800 yrs

B.P., climate around Lake Tilla NE Nigeria was very dry. The TOC values drastically reduced. The latter phenomenon, according to the authors, indicated increase of C4 savanna grasses. Pollen of open savanna and drier Sahel savanna taxa increased (*Balanites, Commiphora* and *Salvadora,*) as well as those of Cyperaceae and *Typha*. This suggested that there was a shift towards drier environmental conditions. Thus, by 3,800 yrs B.P., the dry phase occurred around Lake Tilla. Maley (1991) noted that the late Holocene dry phase occurred between 4,000 yrs and 3,500 yrs B.P. in the Lake Bosumtwi area, Ghana, when the level of the lake dropped to more than 30 m below the present surface level. Dry climatic conditions occurred at the Ngamakala pond, Congo between 3,100 yrs and 3,000 yrs B.P (Elenga *et al.,* 1994). According to Vincens *et al.,* (1998), the late Holocene dry phase had its maximum in lake Sinnda, Congo, around 3,000-2,500 yrs B.P and extended to 1,300 yrs B.P. Sowunmi (2004) indicated that this late Holocene dry phase took place in Ahanve (probably including the Badagry areas) between ca 5,780 yrs and prior to 3,109 ± 26 yrs B.P., but had its maximum at the latter date i.e. 3,109 ± 26 yrs B.P when the mangroves were completely destroyed. Drier conditions were noted in Nguène and Maridor lakes in Gabon beginning from 4,000 yrs B.P., but the dry climate reached its peak between 2,700 yrs and 2,400 yrs B.P. in those two lakes (Ngomanda *et al.,* 2009).

Taking a closer look at the period when this dry phase occurred, one can easily see that it occurred first at the northern parts of West Africa (Dogonboulo, Niger; Lake Tilla, Biu Plateau, N.E. Nigeria and Lake Bosumtwi, Ghana) and at later dates around the coasts (Ahanve in Nigeria; Ngamakala pond and Lake Sinnda in Congo, and Nguène and Maridor Lakes, Gabon). This is not surprising because the dry and dusty wind which ushers in the harmattan season blows from the Sahara, and its effects would first be seen in areas located in the north and then at later dates in the south. This explains why there were time lags between the dates of the late Holocene dry phase in different locations in West Africa. Therefore an attempt to locate the period of occurrence of the late Holocene dry phase in Ogudu must take into consideration its coastal location. In other words, the dry phase commenced at 470 cm in Ogudu at a later date (in comparison with the North and Sahara). But the dry phase during this period would have occurred at a much later date probably around 4,000 yrs. This is because the dry phase had already commenced at Ogudu at 470 cm and continued between 470cm and 380 cm.

Zone III: 380-290 cm

Rhizophora, *Avicennia* and *Acrostichum* were greatly reduced in this zone. Two major factors affecting mangroves are deliberate felling by humans and reduced salinity. In this zone, there is no pollen evidence for the presence of humans even though Poaceae increased; there were also no marked increases in anthropogenic indicators such as *Elaeis guineensis* and *Alchornea* sp. The pollen evidence thus indicated that the drastic decreases in *Rhizophora* and other mangroves were without any anthropogenic input. The occurrence of montane and savanna species can be attributed to long distance transport as already discussed in the preceding section (Zone II). The LRF was fairly abundant being characterized by a combination of pollen of dry and wet forests (*Pycnanthus angolensis, Tetrorchidium didymostemon, Gaertnera paniculata, Celtis, Ceiba pentandra, Nelsonia, Mimusops, Raphia* and *Calamus*). Monolete spores were abundant; increase in monolete spores has been associated with the occurrence of wet conditions (Fall, 2005) but this increase in monolete spores under a dry environment indicates presence of wetlands and swamps (Duffin, 2008).

A date of 2,620 ± 30 yrs BP (Cal BP 2,760-2,730 yrs) was obtained for level 350 cm. The period represents the time of significant reductions in the MSF. As stated earlier, the MSF began to reduce at 470 cm (in the previous zone) and reached its lowest point at 350 cm. In other words, the change in vegetation at Ogudu began sometime before 2,620 ± 30yrs B.P. Based on the pollen evidence, particularly the very low percentage value of *Rhizophora*, there was a change from wet and warm to dry and cold climate, and low relative sea level. Mangroves were noted to have declined and subsquently disappeared from Ahanve ca. 3,109 ± 26 yrs B.P. (Sowunmi, 2004). The disappearance of mangroves from Ahanve is thought have been caused by climatic and hydrological factors (Sowunmi, 2004). Therefore, it was the late Holocene dry phase that was responsible for the drastic reduction in MSF and reductions in forest taxa noted in the Ogudu core. Although 4,500-2,500 yrs B.P. represents the general period of dry climate in the tropics, its timing and/or duration in the tropics is not synchroneous

(Ngomanda *et al.,* 2009). At Ogudu, it occurred before 2,620 ± 30 yrs B.P, and it seems contemporaneous with what occurred at Ahanve. However, in contrast, the MSF, LRF remained unlike in Ahanve where the former completely disappeared (Sowunmi, 2004). Although, the MSF was drastically reduced in Ogudu but the LRF was fairly abundant. This shows that some moist conditions existed in Ogudu which were absent from Ahanve. This can be explained by the locations of the two sites. Ogudu is directly linked to the Atlantic Ocean via the Lagos lagoon (Figs. 42 and 43). This marine influence was the likely reason the LRF and MSF remained in Ogudu. In contrast, Ahanve has no such advantage. If any thing, it is bounded to the north by the freshwater bodies such as the Badagry creek and Yewa river.

Fig 42. Aerial view of the Ogudu MSF (Google Maps)

Fig 43: Aerial view of Ahanve; Ahanve is shown as orange balloon (Google maps)

Between levels 310 cm to 290 cm, very few palynomorphs were recovered. Two factors are likely to have led to this development: non-preservation of pollen and almost absence of or occurrence of sparse vegetation in the area. If there was sparse vegetation, it meant that a major part of the vegetation comprising the LRF and MSF and FWSF, which existed from 380-320 cm was destroyed. The paucity of the palynomorphs at levels 310-290 cm suggests an extension of the effect of the late Holocene dry climate. This period falls under the late Holocene dry phase which occurred from ca. 4,500-2,500 yrs B.P.

Zone IV: 290-200 cm

As in the previous level, few pollen and spores were noted for 290 cm and this was the effect of the late Holocene dry phase. Towards the top of the zone, the MSF increased signaling a return of more favorable conditions and rising sea levels. The occurrence of freshwater/aquatic taxa such as Cyperaceae and *Nymphaea lotus* indicated a rejuvenation of some rivers and the presence of swamps nearby. More pollen of LRF taxa such as *Tetrorchiduim didysmostemon*, *Pycnanthus angolensis, Sacoglottis gabunensis, Hannoa klaineana, Celtis* cf *brownii, Lophira* cf. *alata, Gaertnera paniculata*, *Irvingia gabonensis, Ceiba pentandra, Mimusops warnecki*, *Syzyguim guineense,* and *Antidesma* sp were recovered from here than in the previous level. The LRF species recovered from this period included. Thus the LRF was more diverse at 270 cm than at 280 cm. Therefore the vegetation was characterized mainly by MSF and diverse LRF species. Climate was favourable, warm and wet, and sea levels are inferred to have been higher. Few savanna taxa were recovered (*Daniella oliveri* and *Psychotria* sp.) indicating that the savanna was farther north from Ogudu. At the same time, the FWSF increased indicating expansion of the FWSF and perhaps flooding in Ogudu.

Zone V: 190-80 cm

The low values of MSF and forest taxa which were in contrast to those of monolete spores, Poaceae, Cyperaceae and *Alchornea* showed that the vegetation was more open and dominated by grasses and *Alchornea* shrubs. High percentage value of Cyperaceae showed the occurrence of swamps nearby. Therefore, climate would have been comparatively drier but warm. The subsequent increases in the LRF on one hand, and in *Rhizophora* and *Avicennia* on the other indicated a change to wet climate with abundant rainfall as well as re-establishment of mangrove vegetation, and wet conditions with abundant rainfall. These inferences are corroborated with significant decrease in Poaceae (open vegetation).

The abundance of *Rhizophora* species and other mangroves characterized by *Acrostichum*, *Avicennia* and *Laguncularia racemosa* are indications of an abundance of mangroves in the area, occurrence of abundant rainfalls, frequent flooding of the coastal areas and a warm climate. This part of the core (190cm) was dated to the last 60 yrs i.e. AD 1950. The inferred wet conditions led to the expansion of forest trees as noted in the abundance of LRF pollen. In addition, the high values of freshwater/aquatic species (*Nymphaea lotus* and Cyperaceae) indicated the occurrence of floods within the immediate surrounding of the Ogudu area. This corroborated the inference on floodings of the Ogudu area stated earlier which was based on the abundance of MSF and LRF made above. However, despite the inferred wet environment, the FWSF was not abundant though it was present.

The mangroves flourished during this period, suggesting favourable wet climate yet there were subsequent reductions in the LRF. Forest taxa during this time included mainly those of drier type: *Tetrorchidium, Piptadeniastrum africanum, Blighia sapida, Bosquiea angolensis*, *Pentaclethra microphylla*, *Ceiba pentandra* and *Celtis* cf. *brownii.* This reduction occurred concomitantly with a gradual increase in *Elaeis guineensis* indicating that there was a vegetation change which was not likely to have resulted from dry climate. Whilst secondary forest (*Elaeis guineensis* and *Alchornea*) increased, palynomorphs associated with environmental disturbances were few. These included *Lygodium microphyllum* and Amaranthaceae/Chenopodiaceae. Increase in pollen of *L. microphyllum* is usually indicative of hydrological disturbances such as flooding while increase in Chenopodiaceae has been found to be associated with human impact particularly forest clearance (Li *et al.,* 2008; Heinsalu and Veski 2010; Ding *et al.*, 2011). However the relatively high percentages of *Elaeis guineensis* and *Alchornea* point to human presence at the site. Where humans are present, their activities such as bush clearance and agriculture promote the increase of weeds and plants associated with human habitations. No other pollen of weeds or those associated with human habitations were recovered at this level. Therefore, if humans were present at that time, their impact was minimal.

After this period, the LRF initially increased and was characterised by *Tetrorchidum didymostemon, Pycnanthus angolensis, Tetrapleura tetraptera, Entandophragma utile, Celtis* cf. *brownii, Ceiba pentandra, Paullinia pinnata, Syzygum guineensis, Canthium subcordatum* and *Daniellia ogea*. Similarly, the FWSF also increased. Later, *Rhizophora* became reduced with concomitant increases *Alchornea, Elaeis guineensis* and Poaceae. This indicated an abundance of grasses within the area. At the same time pollen of Guinea savanna were recovered; they include *Protea* sp., *Maytenus senegalensis, Chassalia kolli, Grewia mollis* and *Aeglopsis* cf. *chevlleri.* All these showed that there was a gradual change from vegetation dominated by LRF and MSF to an open vegetation characterized by Poaceae (grasses) and some savanna species.

Zone VI: 80-0 cm

Based on changes in the colour of the sediment from very dark gray or dark gray at previous levels to very dark brownish-red at the top of the zone, there probably was post-depositional oxidation. Given this scenario, the mangrove swamp would have been seldom inundated leaving the swamp exposed for some time; possibly climate was also dry. As a result, majority of the palynomorphs were possibly oxidized before they were fossilised accounting for the paucity of palynomorphs at the beginning of this zone. The inferred dry season would have been brief because the paucity of palynomorphs was only noted at 80 cm. After this time, there were significant increases in the number and types of palynomorphs recovered from these levels in response to favourable environmental conditions. Pollen representing the LRF were recovered; they included *Gaertnera paniculata, Diospyros* and *Celtis* sp. Other palynomorphs recovered include *Alchornea* cf. *cordifolia, Elaeis guineensis, Acrostichum aureum, Avicennia, Symphonia globulifera, Protea* sp., *Gardenia imperialis,* Combretaceae/Melastomataceae, Poaceae and monolete spores. Level 70-80 cm was dated to the last 60 yrs (AD 1950). Later in the pollen record savanna elements such as *Bridelia, Parinari, Protea* and weeds

(*Borreria, Synedrella* and Asteraceae) occurred. Poaceae and secondary forest (*Elaeis guineensis* and *Alchornea* sp.) had significant increases. The increases in the pollen of Poaceae, secondary forest, savanna species and weeds are indications of open environment. More importantly, these increases occurred with concomitant reductions in LRF and MSF. These are the first notable evidence of the human impact on the MSF in Ogudu.

Later *Rhizophora* decreased; because Ogudu is closely linked to the Atlantic Ocean via the Lagos lagoon, the reductions in the values of MSF taxa might give the impression that sea level was also lowered. The pollen evidence suggests that the reduction in *Rhizophora* was not occasioned by dry conditions. This is based on the following reasons: The first is that 350 palynomorphs were recovered during that time suggesting that conditions were generally wet. Secondly, the sediments are peat and the colour of the sediment is dark gray. Therefore, the vegetation change was most probably human-driven. In addition, the Ogudu-Alapere Bridge which was built in 1987 over the Ogudu creek is the main link to the Third mainland bridge, Lagos. During their constructions the MSF would have been cleared and its wood obtained and used as part of construction materials. With their completion, human movement within the area would have increased tremendiously further affecting the MSF. This is because people would have obtained wood from the MSF for use as domestic fuel (Orijemie, 2005). Therefore human impact on the vegetation at Ogudu became more pronounced in the 1980s, particularly during and after the third mainland bridge was built (Figs 44 and 45). These events were registered in the pollen record at 40 cm.

Fig.44: The Ogudu MSF seen from the Ogudu-Alapere Bridge

Fig 45: Aerial view of Ogudu-Alapere Bridge over the MSF (Google maps).

During this same period of mangrove reduction, *Lygodium microphyllum, Ceratopteris cornuta* and *Polygonum senegalensis* were recovered from the site. The occurrence of these spores and pollen is indicative of hydrological disturbances particularly dredging of the swamp. The sand so obtained is sold to building contractors who flock the mangroves swamp at Ogudu. At the top of the core the MSF and LRF became reduced with the latter replaced by secondary forest (*Elaeis guineensis* and *Alchornea*), FWSF and FW species. Presently the LRF is absent from Ogudu but there are pockets of rainforest trees within the area which are remnants of a-once-diverse-LRF vegetation. The LRF pollen recovered from 10-1 cm included those of *Pycnanthus angolensis, Berlinia, Syzygium guineense, Sacoglottis gabunensis, Acanthus montanus, Ceiba pentandra, Newbouldia laevis, Gaertnera paniculata, Paullinia pinnata, Celtis, Mimusops warneckei* and *Alstonia booenii*. Most of these plants are not present in the vegetation of Ogudu today. From all indications, local rivers would have carried the pollen to Ogudu. This is corroborated by the moderately high values of freshwater swamp forest and freshwater/aquatic species. Although the LRF was replaced by secondary forest, the MSF, unlike at Ahanve, was not replaced by coastal savannas. During the late Holocene dry phase, Ahanve was cut off from access to marine influence and inundated by fresh waters which changed the hydrology of the swamp (Sowunmi, 2004; Orijemie, 2005). In contrast, the MSF though reduced in extent and diversity remained in Ogudu. The major reasons are partly because Ogudu had direct link with the Atlantic Ocean which was responsible for the the relatively high salinity noted in Ogudu (Table 10).

5.2 Palynology of Ahanve

5.2.1 Discussion of Ahanve core

Zone I (200-60 cm)

Rhizophora spp. dominated this zone; *Avicennia* and *Laguncularia* were present but not recorded for most part of the zone. These two species are not known to produce large amounts of pollen, and they are insect pollinated (Vedel *et al.*, 2006). As a result, they are usually under-represented in the fossil record. This is in contrast to *Rhizophora*, which is wind pollinated and produces thousands of pollen per flower. For example, *R. harrisonii* produces 531,460 pollen/ flower (Adewole, 1994). *Acrostichum aureum*, a fern whose spores are wind-pollinated, was quite regular in occurrence and was well represented, although it was not recovered from all levels.

The abundance of *Rhizophora* is indicative of a *Rhizophora*-dominated mangrove swamp forest, and consequently it is inferred that sea level would have been high. Furthermore, the abundant occurrence of *Acrostichum* for most part of this zone showed that salinity was high and there was little influence of freshwater into the swamp. This is because *Acrostichum aureum* is the only known salt-water fern in West Africa (Keay, 1959). Freshwater swamp forest species were present indicating the location of a freshwater swamp forest nearby. Therefore, for the early part of this zone, the mangrove swamp forest (MSF) was abundant being dominated by *Rhizophora* and *Acrostichum aureum*. But the vegetation was also characterized by diverse LRF species (*Pycnanthus angolensis*, *Lovoa trichiloides*, *Irvingia gabunensis*, *Piptadeniastrum africanum, Sacoglottis gabunensis, Celtis brownii, Dryospyros abyssinica, Daniellia ogea, Hannoa klaineana, Carapa procera* and *Pterocarpus santalinoides*). Majority of the parent plants of these pollen are found in wet forest. Therefore, their occurrence corroborates the inference about the prevalence of a wet and humid climate made earlier based on abundance of mangrove between 200 cm and 110 cm. In contrast, secondary forest (*Paullinia pinnata*, *Elaeis guineensis* and *Alchornea*) had low percentage and fluctuated indicating the existence of few openings within the forest. In addition, charcoal particles were few which show that human influence in this period was non-existent. The sea transgression noted for periods when *Rhizophora*, *Acrostichum* and the LRF flourished occurred in other parts of coastal West Africa during the mid Holocene. This sea transgression event is called the Nouchottonian sea transgression. It took place in most parts of West Africa between 5,500 yrs B.P. and 4,500 yrs B.P.; in Bénin between 7,500 yrs B.P. and 3,500 yrs B.P., Lac Sélé, Southern Bénin, between 8,400 yrs B.P. and 4,500 yrs B.P., Nigeria between 6,500 yrs B.P. and 5,000 yrs B.P. (Sowunmi, 1981a&b and 2004). In addition, Delègue *et al*., (2001:110), in corroboration of the above reconstructed LRF opined that in Gabon "forest transgression took place in the early and middle Holocene". DeMenocal *et al.,* (2000) in a review of the African palaeoenvironment of the last 100,000 yrs B.P. noted that wet and humid conditions occurred between 14,800 yrs and 5,500 yrs B.P. i.e the early to early-late Holoecene. Thus evidences from tropical Africa have indicated that during the early-mid Holocene and the early part of the late Holocene i.e. between 7,500 yrs and 5,000 yrs B.P., climate was generally wet. The early period of this zone might have been deposited between ca. 6,500 yrs and 4,500 yrs B.P.

Savanna and Poaceae were present albeit in small amounts. Savanna species (*Parinari kerstingii, Phyllanthus discoideus, Protea* sp. and *Isoberlinia* cf. *doka*) present during this time are those naturally found in fringing forest, drier parts of forest and/or moist parts of savanna. This vegetation is, however, not synonymous with the typical savanna in northern Nigeria which is naturally dominated by abundant grasses, sparse trees and shrubs such as *Acacia* sp, *Vitellaria paradoxa, Parkia biglobosa, Bridelia* sp., *Hymenocardia acida* and *Dichrostachys cinerea*. In summary, the vegetation in this zone consisted of abundant and diverse lowland rainforest and MSF. Charcoal counts were low indicating that fire, whether natural or human-made, was not common during this time.

Zone II: 50-0cm

This zone is characterized by major and significant changes in the Ahanve vegetation. *Rhizophora* pollen began to decline at 50 cm and decreased further until it completely disappeared. Thus this signaled the complete disappearance of *Rhizophora* from the area and consequently total destruction of the mangrove swamp forest.

Coupled with the disappearance of *Rhizophora*, was the disappearance of *Avicennia* and *Laguncularia*, and drastic reduction of *Acrostichum*. The LRF was also reduced being represented by pollen of open forest vegetation such as *Tetrorchidium didymostemon, Triplochiton scleroxylon, Newbouldia laevis, Celtis* sp., *Ceiba pentandra* and *Pycnanthus angoloensis.* There were further reduction in the LRF at the top of the zone at which point only *Tetrorchidium didymostemon, Hymenostegia afzelia* and *Pycnanthus angolensis* were recovered. These changes coincided with unprecedented upsurges in secondary forest, Poaceae, FWSF and subsequently, pollen of some cultivated plants and weeds associated with anthropogenic disturbances. At the same time, freshwater/aquatic taxa increased, while the pollen of some typical savanna species (*Borassus, Bridelia* cf. *ferruginea, Dichrostachys cinerea, Grewia bicolor, Entada abyssinica*) which were not recorded hitherto occurred. Thus, from the pollen evidence, it is clear there were drastic changes in the vegetation. The LRF and MSF vegetation became replaced by secondary forest (*Elaeis guineensis* and *Alchornea*) and abundant freshwater swamp species, and coastal savannas (*Borassus, Bridelia* cf. *ferruginea, Dichrostachys cinerea, Grewia bicolor, Entada abyssinica*) respectively.

The decline and eventual disappearance of *Rhizophora, Avicennia, Laguncularia*, and reduction in *Acrostichum aureum* are similar to results obtained in the same area by Sowunmi (2004). The level at which these vegetation changes were noticed in the Sowunmi's 11 m core was 50 cm, which is the same with that of this present study. This level was dated to ca. 3,109 ± 26 yrs B.P. Therefore, the period during which the mangroves disappeared and the LRF drastically reduced in the Ahanve core is considered to be contemporaneous with that noted by Sowunmi (2004). These vegetation changes are attributable mainly to (a) sea regression and (b) influx of freshwater into the area. Lowering of sea level, due to a dry period, has been noted for parts of West Africa ca. 4,500-2,500 yrs B.P. (Talbot *et al.*, 1984; Shanahan *et al.*, 2006). Similar periods of dry conditions which led to the reductions or disappearance of mangroves and rainforest vegetation was noted between 4,000 and 2,500 yrs B.P. in the Niger Delta area, Nigeria (Sowunmi, 1981a&b), in Bénin (Salzmann and Hoelzmann, 2005; Tossou *et al.*, 2008), and in Congo (Caratini and Giresse, 1979). In contrast, Marius and Lucas (1991) noted the abundance of mangroves in the Casamance Gulf of

Senegal ca. 3,000 yrs B.P. The latter result notwithstanding, majority of the palynological studies on mangroves in West Africa, some of which have already been mentioned indicated the reduction in mangroves during the late Holocene dry phase. Other areas in Africa where forest fragmentations due to this dry phenomenon were noted are: in Lake Eteza, in the coastal region of Kwazulu-Natal, South Africa (Neumann *et al.,* 2010) and in East Africa (Mayewski *et al.,* 2004). In the former area, dry conditions occurred after ca. 3,600 yrs B.P. This led to the decline of most forest trees and increases in Poaceae, *Phoenix*, Asteraceae and Amaranthaceae/Chenopodiaceae between 3,500 yrs B.P. and 2,500 yrs B.P. (Neumann *et al.,* 2010). Mangroves also decreased in Central India and in Rajastan between 4,500 yrs and 3,000 yrs B.P. due to drier periods arising from reduced monsoon rainfall (Ellison and Stoddart, 1991). At Lago crispim, Brazil, the vegetation which was dominated by rich, dense and tall Amazon forest and appreciable mangrove vegetation between 7,640 yrs B.P. and 6,620 yrs B.P experienced a reduction in mangroves between 6,620 yrs B.P. and ca. 3,630 yrs B.P. due to the occurrence of a dry climatic phase (Behling and Costa, 2001). These evidences suggest that the environmental changes seem pantropical in nature.

As stated earlier, a phenomenal increase in FWSF species occurred during this period. The occurrence of abundant freshwater species (*Nauclea diderichii*, *Mitragyna ciliata*, *Symphonia globulifera*, *Uapaca* spp.) as well as *Lygodium microphyllum* indicated that there were influxes of fresh water into Ahanve. The fresh water would have come from local rivers, possibly Yelwa River, Badagry creek and other rivers which were active in the past but may have now dried up. The inundating of the Ahanve swamp by fresh water reduced the salinity of the swamp which was not situable for development or expansion of *Rhizophora* or the mangroves generally. This change in hydrology of the swamp altered the mangrove ecosystem beyond a point where mangroves could possibly be re-established as noted by Sowunmi (2004).

At the top of this zone, the FWSF and freshwater/aquatics decreased indicating possible reductions in the influx or flow of freshwater into the site. With this probable reduction in the inflow of freshwater, marine water would expectedly have inundated the swamp and salinity level would have been slightly increased. Such hydrological changes would have facilitated the re-establishment of the mangroves. But there is no evidence that the MSF ever recovered. This was because of the following reasons: firstly, the reduction in the inflow of fresh waters into the site did not last long enough, and as a result, conditions favourable to the development of the MSF were not fully attained. Secondly, the vegetation and environment had been altered beyond the threshold capacity by the environmental change that took place from 4,500-2,500 yrs B.P. Thirdly, human activities (bush burning, clearing and agriculture) may have contributed to altering and transforming the landscape, preventing the re-establishment of mangroves, and favouring its replacement by secondary forest and coastal savannas. Fourthly, the mangroves had been completely destroyed without any remnants.

Of the four possible reasons given above the first seems most plausible because the FWSF increased at levels 5-0 cm signaling a re-establishment of conditions favouring the growth in FWSF vegetation such as influx of fresh water into the site. In fact, salinity level from Ahanve was the lowest in comparison with other areas in south western Nigeria (Table 10). This further strenghtens the inference made above that there was an influx of freshwater into the site, which lowered the salinity of the Ahanve swamp.

5.2.2 Occurrence of montane pollen at Ahanve: Implication for palaeoenvironment in Southern Nigeria

This section discusses the occurrence of montane species in the pollen record of Ahanve and the palaeoenvironmental implications of such occurrence. This is important because the dramatic changes which occurred at Ahanve ca. 3,100 yrs B.P. have been linked to a dry and cold climate. The recovery of pollen indicative of such a climate will therefore provide palynological evidence that will confirm the prevalence of a dry and cold climate ca. 3,000 yrs B.P. From 60 cm when the mangroves started to decline till 40 cm when *Rhizophora* completely disappeared, pollen of some montane species and those of typical savanna plants were recovered. The occurrence of the latter indicated that conditions were dry. The montane taxe recovererd included *Ilex mitis*, *Podocarpus milanjianus*, *Myrica arborea*, *Canthium* cf. *gueinzii* and Ericaceae. These pollen, which were hitherto few, subsequently increased indicating the prevalence of cold climate at that period. This partly accounts for why the mangroves, which are known to be susceptible to destruction by low temperatures (USGS Report, 2004), were completely destroyed.

At this point it is pertinent to take a closer look at these montane species and, if possible, infer how cold the environment was during that period. *Ilex mitis* is a tree of about 13m in height and is found in montane forest especially by stream side. At present, it is found at an altitude of 1,219-2,286 m (4,000-7,500 ft) in the Cameroon Mountain. *Podocarpus milanjianus* is an indigenous West African shrub or tree of about 100 ft. It is currently found at an altitude of 1,500-3,000 m (4,900-9,000 ft) in Cameroon and also in East African Mountains. *Myrica arborea* is a tree of about 6-9 m (20-30 ft) in height. It is found at an altitude of 7,600 ft in the Cameroon Mountains. *Canthium gueinzii* is a shrub found in Bamenda (Cameroon) at an altitude of 1,828 m (6,000 ft). Ericaceae is a family with three genera; these genera are *Aguaria, Philippia* and *Blaeria* (Hutchinson and Dalziel, 1958). These three genera have one species each, namely *Aguaria salicifolia, Philippia mannii* and *Blaeria mannii*. *A. salicifolia* is a small shrub of 12.2 m (40 ft) in height and is found in montane forest and grassland at an altitude of 1,219-3,048 m (4,000–10,000 ft). *Philippia mannii* is a shrub of 3.6 m (12 ft) and is found in Bamenda at an altitude of 1,370-3,352 m (4,500-11,000ft). *Blaeria mannii* is a "heath-like undershrub" (Hutchinson and Dalziel, 1958:2). *B. mannii* is found in the Cameroon Mountains and in Bamenda at an altitude of 1,829-2,407 m (6,000-7,900 ft). Of these three Ericaceae pollen grains, the Ericaceae pollen recovered from Ahanve (40 cm) is very similar to *Aguaria salicifolia*.

The present day temperatures of the Cameroon mountainous areas range from 16-22° C, while that of Ahanve, which is 0.5-2.0 m asl, is 27° C. Therefore the occurrence of the pollen of these montane plants at 40 cm of the Ahanve core indicates that temperatures during the Late Holocene Dry phase would have been at least 5°C lower than present temperatures. This 5°C lowering of tmpearature is consistent with Maley (1996)'s position. This dry condition was due to a redistribution of solar energy occasioned by a southward shift of the position of the Inter-tropical Convergence Zone (ITCZ) (Marchant and Hooghiemstra, 2004; Wanner *et al.,* 2008). This resulted in the pronounced weakening of the south west monsoon winds and led to increased drier conditions in Africa. Salzmann and Hoelzmann, 2005:198 suggested that this dry condition was also "associated with cold-water upwelling in the Gulf of Guinea". During this period in most parts of tropical Africa, the rainforest (LRF) and mangrove swamp forest (MSF) were drastically reduced. But in Ahanve, the MSF completely disappeared ca. 3,109 ± 26 yrs B.P.

It is also important at this point to note that none of these montane plants mentioned above are currently found in the present-day vegetation of Ahanve. Of the five montane pollen recovered from 40cm, none is found outside the Adamawa, Vogel Peak and Cameroon mountains. Furthermore there are no rivers directly linking these mountanous areas with Ahanve. Knaap (1971) reported the presence of *Podocarpus milanjianus* pollen in recent sediments in the Lagos lagoon, but did not provide the possible location where the pollen would have likely come from, and by what means. The pollen of *Podocarpus milanjianus* was also recovered from recent sediments in Ikorigho, a coastal village to the East of Lagos in Southern Nigeria (this thesis). It is proposed that the pollen of *P. milanjianus* might have been transported to Ikorigho from Lagos lagoon via the Oluwa River. The Oluwa River connects Ikorigho with the Lagos lagoon (Fig 3). Even if it is accepted that *P. milanjianus* was transported to Ikorigho from the Lagos lagoon, how the pollen got to Lagos lagoon in the first place remains unanswered. Furthermore, pollen of plants of typical savanna vegetation were recovered at 40 cm. These included the following *Borassus aethiopum, Bridelia* cf. *ferruginea, Dichrostachys cinerea, Grewia bicolor, Parkia biglobosa, Entada abyssinica*. The presence of these savanna pollen suggests that they were derived from somewhere north of Ahanve which is in line with the Apata and Kukuruku hills source of the montane pollen as discussed in pages 193-194 of this thesis.

5.2.3 Evidence of Vegetation disturbances in Ahanve

For a clearer picture and understanding of palaeoenvironment of Ahanve, it is important that the reconstructed vegetation, part of which will be highlighted below, be considered in the light of chronology i.e. dates. Because the core studied was not dated, due to lack of funds, an attempt was made to correlate it with the dated 11m core drilled in Ahanve by Sowunmi (2004). The pollen records obtained from the studied 200 cm core and those of the palynological results obtained for the upper 200cm of the 11 m core drilled by Sowunmi (2004) are quite similar. These similarities are summarized below.

First, the patterns exhibited some major species i.e. the MSF, LRF, secondary forest and savannas of the present core are similar to those of Sowunmi's (2004) core. For instance *Rhizophora* spp were abundant from 200 cm to 60 cm but started to decline at about 50 cm in both cores. Second, *Rhizophora* spp. completely disappeared at 30 cm in both cores. Third, increase in *Lygodium, Elaeis guineensis* and Cyperaceae was noted at 160 cm, 90 cm and 40 cm upwards in both cores. Fourth, the emergence and abundance of "true" savanna taxa were noted from 40 cm upwards. Fifth, unprecedented upsurges in *Elaeis guineensis* and *Alchornea* occurred from 40 cm upwards. Sixth, there was a general change in vegetation and species composition and diversity in both cores from 50 cm upwards. Seventh, freshwater swamp species became abundant at 50 cm in present core and, in the Sowunmi (2004) core; they increased from 60 cm but peaked at 50 cm.

Both cores are thought to be contemporaneous (at least the 2 m of the studied core and the uppermost 2 m of the 11 m of Sowunmi, 2004) based on the striking similarities in the palynological results as already outlined above. Furthermore, both cores are approximately 5 m apart. The period 200-60 cm in the 11m core obtained by Sowunmi (2004) was dated to between ca 5,900 yrs and 3,109 ± 26 yrs B.P. These dates were assigned to the samples at which point the mangroves existed and eventually disappeared in the studied core. At that time, pollen and spores of species linked to forest and hydrological disturbances became abundant in the pollen record. These include *Ceratopteris cornuta*, *Lygodium microphyllum* and *Polygonum senegalense*. Their environmental significance is discussed below.

Ceratopteris cornuta

This spore of this fern first appeared in the core at 40 cm when *Rhizophora* had declined or disappeared. *Ceratopteris cornuta,* though a fern, is a pioneer plant known to occur in places where the original vegetation has been disturbed, and is also indicative of freshwater incursions (Kumaran *et al*., 2004).

Lygodium microphyllum

Lygodium microphyllum first appeared at 190 cm; it fluctuated and became stable towards the top of the core. This species is a freshwater fern, and it is particularly known to colonise recently disturbed forest, and areas with changes in hydrology. Its appearance and subsequent increase is an indication that there were environmental changes in the area particularly the influx of freshwater over the area.

Polygonum senegalense

This species is also known to colonise disturbed areas, especially tiled soils. It first appeared at 120 cm and fluctuated, but its regular occurrences afterwards are indications that environmental disturbances and possibly human impact became more pronounced immediately after the mangroves disappeared.

5.2.4 Evidence of anthropogenic influence at Ahanve after 3,000 yrs B.P.

The pollen of weeds and plants associated with humans and cultivated lands which became abundant in the pollen record from 40cm upwards included *Vernonia amygdalina, Oldenlandia corymbosa, Cocos nucifera*, Asteraceae, *Euphorbia hirta* and *Elaeis guineensis. Vernonia amygdalina* is the common bitter leaf shrub used by humans for culinary, domestic and medicinal purposes. *V. amygdalina* is used to induce blood clotting in cases of minor injuries and is used in preparing the common bitter leaf soup in Southern Nigeria. It was not recorded until 20 cm. The occurrence of *Vernonia amygdalina* pollen is considered to be the result of deliberate cultivation of this plant, and possibly other vegetables, near homes and/or gardens and farmlands. *Oldenlandia corymbosa* was first recorded at 200 cm and later at 130 cm. But from 60cm upwards, it occurred regularly until the topmost level. *O. corymbosa* is an erect and diffusely branched herb... a weed of cultivation and beside paths "(Hutchinson *et al*., 1963:211). The presence and regular occurrence of this weed signify firstly, the presence of humans in the area. Secondly, that humans had started transforming the landscape through bush clearing and tree felling, since *O. corymbosa* is found in cultivated areas and beside paths, and thirdly that humans had started cultivating in the area. *Euphorbia hirta* is a common weed "widespread in tropical and subtropical countries" (Hutchinson and

Dalziel, 1958:419)". The occurrence of this weed at 60 cm signifies changes in vegetation probably through forest clearance.

Asteraceae pollen were first recorded at 180 cm and then at 120 cm, but they occurred regularly from 50 cm upwards. Asteraceae is said to have the highest number of angiosperms in the plant kingdom (Panero *et al*., 2008), and many of its members are herbs and weeds. The upsurge in Asteraceae referred to earlier was an indication that during recent times, the vegetation was more open and that weeds were prevalent at Ahanve. This is because many of the Asteraceae (especially *Aspillia africana*, *Ageratum conyzoides* and *Tithonia diversifolia*) are known to colonise agricultural sites, and are commonly referred to as weeds. *Cocos nucifera*, (coconut) a palm, is thought to be a native of South America and is cultivated throughout the tropics. It is thought to have been introduced into the Badagry area by the Portuguese in their first visit to the Badagry area during the 19th century and is spread by humans. However, according to Hodder 1963 (in: Alabi, 1998), coconut was introduced to Badagry by the Portuguese in 1880s. In this study, it was first recorded at 20 cm and appeared regularly till the topmost layer. Its occurrence during this period indicated the presence of human habitations in the area. The next *Elaeis guineensis* is the common oil palm considered native to West Africa as its pollen was first recorded in the Palaeoecene sediments of Senegal (Sowunmi, 1999). The occurrence of its pollen between 200 cm and 100 cm was sporadic but became regular between 90 cm and 0 cm. This shows that the oil palm tree became abundant in the pollen record after 100 cm. The oil palm tree is utilized for various purposes by the peoples of the West and Central African sub-region. Its fruits are used in making red palm oil which is used in cooking; the fruits are also eaten fresh, being a source of vitamin A; the endocarp or the kernel is eaten being a source of fat, oil and carbohydrate; the kernels are cooked to extract a dark-coloured oil used as pomade, massage cream for traditional massagers and bone-setters/or traditional orthopaedics and physiotherapists; the dried shaff-extract of the fruits is used as source of domestic fuel. The palm fronds or leaves are used in making brooms; palm wine is sometimes obtained from this tree, although the main wine palm tree is *Raphia hookeri*. The sudden and phenomenal increase and abundance of *Elaeis guineensis* pollen, with concomitant increase in the pollen of weeds and those of plants associated with human habitations as well as reduction in forest pollen are indicative of forest clearance and possibly cultivation by humans in forest regions (Sowunmi, 1981a&b, 1985, 1999). The increase in the pollen of *Elaeis guineensis* in the core was closely followed by *Alchornea*. Though *Alchornea* is not of any known economic or food value to humans, it is a pioneer in disturbed forest vegetation. Its increase also signals the occurrence of forest disturbance. But the increase alone does not necessarily indicate that the disturbances were directly due to human impact. However, the fact that its increase coincided with that of *Elaeis guineensis* as well as those of the other pollen stated above is evidence of an anthropogenic influence on the vegetation. It is important to note that the occurrence of these pollen coincided with the drastic reduction in the LRF. Thus the pollen evidence shows that from sometime around when 40 cm was deposited (i.e. after ca. 3,100 yrs B.P. correlated with Sowunmi's 11 m core of 2004) and from then onwards, human impact on the vegetation became more pronounced. This was particularly clear with the increase in the pollen of *Elaeis guineensis, Alchornea, Vernonia amygdalina, Oldenlandia corymbosa,* Asteraceae, and the emergence of *Cocos nucifera*.

5.2.5 Evidence of human impact from analyses of charcoal particles

Microscopic characoal which had hitherto been at minimal levels increased from 60 cm upwards indicating increased burning of trees and bushes (Athens and Ward, 1999; Kangur 2002). The increase in charcoal in this part of the core shows that the fires were continuous and regular in occurrence. Although natural fires occur in forest regions especially during the dry season, it seldom happens. Furthermore, continuously occuring natural fires are even rarer in coastal areas because the wet and humid conditions of the vegetation will not support such occurrence (Jensen, 2005).

In the forest regions of West Africa, bush burning is usually done preparatory to farming. This method, called "slash and burn" is practised throughout the tropics particularly in West Africa, occurs frequently and most likely accounts for the high amounts of charcoal noted in fossil record of rainforest regions. Therefore, the increase in pollen of weeds and plants associated with human habitation and cultivated areas on the one hand, and the significant and consistent increase in charcoal particules from

30cm upwards on the other, are evidences of human impact on the vegetation. These events, as noted above, occurred sometime between 30 cm and 0 cm when the *Rhizophora* spp (MSF) had already disappeared. This means that the disappearance of the mangroves in Ahanve, as reflected in this core, pre-dated any signs of the presence of humans in Ahanve. Therefore, it is suggested that humans did not contribute to the reduction or the disappearance of the mangroves at Ahanve ca. 3,100 yrs B.P.

5.3 Palynology of Otolu

Zone I (50-35 cm)

The mangrove swamp forest vegetation dominated the landscape during this time period (this zone) based on the abundant mangrove pollen (*Rhizophora*, *Avicennia* and *Acrostichum*). Pollen of freshwater swamp forest and freshwater/aquatics were also well represented in this zone. These increases in MEF, FWSF and FW indicated the prevalence of wet and warm climate. The abundance of LRF pollen between 50 and 40 cm is significant; its main constituents were *Celtis* cf. *brownii*, *Pterocarpus santalinoides* and *Syzygium guineense.* In addition, secondary forest represented by *Alchornea* and *Elaeis guineensis* were also well represented suggesting that firstly the LRF was not a closed forest, and secondly that the openings within the forest was most likely anthropogenic in nature. The second point is considered because of the high values of *Elaeis guineensis* which indicate that it was abundant in Otolu, and being a light-demanding secondary forest species, cannot thrive in closed forest. The significant increase of its pollen in the fossil record is associated with forest clearance in Nigeria (Sowunmi, 1999). Therefore, the prevalence of oil palm trees (*Elaeis guineensis*) in the vegetation may have been due to an anthropogenic influence. Furthermore, the low values of Poaceae suggest that the openings in the LRF were not climate driven but support an anthropogenic influence.

The subsequent decrease in the LRF was unexpected because the pollen record at that time indicated a wet environment. This coincided with further increases in *Elaeis guineensis* and appearance of the pollen of *Mangifera indica* (mango) appeared. The mango tree is planted because of its edible fruit; it is thought to have originated from Himalayas of India and Burma with the first evidence of its cultivation from the Hindu book (i.e. the *Sanskrit* literature) dated to 4,000 BC. This indicated that mango had been cultivated in Southeast Asia for at least 6,000 yrs B.P. (Blogger website, 2009). It was introduced to West Africa by the Portuguese between the 15th and 17th centuries but its acceptance by Africans and spread into the hinterland was slow (Blogger website, 2009). As a result, its presence in Nigeria may have been in the 18th or 19th century. Therefore, the increase in *E. guineensis* as well as the appearance of

Mangifera indica shows that the reduction in forest was most likely due to human impact. In addition, it is pertinent to note that there was an unprecedented increase in charcoal which could have been due to natural or anthropogenic fires. Fires are known to occur in the tropics especially in the savanna where dry conditions are obtained for about eight to ten months a year during which dry and highly inflammable vegetal materials are abundant in the environment. These materials can be ignited by lightning or burn naturally when a spark of fire occurs. Dry plant materials and cleared plant parts which have been left to dry are also gathered and burnt preparatory to farming in forest regions. However, natural fires are quite rare in wet forests and in the coast. The sudden increase in charcoal noted above, occurred during a period considered to be relatively wet. Therefore, considering the above the increase in charcoal particles in the top of the zone is an indication of human activities leading to the reduction in forest trees. Savanna species were present but few (*Daniellia oliveri* and *Parinari* cf. *kerstingii*) are the savanna species recovered from this zone. Of the two, only *D. oliveri* can be said to be a true savanna species. *P.* cf. *kerstingii* occurs in fringing forest and also in southern Guinea savanna vegetation in Nigeria. But the presence of *D. oliverii* at the site does not necessarily indicate change in vegetation or climate to a drier type rather that the pollen was transported there by wind and/or water, the site being located along the Lekki lagoon which stretches into the Lagos lagoon.

Zone II (35-15 cm)

There were fluctuations in the MSF but the relatively high values of *Rhizophora* showed that the MSF was still quite extensive. Reductions in mangroves resulting from a lowered sea level is usually followed by an upsurge in freshwater swamp forest species as was the case at Ahanve, South-western Nigeria (Sowunmi, 2004). However, in this zone, the values of freshwater swamp forest remained largely unchanged. Furthermore, this site, being very close to the Lagos lagoon, would have been directly fed with brackish water from the ocean via the lagoon. It therefore appears that the reduction in *Rhizophora* was not due to any reduction in sea level. Rather, it was most likely a consequence of further human impact on the vegetation. The recovery of *Anacardium occidentale, Zea mays* and Asteraceae and *Cocos nucifera* is significant.

The occurrence of the pollen of these food crops along with abundance of secondary forest (*Elaeis guineensis* and *Alchornea*) and fairly high charcoal particles are clear indications of forest clearance. Given the occurrence of the pollen of crops, the people in the area would have probably set fire before farming as in most parts of West Africa. It is suggested that the low amount of charcoal may be due to the location of the farming sites far from where the core was taken, and that fire was probably neither frequent nor widespread in the area. It has been reported by several authors that the identification of fire incident in the fossil record depends greatly on the distance of actual fire incident from the coring site (Nielsen and Odgaard, 2004; Asselin and Payette, 2005; Duffin 2008). In other words, the farther the coring site is from the actual site of burning, the less the amount of charcoal particles that will be deposited in sediments. This in turn determines the amount of charcoal that will be recovered in the fossil record. The Otolu core was drilled right in the middle of the mangrove swamp forest, and far from human settlement, and may have accounted for the low amount of charcoal recorded in Otolu in this zone.

It is known that forest clearance by fires may favour some plants and not others. Gobet *et al*., (2003) opined that forest clearance by fire favours *Alnus viridis* while being a disadvantage to *Pinus cembra* in temperate forest of Europe. Gobet *et al*., (2003) in a palynological study of a core from the Upper Engadine, Switzerland, found that increase in charcoal particles was followed by an increase in the pollen of *Alnus viridis* ca. 5,500 yrs B.P. The authors therefore concluded that this was evidence that humans had cleared the forest and practiced bush burning in the mid Holocene. Similarly, when the slash-and-burn farming method is used as a means of clearing forest in West Africa, the oil palm (*Elaeis guineensis*) is usually protected. As a result, this phenomenon creates an open environment which is advantageous to the spread of the oil palm. Subsequently, with each farming season, the bark of the oil palm becomes more tolerant of the repeated occurrence of fires. Thus while fire-intolerant plants die, fire-tolerant plants such as *E. guineensis* remain. Therefore, the increase in the pollen of such plants in the fossil record is another indication of the possible occurrence of fire in a given area. Of course this is more valid when high amount of the pollen of *E. guineensis* occurs with a concomitant increase in charcoal particles. Furthermore, the pollen of *Alchornea*, a pioneer plant in secondary forest and which is well known to colonise recently disturbed areas increased. These increases in *Elaeis guineensis* and *Alchornea* closely follow the increase in charcoal suggesting that fires set by humans provided the opportunity for the increase in at least these two plants. The LRF at this time was a dry type being characterised by *Celtis* sp., *Canthium setosum* and *Syzygium guineense.*

Fig 46: Destruction of mangrove trees in Otolu, Lagos State

Fig 47: A view of *Rhizophora* trees at Otolu, Lagos State

Monolete spores and FW/aqautic species (Cyperaceae and *Eichornnia crassipes*) were present but not significant. The pollen of *Parinari* cf. *kerstingii*—a savanna plant appeared in this zone; it is "a tree up to 60ft. high, in fringing forests and in the savanna regions" (Hutchinson and Daziel, 1958:428). Its occurrence may suggest the presence of savanna vegetation but just one pollen of *P.* cf. *kerstingii* was recovered which is not sufficient reason to infer that savanna vegetation occurred at that time. But the occurrence of *Parinari* cf. *kerstingii* suggests that the LRF vegetation was a secondary forest. Further increases in *Elaeis guineensis* indicated further openings, facilitated by human actions, within the LRF.

A very puzzling phenomenon noted in the pollen record was the increase in LRF pollen (*Irvingia gabonensis*, *Morus mesozygia* and *Syzygium guineense*). Of these three, the latter two are naturally found in drier parts of forests but the former is a typical wet forest species. *Irvingia gabonensis*, although a forest species, is also often planted on account of its edible fruit, and humans use its seed (*Ogbono*) as a soup thickner. Its occurrence may be linked to the presence of humans in the area. *Morus mesozygia* and *Syzygium guineense* dominated the LRF indicating that it was more of a secondary forest than a closed wet forest.

Zone III (15-5 cm)

The MSF continued to decrease to the top of the zone while secondary forest (*Elaeis guineensis* and *Alchornea*) was abundant with presence of some. Forest species remained relatively stable but there was an increase in the charcoal curve at this further strengthening the fact that there was a continuation of human impact. This is reflected in the present-day destruction of the LRF (Fig 46).

The appearance of freshwater species such as *Pancratium* and *Ottelia ulvafolia* was also noted at this time. Their occurrence indicated the occurrences of hydrological disturbances. One of the major human activities causing mangrove forest destruction particularly in Lagos State is dredging of the mangrove swamp. This dredging activity was recently prohibited by the Lagos State Government (Alhaji Raimu, 2008, Pers. Comm.). However, the effects of this activity in the past can be traced from the fossil record. The pollen record here provides evidence of dredging of the swamp, which led to the reduction of the mangroves and the prevalence of *Pancratium* and *Ottelia ulvafolia*. Reduction in fern spores may be indicative of reduced wet conditions but human impact might have obliterated the natural factors, making it difficult to determine what may have caused the fern spores to decrease. The occurrence of *Chrysobalanus icaco* is another indication of the influence of the sea. *C. icaco* is a plant whose natural habitat is near the sea. The appearance of *Cocos nucifera* and its steady increase to the top of the zone is another clear indication of changes in the vegetation due to anthropogenic impact on the vegetation. *Cocos nucifera* is a palm deliberately planted by humans usually along beaches. It was introduced by the Portuguese first into the Badagry area sometime in the 17th century (Alabi, 1998). It is currently planted in many parts of tropical Africa.

From the reconstructed vegetation, the climate was wet and warm, and would naturally support a wet LRF located by the coast but it was more of an open or secondary forest because of human impact. The reconstructed vegetation can be summarized as follows. Firstly, there was a reduction in *Rhizophora*, secondly, there was an increase in *Elaeis guineensis*, thirdly, the first appearance of the pollen of *Cocos nucifera*; fourthly, there were the appearance of pollen (*Pancratium* and *Ottelia ulvafolia*) indicative of hydrological disturbances (dredging of the mangrove swamp) and finally the continuous increase in amounts of charcoal particles. The present vegetation of Otolu is a combination of mangrove swamp forest, secondary forest, ferns and few grasses. The high amounts of *Elaeis guineensis* on the one hand, and increased charcoal particles on the other noted particularly towards the top of the core suggest that the coastal savanna vegetation may have been maintained by fire. Furthermore, some forest taxa which occurred in the underlying zone (*Daniellia ogea*, *Gaertnera paniculata*, *Mimusops warneckei*, *Pterocarpus santalinoides* and *Canthium setosum*) indicated a more dense and diverse LRF and MSF than now. The reductions in the LRF and MSF were due to human actions. However, the MSF is still present in Otolu; salinity levels in Otolu are high (Table 10), which partly accounts for the continued presence of the MSF there (Fig 47).

5.3.1 Antiquity of human settlement in Otolu

The pollen and anthracological evidences point to human impact on the vegetation which is an indication of human settlement of Otolu during the historic phase of the late Holocene. The time beginnng is, however, not known since this core was not dated. The pollen profile recorded the occurrence of human impact at the lowest part of the core i.e. 50cm based on the abundance of the pollen of *Elaeis guineensis* from level 50cm to level 5cm. Human activities, mainly farming and bush clearance, create conditions that facilitate its growth in secondary forest. The pollen of *Mangifera indica*, *Anacardium officinale*, *Zea mays*, *Cocos nucifera* and Asterceae were recovered in zone II. The first four pollen grains belong to plants that are cultivated in the tropics while the latter is a family of weeds associated with bush clearance and agriculture (e.g. *Aspilia africana, Synedrella nodifolia, Tithonia diversifolia, Ageratum conyzoides* and *Chromolaena odorata*). The occurrence of the pollen of crops is a direct botanical evidence that farming activities had begun in the site at that time. During the vegetation study of the area, mango and cashew trees were noted within the secondary forest. In the outer fringes of the secondary forest are coconut trees. Coconut, upon introduction to Nigeria from the Badagry area sometime in the 19th century, spread to other parts of Lagos and western Nigeria. The occurrence of the coconut pollen therefore indicated a post-17th century date for this zone. But this does not give a precise date for the possible antiquity of humans in the area. Therefore, the Otolu sediments might have been deposited few centuries ago and must await radiocarbon dates for confirmation.

5.4 Palynology of Ikorigho I

Zone I: 200-125cm

Mangrove species dominated this zone especially *Rhizophora*, *Avicennia* and *Acrostichum aureum*. Poaceae were fairly abundant in this zone indicating that there might have been abundant grasses within the local vicinity of mangroves swamp. The absence of forest species probably indicated that the lowland rain forest (LRF) vegetation was absent or very distant from the site. Currently there is no LRF in the site. The low representation of freshwater/aquatics (*Pandanus* and Cyperaceae) and freshwater swamp forest species (*Mitragyna ciliata, Uapaca* spp. and *Symphonia globulifera*) in the early part of this zone showed that they were not abundant.

Herbs, which are typical of or indicative of vegetation disturbances were present though in very low occurrences; they included *Ageratum conyzoides*, Asteraceae, *Sida acuta* and Chenopodiaceae/Amaranthaceae. The presence of these pollen types may signal occurrence of disturbances within the vegetation. Similarly *Alchornea* and *Elaeis guineensis* and charcoal particles were well represented in this zone. It is most likely that these increases in were probably a result of human impact on the vegetation. Subsequently, fluctuations were noted for *Rhizophora* while *Avicennia* increased. What then was responsible for the fluctuations in *Rhizophora* with a concomitant increase in *Avicennia*? To examine this situation, a closer attention shall be paid to the relationship between *Rhizophora* and *Avicennia*.

Ikorigho is located on the Oluwa River on the south-western coast of Nigeria (Fig. 3). This river runs somewhat parallel to the Atlantic at some point but eventually empties into the Atlantic. A well known factor influencing the growth and establishment of coastal vegetation is change in sea level (Blasco *et al*., 1996). An increase in sea level leads to expansion of mangrove swamp forest. Sea transgression is particularly important for mangroves although sea level influences mangroves species differently. These coastal species depend on marine influence, an increase or decrease in their pollen in the fossil record can be used to reconstruct past changes in sea level. According to Blasco *et al.*, (1996:5) "mangrove pollen are particularly good markers because their presence in the sediments indicates a warm climate (with a mean monthly temperature above 16° C) and a nearby shoreline at the time the pollen was deposited". The *Rhizophora-Avicennia* (R/A) ratio was used to interpret the mangrove and environmental dynamics at Ikorigho based on a *Rhizophora/Avicennia* model used by Vedel *et al.,* (2006) and Cohen *et al.,* (2005) from Taperebal, Northern Brazil. This model was adopted for the Nigerian mangrove forest because *Rhizophora* spp (red mangroves) and *Avicennia africana* (white mangrove) are the most dominant species although the former are the most dominant. These species occupy different elevations, and have different salinity tolerance levels within the mangrove swamp forest. The area *Rhizophora* trees occupy is referred to as the *Rhizophora* zone in which *Rhizophora racemos* is a pioneer and occupies areas the limit of diurnal tides which is flooded twice daily (Keay, 1959). The next, *R. harrisonii*, is dominant in middle areas of the *Rhizophora* zone while *R. mangle* is found in the drier inner limit of the *Rhizophora* zone. *Avicennia africana,* otherwise called white mangrove in West Africa (a related species, *A. germinans,* is known as black mangrove in West Indies and Florida) is found behind the *Rhizophora* zone. This is why it is sometimes referred to as back-mangrove; it is usually found at edges of hardened soils on the "landward side of the MSF" (Adegbehin, 1993:141), and usually on elevations higher than those occupied by *Rhizophora* species (Vedel *et al*., 2006). The pollen of *Rhizophora* species, being the dominant mangrove species in Nigeria reaches over 80 % of the pollen sum because they produce large quantities of pollen and are wind-pollinated. On the other hand, *Avicennia*, which is insect-pollinated, produces very few amounts of pollen (Vedel *et al.,* 2006; Behling *et al.,* 2004). Studies have shown that *Avicennia* pollen is low even in the immediate proximity of parent trees, are poorly dispersed in the atmosphere and are not transported over long distance (Lezine *et al*., 2002). This accounts for its low representation in the pollen record. Therefore, because *Rhizophora* grows on tidal areas and comes in direct contact with the ocean or sea, its pollen is usually used to determine relative sea level. Where the value of *Rhizophora* in the pollen sum is high i.e. over 60 %, sea level is thought to be high and vice versa but where percentage of *Avicennia* in the pollen sum is higher than that of *Rhizophora*, relative sea level is thought to be gradually reducing and a cooler climate is inferred.

According to Vedel *et al.*, (2006), the modern pollen rain in Taperebal, Northern Brazil has an average R/A ratio of 115; a R/A ratio value of between 6 and 205 indicated a *Rhizophora*-dominated forest; a ratio of 2-5 was considered to represent a mixed *Rhizophora/Avicennia* mangrove swamp forest while a ratio of less than 1 was an *Avicennia*-dominated MSF. The modern pollen rain of the Ikorigho mangrove swamp forest, where *Rhizophora* is dominant, has a maximum R/A ratio of 56.7 and a minimum of 40.8. These values were regarded as standard R/A values for the MSF at Ikorigho. Therefore where the R/A values, in the fossil record, were found to be between 40.8, 56.7 and above, the mangrove vegetation is a *Rhizophora*-dominated. But there were no means of determining the present-day R/A values of either a mixed *Rhizophora/Avicennia* mangrove swamp or an *Avicennia*-dominated forest. This was due to obvious reasons. However, it is assumed that where the R/A values are between 2 and 10, the mangrove is a mixed *Rhizophora/Avicennia* forest, and where R/A values are below 2, the mangrove is *Avicennia*-dominated.

Thus, at the beginning of this zone (200cm) where the R/A ratio was 145, it means that the MSF at that time was dominated by *Rhizophora*. At l85cm, the R/A ratio was 36.0. This figure is significantly lower than what was recorded for 200cm but not low enough to be regarded as a mixed *Rhizophora-Avicennia* mangrove swamp forest but signaled a comparative increase in *Avicennia* trees. At 165cm, the R/A ratio was 28. This indicated a further increase or proliferation of *Avicennia* with a reduction in *Rhizophora* because the higher the percentage values of *Avicennia* pollen, the lower the R/A ratio. What this means is that *Avicennia* was gradually becoming quite abundant at the site. The R/A ratio continuously decreased from 200cm to 165cm. The decreasing R/A ratio indicating that there were some environmental changes within the MSF at Ikorigho between 200cm and 160cm.

The LRF species continuously decreased from 200cm to 170cm. Freshwater swamp forest (FWSF) species were well represented between 200cm and 165cm. From the foregoing therefore, the fluctuations referred to earlier were due to some unstable environmental conditions. *Avicennia* is known to dominate during periods of lowered sea level (Lugo and Snedaker, 1974). In addition, the dominance of *Avicennia* coincided with the abundance of freshwater swamp taxa such as *Mitragyna ciliata*, *Macaranga*, *Uapaca* spp., and *Symphonia globulifera* indicated that there were reductions in marine influence over the area, which were consequences of the gradual fall in relative sea level. The pollen record shows that mid-way in this zone (Fig 39) the vegetation was dominated by freshwater swamp forest, freshwater, ferns and few mangroves. Upsurges in *Elaeis guineensis* as well occurrence of few LRF pollen are indications of an open LRF which enhanced the abundance and spread of *Elaeis guineensis*.

5.4.1 Evidence of human disturbances between 130cm and 125 cm

At 130 cm, pollen of *Spondias mombin*, Asteraceae, *Sida acuta* and *Talinum triangulgare* were noted. These pollen, particularly those of the latter three are known to colonise disturbed lands while the formermost, though a forest tree, is usually protected around human dwellings in the tropics. The occurrences of these pollen are therefore indications of some possible human disturbances at Ikorigho.

At 125 cm, there were marked reductions in many species especially the mangroves. Reductions in mangroves indicate either occurrence of dry conditions or human impact on the MSF. The occurrence of drier climate seems unlikely because Poaceae pollen which is known to increase particularly during dry conditions reduced. Similarly, *Typha australis* which was hitherto stable decreased. In contrast, there were increases in *Elaeis guineensis*, Asteraceae (cf, *Aspillia africana*), *Ageratum conyzoides*, *Mangifera indica* and *Vernonia* cf. *cinerea*. These species are associated with human habitations and disturbances within forest vegetation. The upsurge in these pollen coincided with moderate increases in charcoal particles. In addition, the pollen of *Spondias mombin* and *Blighia sapida* increased. The increase in the pollen of *Elaeis guineensis*, cf. *Aspillia africana, Ageratum conyzoides, Vernonia* cf. *cinerea, Mangifera indica, Blighia sapida* and *Spondias mombin* at a time when the MSF became significantly reduced appears to be more than a coincidence. *Blighia sapida*, according to Hutchinson and Dalziel (1958:722) "is a forest tree 20-80 ft. high…but most usually seen planted near dwellings". Hutchinson and Dalziel (1958:728) stated that *Spondias mombin* is "widespread and common in farmland regrowth and villages especially in the forest regions, but also in savanna regions; usually thought to be an ancient introduction from

America, but possible native in West Africa". The fruit of *Spondias mombin* is usually eaten as it gives a distinct sweet taste. It therefore appears that deliberate protection of the tree for the purpose of obtaining its fruit may have been done. Furthermore, although Hutchinson and Dalziel (1958) did not state that *S. mombin* is actually cultivated, the occurrence of its pollen in association with other pollen associated with agricultural activities (*Elaeis guineensis*, *Aspillia africana*, *Ageratum conyzoides*, *Mangifera indica* and *Vernonia* cf. *cinerea*) and *Blighia sapida* suggests some clearance and farming activities during this period.Reductions in *Rhizophora* and *Avicennia* at 130-125 cm coincided with increases in *Spondias mombin*, *Blighia sapida*, Asteraceae and charcoal (Fig 39). Therefore, human activities led to the reductions in the MSF. The people utilize *Rhizophora* and *Avicennia* for building, and smoke-drying of fish and fuel. Thus it is not impossible that during this period, the people had started destroying the mangrove swamp forest (MSF) during this period.

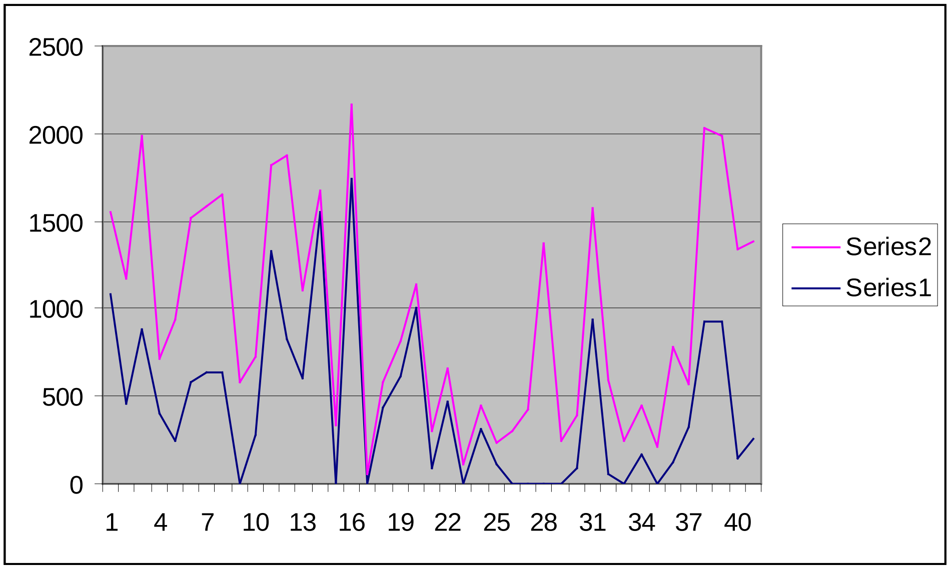


Fig 48: Comparison between *Elaeis guineensis* and charcoal counts of Ikorigho I core [Series 1: % of *Elaeis guineensis* pollen; Series 2: Charcoal counts from 0-200cm]

The diagram in Fig. 48 shows that the increase in charcoal (increased use of fire) corresponds to an increase in the pollen of *Elaeis guineensis* pollen, and therefore a spread of Oil palm trees. In many parts of West Africa, slash and burn method is the most common and traditional farming practice used. In this case, the Oil palm was deliberately protected while other forest trees, weeds and grasses were cleared and burned. As a result, artificial openings were created within the forest and the oil palm was left to thrive. At the same time, fairly high amount of charcoal particles were deposited in the sediments due to the continuous bush burning. Thus, an increase in charcoal particles coinciding with an increase in the oil palm pollen is here considered an evidence for human impact on the environment. As can be noticed from the pollen diagram (Fig. 39), the period of increase in the amount of *E. guineensis* and charcoal coincided with that when *Rhizophora* and *Avicennia* reduced drastically. This is the first clear botanical evidence of human interference with the mangrove swamp forest at Ikorigho i.e at 125 cm. However, LRF increased; if the pollen and charcoal records signaled felling of trees as a result of human impact, why then did pollen of forest taxa increase?

The LRF species included *Blighia sapida*, *Pterocarpus santalinoides* and *Berlinia* cf. *grandiflora*. *Blighia sapida* is a forest tree and is usually protected while the other two are riverine forest taxa .This means that the major part of the forest vegetation consisted of protected plants and riverine taxa. Therefore, the pollen of *B. sapida* along with those of Asteraceae, *Aspillia africana*, *Ageratum conyzoides*, *Vernonia* cf. *cinerea*, *Mangifera indica* and *Spondias mombin* indicated that part of Ikorigho was a human settlement. It further revealed that human settlement within the area was located close to a river source. The marked increases in the value of *Typha* and Cyperaceae are suggestive of a freshwater incursion into the site. Though, this evidence is coming from two taxa (*Typha australis* and Cyperaceae), the absence of other FW species such as *Nymphaea* and *Pandanus* sp may suggest that the fresh water incursion was a brief event. The R/A ratio index which was 8.6 is a indication that the MSF was a mixed mangrove swamp forest.

Zone II: 125-65 cm

The continuous increases in *Avicennia* and FWSF, and reductions in *Rhizophora* and *Elaeis guineensis* coincided with low values of charcoal, increase in *Typha*, Poaceae and in monolete spores showed that environmental conditions favoured the growth of *Avicennia* and led to it being the dominant tree in the mangrove swamp forest. The low R/A values noted for this period indicated an abundance of *Avicennia* over *Rhizophora*. Could an over-exploitation of *Rhizophora* by the people have led to its reduction?

Ethnographic study carried out at Ikorigho by the author indicated that there seems to be no significant preference for any of the major mangrove trees i.e. *Rhizophora* and *Avicennia* by the people, although both trees are used for slightly different purposes. The wood of *Rhizophora* is usually used in building houses, while that of *Avicennia* is used in constructing pedestrian bridges or walk ways (Figs 49-50); both are used in smoking or drying fish. If an over-exploitation of *Rhizophora* by the people led to its reduction, the effect of human impact on other aspects of the vegetation would most likely have been recorded in the pollen record. The pollen of *Elaeis guineensis* and *Alchornea* which are indicators of human impact were few while those of weeds, Amaranthaceae/Chenopodiaceae and Astereceae were not present at this time. From the pollen evidence, it appears that human population may have been low at this time. Furthermore, the amount of charcoal was lower than that when humans were first noted in the Ikorigho core. Therefore, the comparatively low amount of charcoal particles recovered from levels 90-80 cm supports the suggestion made earlier that human population may have reduced in Ikorigho at that time. Thus the reduction in *Rhizophora* may not have been due to an over-exploitation of its trees but lowered salinity levels and reduced marine influence which are advantageous to the growth of *Avicennia*.

Fig. 49: Wood of *Rhizophora* used in building in Ikorigho

Fig. 50: Wood of *Avicennia* (white mangrove) ‘harvested’ in Ikorigho

The environmental conditions which prevailed at Ikorigho would have exposed the swamp and allowed for a greater access to *Avicennia* trees or wood which would serve as source of fuel to the people. However, it appears that the Ikorigho people did not take advantage of this situation because of the high values of *Avicennia*. Perharps, the Ikorigho people temporarily abandoned the area due to the inferred drier environmental conditions that took place during that period.

Zone III: 65-25 cm

This early part of this zone is characterized by marked reduction in *Rhizophora* and increase in *Avicennia*, *Typha*, Poaceae and *Pandanus* suggesting that the environment was an open vegetation and drier climate. *Tetrorchidium didymostemon*—a tree naturally found in dry or more open forest—which was hitherto absent appeared at 65 cm. The reduction of the MSF during this period, most probably was due change in hydrology and local climate which eventually led to the proliferation and dominance of freshatwater/aquatic species. Afterwards, *Rhizophora* increased with decreases in *Avicennia*, Poaceae, *Typha* and *Pandanus*. These reductions in the above-mentioned elements were due to increased wetness and a general amelioration of climatic conditions.

Few forest species were observed in this zone (*Celtis* sp. *Flabellaria paniculata*, *Macaranga sp., Syzygium guineense, Tetrorchidium didystemon a*nd *Elaeis guineensis*). The sparseness of pollen of forest taxa is sufficient evidence that the LRF was not present at Ikorigho at that time. What may have been present was at best a riverine and freshwater swamp forests because eof the abundance of their species. Human interference here may have been very minimal. Subsequently changes in the vegetation were due to combination of human and hydrological factors. This is because of the following reasons: The first is that when *Rhizophora* decreased, there were increases in *Avicennia, Typha, Pandanus*, Poaceae, and pollen of plants associated with human disturbance. The latter set of pollen includes *Ageratum conyzoides, Chromolaena odorata,* Asteraceae and Amaranthaceae/Chenopodiaceae. The second is that of significant increases in charcoal.

Again *Rhizophora* and *Acrostichum* became reduced while *Avicennia Typha, Pandanus,* Poacaeae, *Polypodium* and monolete spores increased. The vegetation, at that time, was dominated by freshwater species and ferns. The appearance of *Podocarpus milanjianus* and *Myrica arborea* at 45 cm and 50 cm respectively is significant. These montane species are presently not found any where near the site but occur around the Adamawa highlands and the Cameroon mountain range. In these areas, the average temperature is between 20° C and 22.5° C, at an average height of 1250-1500 m asl. These species are indicative of cool and drier environments. So where did they come from, and how did they reach the Ikorigho site? This has been discussed in more detail in pages 194-195 of this thesis. Further decreases in *Rhizophora* coincided with increase in *Avicennia, Typha, Pandanus* and Poaceae. The drastic reduction in *Rhizophora* could have been climate driven trather than being anthropogenic because of the low value of *Elaeis guineensis* and *Alchornea* and lack of pollen of weeds and/or plants associated with humans.

Zone IV: 25-0 cm

Rhizophora spp had a regular increases indicating that the MSF was now dominated by *Rhizophora* sp. In contrast, *Avicennia* declined continuously. Poaceae, *Typha* and members of the FWSF decreased; very few LRF taxa were present: *Tetrorchidium didystemon, Bosquiea angolensis, Pycnanthus angolensis* and *Lophira* cf. *alata*. The pollen diagram (Fig 39) thus indicates a return of favourable environmental/climatic conditions because of the dominance of *Rhizophora* in the MSF. The MSF can be referred to a *Rhizophora*-dominated MSF being inundated by marine water from the Atlantic Ocean at that time. The effect of marine influence is further reflected in the salinity levels (Table 10) obtained for the site. That Ikorigho produced the hightest salinity figures obtained from all the sites partly explains why the MSF there is dense even today. Secondary forest decreased slightly but charcoal increased sharply (Fig 51). These marked increases in charcoal, which occurred during a wet period, resulted from domestic activities such as in smoke-drying of fish, cooking, and bush burning. These activities indicate increased use of fire and more permanent stay at the site. The people of Epe (Lagos State), Okitipupa and

Aiyetoro (Ondo State) are known to be very active in the smoked fish trade (Akegbejo-Sampsons, 1999). Aiyetoro is located along the same Oluwa River that connects Ikorigho.

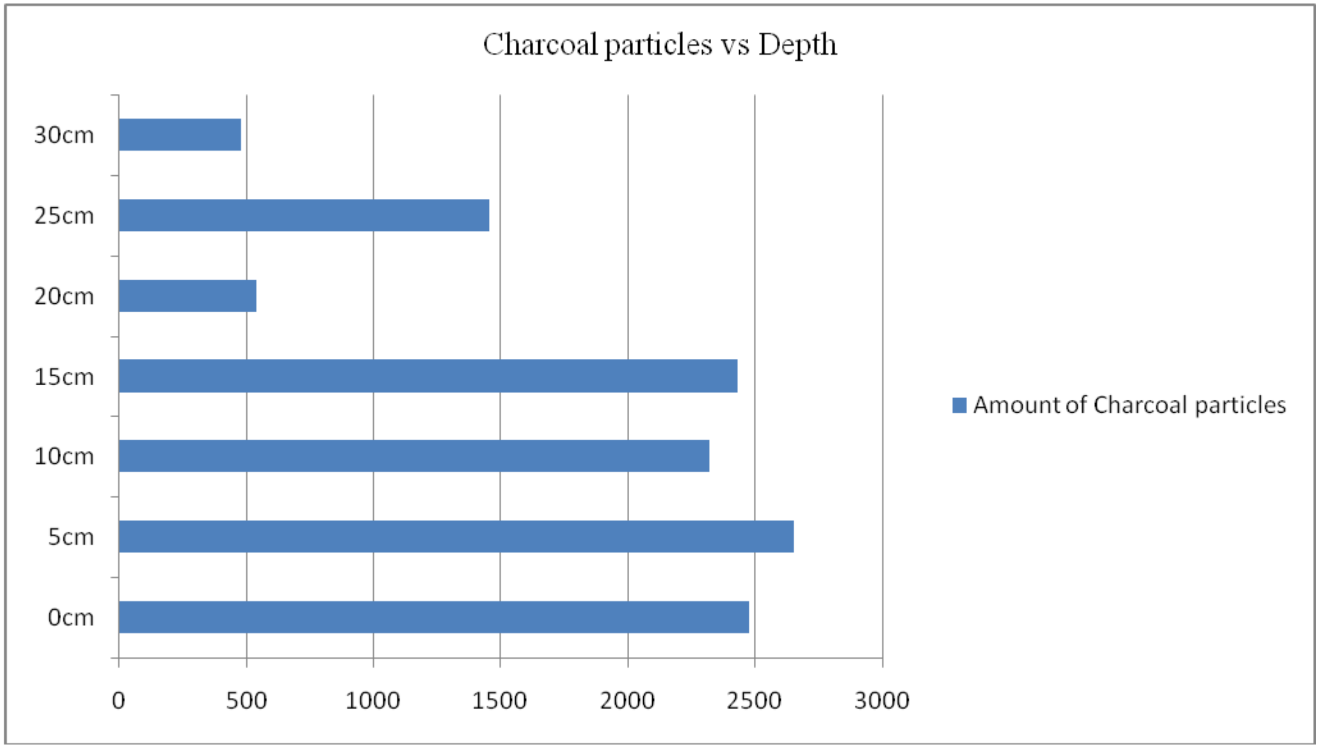


Fig 51: Graph showing charcoal (x axis) plotted against depth (y axis) in Ikorigho I core

That the increases in charcoal occurred at the top of the core suggest that these activities are recent. According to our informants, the people settled in Ikorigho less than 100 years ago (Segede, pers comm., 2010). The pollen and charcoal records corroborate the oral history of the people's antiquity in the area. Therefore levels 30-0 cm might have been deposited within the second half of the last century.

In summary, the first pollen evidence of human presence in the site was at 125 cm where the pollen of *Spondias mombin, Blighia sapida,* Asteraceae, *Mangifera indica, Vernonia cinera* became abundant in the pollen record. The parent plants of these pollen are associated with human habitation; the abundant pollen of *S. mombin* and *B. sapida* during this period siginified that the people engaged in farming. The marked increase noted in the pollen associated with human habitation which coincided with abundant riverine taxa indicated that the human settlement was near a river source. However, on account of the fluctuations in the values of pollen and charcoal, human habitation at that time was probably sporadic. Subsquently, charcoal particles continously increased while the pollen of plants associated with humans became regular in appearance from 25-0 cm. Thus, both pollen and charcoal evidence indicated permanent and/or increased human presence at the site during the historical period probably within the last 100 years. This coincided with the period of human settlement in the area, and is consistent with the oral history of the Ikorigho people.

5.4.2 Significance of the dominance of *Avicennia* in Ikorigho mangrove swamp forest

Perry and Mendelssohn (2009) noted expansion of *Avicennia germinans* (black mangrove) into salt marshes dominated by *Spartina alterniflora* in Louisana, U.S.A; the salt marshes had a higher elevation, low soil moisture content and pore-water salinity. The two latter characteristics are indicative of drier environmental conditions. Vedel *et al*., (2006) reported that before 6,500 yrs B.P., the mangrove swamp forest was the dominant vegetation at Taperbal, North East Para State. Although the vegetation consisted of *Rhizophora, Acrostichum aureum* and *Avicennia*; the lattermost was the most dominant. Associated with this *Avicennia*-dominated mangrove swamp vegetation were coastal Amazonian rainforest, restinga and saltmarsh. The dominance of *Avicennia* was interpreted as indicative of lower relative sea level (RSL) accompanied by rare marine inundations at that time. During the mid-Holocene, some time after 6,500 yrs B.P., the local vegetation became dominated by *Rhizophora* trees while *Avicennia* became less important. Vedel *et al.*, (2006:121) stated that the "*Rhizophora*-dominated mangrove and the decrease in *Avicennia* clearly indicated a rise of the RSL, and an increase of ocean incursion in the study area". Therefore, when an increase in *Avicennia* occurs with a concomitant decrease in *Rhizophora*, a lower RSL and possibly reduced soil moisture and cooler climate could be inferred. The reverse would be the case when *Rhizophora* increases at the expense of *Avicennia*.

Rull (1998) reported a maximum sea transgression during the middle Eocene in the Maraciabo Basin of Venezuela. This sea transgression was accompanied with increase in pioneer mangrove pollen. Based on the abundant pollen of pioneer mangroves, a higher sea level and wet climate were inferred for the Mid Eocene in Maracaibo Basin. In contrast, a sea "regressive phase is characterized by pollen from back-mangrove open forest due to the cooler climate" (Rull, 1998:293). The back-mangrove is defined as that vegetation located behind pioneer mangroves, and charactersied by palms and ferns in the Maracaibo basin during the mid-Eocene. Admittedly, neither *Rhizophora* nor *Avicennia* was a component of the mangrove and back-mangrove vegetation during the mid-Eocene in Venezuela. This was because both species were not present in the Americas at that time. The earliest record of *Rhizophora* in Venezuela was in the Early Miocene (Kuyl *et al.,* 1955) while *Avicennia* did not evolve until the Late Miocene in the Atlantic Carribean and East Pacific (ACEP) area under which Venezuela belongs (Ellison *et al.*, 1999). But, Rull (1998)'s inference of a sea regressive phase reflected by an abundance of pollen from back-mangrove was not based on the characteristic pollen and spores, but on the source of the palynomorphs. In other words, irrespective of the constituent palynomorphs in the back-mangrove, what is important is that the palynomorphs were derived from back-mangroves. Thus, an abundance of pollen from back-mangove represents sea regression and cooler climate. Evidently, this was what occurred in Taperebal, NE Para State, Northern Brazil just before 6,500 yrs B.P., which has already been discussed above.

The same situation is presumed to have occurred at Ikorigho when there were significant increases and subsubsequent dominance of *Avicennia* reflecting drier conditions and incursions of freshwater into the area. The drier conditions were due to combinations of more seasonal climate and longer drier seasons. These inferences are supported by marked increases in Poaceae, *Typha australis*, Cyperaceae and monolete spores. Significant increase in the formermost (with marked reduction in LRF) is linked to drier environmental conditions while increases in *Typha* and Cyperaceae indicate increased influence of freshwater and local lowering of sea level. Such an environmental condition is usually drier and is known to be associated with abundance of Poaceae (grasses) which increased and supports the prevalence of some possibly drier and colder environmental conditions. The pollen record shows that the MSF was *Avicennia* dominated between 80 cm and 70 cm and at 25cm while *Rhizophora*-dominated between 65 cm and 30 cm. From the foregoing therefore we can infer that during the period of the dominance of *Avicennia*, the environment was drier than previous periods. At the same time, Poaceae had an upsurge. In addition, increases in *Typha* and Cypearceae at that time indicated less marine influence over the area and occurrence of an open vegetation. But when *Rhizophora* became dominant, the environment was characterised by wet climate and marine influence.

5.5 Palynology of Ikorigho II

Zone IK I: 800-670 cm

The vegetation during this time was that of a mangrove swamp forest though it may not have been extensive. This is because the mangroves fluctuated and eventually decreased. In contrast, from the initial stages of this zone, when there were decreases in the MSF, there was an increase in monolete spores. When the MSF species decreased, there were no significant increases in *Alchornea* and *Elaeis guineensis*; they fluctuated throughout this part of the zone. As a result, the effect of human impact on the vegetation seems unlikely. Freshwater swamp forest (FWSF) and freshwater/aquatics (FW) species were well represented indicating the presence of freshwater swamp, influx of freshwater into the site, and that local rivers in the area would have been quite active. Furthermore, the pollen of *Podocarpus milanjianus* was recovered at levels 800 cm and 750 cm. Its occurrence indicated a long distant transport of its pollen into the site, maybe by river. This seems to support the inference made above. It might be possible that the influx of local rivers caused a lowering of salinity levels that led to the decreases noted in the MSF. During this same period, few and fluctuating LRF pollen, many of which are naturally found in dry/open forest were recovered. The LRF pollen included *Morus, Syzygium, Pycnanthus angolensis, Celtis, Diospyros, Entada gigas, Alstonia booenii, Parkia bicolor, Canthium setosum, Flabellaria paniculata* and *Tetrorchidium didymostemon*. The fluctuations noted in the LRF indicated that during the earliest period of the deposition of this core, the LRF was a secondary forest.

Although, only one savanna taxon (*Brachystegia eurycoma*) was recovered, there were marked increases in Poaceae and Cyperaceae. Increases in Poaceae and Cyperaceae are indicative of semi-open landscape (Niinemets and Soarse, 2006). Therefore, the fair representations of Poaceae and Cyperaceae suggest a landscape that was open. A date of 1,190 ± 30 yrs B.P. was obtained for level 770-780 cm. This period as stated earlier was when the LRF was not abundant. The LRF here appears to be the relict of that which survived the late Holocene dry phase. Increases noted in Poaceae (grasses) and *Typha* at 730 cm with concomitant reductions in LRF and MSF (Fig 40) are indications of some environmental instability such as drier climatic conditions. This period is probably contemporaneous with changes in vegetation noted in Lac Sélé in Southern Bènin during which period, rainforest and mangroves completely disappeared. This period was dated to ca. 1,100 yrs and “indicates dry environmental conditions at the Dahomey Gap, resulting in the renewed establishment of an open savanna which persisted until present”. The vegetation changes at 730 cm in Ikorigho are likely contemporaneous with those which occurred at Lac Sélé ca 1,100-1,000 yrs B.P. suggesting that a second but brief dry phase occurred after the major one that took place ca. 4,500-2,500 yrs B.P.

Wetter conditions were noted in coastal Gabon beginning from 1,300-1,200 yrs B.P. but forest expansion was limited due to human impact (Delègue *et al*., 2001). Vincens *et al.*, (1997) noted that between 1,300 yrs and 1,100 yrs B.P. immediately after a dry phase that lasted from 4,200-1,300 yrs B.P., there were humid conditions around Lake Sinnda in Congo but quickly added that forest expansion was limited due to low rainfall, longer dry season, and low water availability in soils and burning of grasslands by humans. In other words, forest vegetation did not expand due to a combination of natural seasonality in climate and anthropogenic burning. Therefore, where these conditions i.e. seasonality in climate and anthropogenic burning, are present, forest expansion within a wet period is delayed or limited. These conditions, except human burning, probably occurred and might have been severe at Lac Sélé which led to the complete disappearance of the rainforest and mangrove swamp forest vegetation.

The pollen evidence shows that, in contrast to those at Lac Sélé in Bénin, the MSF and LRF recovered after this dry phase. Why was there a subsequent increase in MSF and LRF in Ikorigho in sharp contrast to what occurred at Lac Sélé? The reasons for these changes are as follows: Firstly, the location of the sites and secondly access of the sites to marine waters from the Atlantic Ocean. Lac Sélé is located 90 km into the hintherland, within the Dahomey Gap—an area noted in West Africa to be characterized by abundant grasses, less rainfall (present-day 1200-1000 mm/ yr), sparse trees and drier climate. Ikorigho, on the otherhand is located within the rainforest zone and is adjacent the Atlantic Ocean. Present-day rainfall there is between 2600 mm/yr and 2800 mm/ yr. Thus, abundant rainfall allowed the LRF and MSF to remain in Ikorigho. Secondly, in Lac Sélé, pollen of *Rhizophora* and those of LRF such as *Holoptelea grandis, Triplochiton scleroxylon, Fagara* and *Uapaca* which were hitherto abundant disappeared from the record while Poaceae (92 %) and Cyperaceae (62 %) had phenomenal increase. The non-recovery of the LRF and MSF as well as the phenomenal increase in Poaceae and Cyperaceae indicated dry climatic conditions at Lac Sélé, and that perhaps lowered sea level. In fact, Talbot *et al.*, (1984) reported the occurrence of a second reduction in lake levels of the Bowuntwi Lake around 1,100 yrs B.P. Thus, it can be inferred that sea level in Lac Sélé was also lowered and that it was perhaps cut off from the Atlantic Ocean ca. 1,100 yrs B.P. In contrast, though the sea level might have been lowered, Ikorigho had direct access to the Atlantic Ocean. This enabled the re-establishment of the LRF and MSF in Ikorigho. The recovery of *Podocarpus milanjianus* at a point when FWSF was abundant suggests that the Oluwa River in Ikorigho was active and transported the pollen of *Podocarpus milanjianus* from areas where it may have existed. The suggested areas are the highlands of Apata and Kukuruku hills. The pollen would have reached these areas by water during a period of colder climate or a slight reduction in temperature. This has already been discussed in more detail in pages 193-194 of this thesis.

Zone IK II: 670–490 cm

There were some environmental changes between 670-660 cm because very few pollen were recovered. After this time, the environment became characterized by abundant MSF and FWSF species. The rainforest pollen are mainly those of a drier type (*Celtis brownii*, *Tetrorchidium, didymostemon Pycnanthus angolensis* and *Acanthus montanus*). There were also increases in Asteraceae, Poaceae, Cyperaceae and monolete spores. Increases in these taxa are linked with the dry conditions, and presence of some swampy environment (Duffin, 2008; Dominguez-Rodrigo *et al.*, 2007). Therefore the occurrence of these pollen and spores inferred that although climate would have been predominantly wet, there were few occasions of seasonality in climate. The seasonality in climate would be expected to favour the growth of secondary forest taxa such as *Elaeis guineensis* and *Alchornea*. But their pollen were very few and irregular in occurrence. Microscopic charcoal particles were also quite low. The combined evidence of pollen and spore and microcharcoal do not give any evidence of humans at the site.

Thus the vegetation changes could not be attributed to a human factor but due to natural environmental fluctuations.

Afterwards, there were decreases in *Rhizophora*, *Avicennia* and *Acrostichum aureum*. The general decrease in MSF indicated some environmental disturbances within the MSF. During the same period *Peltophorum pterocarpum, Lophira* cf. *alata* and *Selinagella* cf. *flagellata* were recovered. The occurrence of the lattermost pollen (broken; Fig. 3 i) identified as *P. pterocarpum* is puzzling; it is reported to be native to Indo-Malayan region and introduced to Nigeria in the 20th century. Although, the level—560 cm—where *P. petrocarpum* was recovered was not dated, being not too far from the dated 770-780cm (1,190 ± 30 yrs B.P.), it does not appear to have been deposited in the 20^{th} century. The period of its occurrence in Ikorigho has no evidence of human impact indicating that its presence was without any human input. How did this pollen reach Ikorigho? Could *P. pterocarpum* have been a natural component of the forest vegetation in the Ikorigho area at that time? Although this may not be entirely far-fetched, the non-recovery yet of any pollen of *P. pterocarpum* in the fossil records of Nigeria or West Africa known to the author makes it less likely. Exotic pollen grains (*Casuarina equisetifolia, Delonix regia* and *Lagerstroemia indica*) were recovered from sediments dated to AD 1263 in Ajaba, Northern Osun State, Nigeria (Orijemie *et al*., 2010). These exotic pollen and *Peltophorum pterocarpum* are trees native to Madagascar, Southeast Asia and Australia suggesting the possibility of early direct or indirect contacts with people from those regions. At the moment, this issue is inconclusive although in the absence of any other evidence, such an occurrence in palynology is regarded as a contamination.

The abundance of *Rhizophora* and recovery of forest taxa such as *Ceiba pentandra, Pycnanthus angolensis, Stenochlaena palustris, Pteris* sp*, Pteris* cf. *togoensis, Cyathea* sp*, Cyclosorus* sp*, Selaginella* cf. *flagellata*, *Stenochlaena palustris*, and three other unidentified spores are indications of humid climate.

Zone IK 1II 490-200cm

In this zone, the pollen of *Rhizophora* sp. and *Avicennia* and FSWF were abundant indicating an extensive MSF and FWSF. The fair abundance of FWSF showed that the vegetation was dominated by the MSF and FWSF.

Poaceae and secondary forest (*Elaeis guineensis* and *Alchornea*) fluctuated but LRF and fern spores had fair abundance. LRF taxa included *Lophira alata*, *Pycnanthus angolense, Tetrorchidium, Albizia zygia, Alstonia booeni, Parkia bicolor, Celtis* sp., *Ceiba pentandra* while fern spores were *Stenochlaena palustris, Polypodium vulgare* and *Cyclosorus* sp. The occurrence of taxa characteristic of riverine vegetation is note worthy–*Chrysobalanus icaco* and *Mimusops warneckei* suggesting the presence of some rivers. Afterwards there general environmental fluctuations until at 330 cm where there were reductions in *Rhizophora* (MSF) and secondary forest but increases in the LRF, FWSF, Poaceae and spores. The environmental condition which prevailed during this period is linked to less frequent marine influence over Ikorigho.

Rull (1998:293) described a palaecological situation where mangroves reduced and a sea "regressive phase was characterized by pollen from back-mangrove open forests due to cooler climate." Rull (1998) had submitted that abundant fern spores are usually transported and carried by erosion from coastal swamps and inland forests, and this reflects a phase of low sea level. Although Rull's (1998) study is based on the palynological study of Middle Eocene mangroves in Maracaibo Basin of Venezuela, Rull's palaeoenvironmental reconstruction is similar to that of this present study in the following ways: These are **(a)** the reduction in mangrove swamp forest species and this occurrence coincided with **(b)** increase is fern spores and pollen of back-mangrove open forests. However Rull (1998) ascribed this phenomenon–regressive sea level characterized by pollen of back-mangrove open forests– partly due to cooler climate. In this present study, there were no indications of occurrence of a cooler climate in the environment. This is because no pollen of plants indicative of a cooler climate was recovered. This gradual increase in the above mentioned taxa reflected increased openings or gaps within a drier forest. Towards the end of this zone, the MSF (*Rhizophora, Avicennia* and *Acrostichum*), monolete spores, *Uapaca* and the LRF had good representations. At 210 cm, the LRF became reduced while secondary forest species (*Elaeis guineensis* and *Alchornea*) and Poaceae increased. Despite the abundance of the MSF, the abundance of secondary forest and Poaceae indicated that the LRF was that of open/dry type.

Zone IK IV: 200-120 cm.

At the beginning of this zone, all the MSF and FWSF taxa were well represented, an indication of a well developed MSF and FWSF. In fact, the R/A values indicated a *Rhizophora*-dominated mangroves swamp forest. Few LRF taxa (*Ceiba pentandra* and *Pycnanthus angolensis*) were recovered suggesting a much reduced LRF. Towards the end of the zone, *Rhizophora* and FWSF elements decreased while *Acrostichum aureum* and *Avicennia* had marked increases. The R/A values showed a dominance of *Avicennia* over *Rhizophora* indicating an *Avicennia*-dominated. Similarly, freshwater taxa (*Typha australis*) and monolete spores were quite abundant. Therefore, the changes in the environment indicated significant prevalence of freshwater over marine influence. These hydrological changes were as a result of nature rather than anthropogenic influence.

Zone IK V: 120-60cm

In the earliest part of this zone, all the mangrove swamp forest taxa (except *Avicennia*) and secondary forest (*Elaeis guineensis* and *Alchornea*) were still reduced attributed to the hydrological changes noted in the end of the last zone. Afterwards, increases in *Rhizophora* and *Acrostichum aureum*, and reductions in *Avicennia* and monolete spores suggest increased marine influence in the area, which favoured *Rhizophora*. Similarly, the high R/A value (12.5) is in line with the inference made on the favourable environmental conditions for *Rhizophora*. But this was a brief occurrence because *Rhizophora* and *Acrostichum aureum* became reduced while *Avicennia* increased but there were no significant increases in freshwater swamp forest, secondary forest taxa and Poaceae. These evidences indicated that the MSF was evidently *Avicennia*-dominated. The reduction in *Rhizophora* was not caused by humans but by natural factors because of the absence of the pollen of weeds and *Elaeis guineensis*, and few occurrence of *Alchornea*. The natural factors are hydrological changes such as local sea regression. This inference is made because *Rhizophora* naturally inhabits shorelines while *Avicennia africana* prefers inshore areas (Ukpong, 2000). Therefore, an abundance of *Avicennia* over *Rhizophora* is indicative of reduced *Rhizophora* and marine influence along the shores. This is consistent with Fall (2005)'s observation that reduction in *Rhizophora* with concomitant increase in *Avicennia* indicates changes in shoreline of the coast. Furthermore, there was a marked increase in the amount of charcoal particles counted at this time. Abundant charcoal is indicative of biomass burning. What then was responsible for this burning, was it nature- or human-driven?

Humans usually engage in bush burning preparatory to agriculture. This bush burning exercise removes dry or dead wood and undergrowths. This practice is also known to enhance the early growth of the seeds of some plants. For example, it is known that the oil palm "seeds show enhanced germination following a heat treatment" **(**Swaine and Hall 1986, pp 65-66). Furthermore, during bush burning, trees such as those of the oil palm (*Elaeis guineensis*) are protected, thus leading to the artificial spread of the oil palm in open forest in the forest zone of tropical West Africa. But only one pollen of *Elaeis guineensis* was recovered indicating that there were few oil plam trees at Ikorigho during this period. *Alchornea*, a shrub known to exhibit similar patterns with that of *Elaeis guineensis* in West Africa had low occurrence. It then appears, at least, from the very low values of *E. guineensis* and *Alchornea* that human influence in the area was insignificant. But where the relatively high amount of charcoal came from remains unanswered. Could the charcoal particles have arisen due to natural fires?

According to Jensen (2004), natural fires are generally caused by lightning during summer and are less frequent in coastal lands than at hinterland. Thus, the occurrence of significantly high amount of charcoal particles recovered from coastal areas represents occurrence of probably wide spread fire. The high amount of charcoal particles recovered from level 80 cm suggested intensity of fire; previous amounts of charcoal increased gradually indicating that there were gradual build-up of continuously re-occurring fires. Such fires in wet forest or forest along coastal regions are not natural but human-made. Therefore, the charcoal particles provide some evidence that the high amount of charcoal recorded at 80 cm was probably due to human impact. Therefore, apart from the freshwater influx which affected *Rhizophora* trees at 80 cm, humans may have deliberately felled *Rhizophora* trees. Towards the end of this zone, *Rhizophora* and *Avicennia* decreased significantly but *Acrostichum*, monolete spores and *Typha* had marked increases. Phenomenal increases in ferns along with similar increases *Typha* in a pollen record are indicative of continuous local freshwater input from rivers (Lezine *et al.*, 2002). Therefore, this period when *Typha* and ferns increased, the mangrove swamp forest at Ikorigho was frequently inundated by freshwater from Rivers Osun, Oni and Oluwa. These hydrological changes reduced the salinity of the mangrove swamp which negatively affected *Rhizophora* taxa.

Zone IK VI: 60-0 cm

In the earliest part of this zone, *Rhizophora* and *Avicennia* were still reduced but *Acrostichum* and *Typha* recorded phenomenal increases. The pollen record shows that the site was still under the influence of increased amount of freshwater into Ikorigho, which effect began in the last zone. This hydrological change must have drastically reduced the salinity of the swamp which was not favourable for the growth of *Rhizophora* and possibly *Avicennia*. Subsequently, *Rhizophora*, *Avicennia* gradually recovered while *Acrostichum aureum*, though still present, was irregular in occurrence. The pollen of *Alchornea* and *Elaeis guineensis* occurred more regularly while charcoal particles continuously increased towards the top of the zone. The pollen and charcoal evidences are consistent with evidence of a more permanent human settlement in the area, as well as their consistent use of fire. *Rhizophora* and *Avicennia* values were dominant while Poaceae, FWSF and freshwater taxa were also present. Between 40 cm and 20 cm, *Typha* and *Acrostichum aureum* increased while *Rhizophora* and *Avicennia* were reduced. The high values of *Typha* indicated a second phase of the occurrence of high influx of freshwaters into the area. Because this increase in *Typha* occurred at the top of the core, it must have been a recent phenomenon. It is still not clear what was responsible for the relatively recent influx of freshwater into Ikorigho.

Subsequently, at the top of the zone (0-10 cm), *Typha* became reduced while *Rhizophora* increased indicating that it was the dominant plant in the MSF and marine influence was higher than previous levels. At 0 cm, the MSF was very extensive and diverse (*Rhizophora*, *Avicennia* and *Acrostichum*). The high salinity level (Table 10) is consistent with the occurrence of higher marine influence in Ikorigho. Other components of the vegetation included FWSF, FW/aquatics and palms. The LRF (*Pycnanthus*, *Celtis* and *Flabellaria paniculata*) was almost non-existent. An important point to note is the occurrence of *Podocarpus milanjianus* at the surface layer i.e. 0-2 cm of this Ikorigho II core. *P. milanjianus* pollen was also recovered from level 0-1 cm of Ikorigho I core. It seems most likely that this pollen was transported from the Highlands of southwestern Nigeria—Apata and Kukuruku Hills—via the Oluwa River into Ikorigho. This has been discussed in some detail in pages 193-194 of this thesis.

Unlike the Ikorigho I core, human occupation was not very clearly delimited in the pollen record of this core. Pollen characteristic of human occupation, e.g. *Elaeis guineensis* as well as those of weeds associated with bush clearance and farming had no significant increase even at the top of the core where indices of human activities were expected to have been significant. However, the high amount of charcoal particles recovered beginning from level 80 cm to 0 cm was an indication that there was a gradual build-up of these charcoal particles from a continuously re-occurring fire. Such continuous increase in charcoal, particularly in the coast, is consistent with anthropogenic fires.

5.5.1 Comparing and contrasting pollen records of Ikorigho I and II cores

The pollen analyses show that the upper sections (200 cm) of Ikorigho II generally correspond quite well with that of Ikorigho I (200 cm) but there are few differences. Details of the comparison and contrast between the two cores are highlighted below.

Firstly, *Rhizophora* decreased continuously with very low values at 125 cm, 100 cm, 80 cm and 20 cm for Ikorigho I and between 120 cm and 80 cm, 40 cm and 20 cm in Ikorigho II. At the same time, *Avicennia* had maximum values at these levels. The increase in *Avicennia* over *Rhizophora* was an indication of hydrological changes within the mangrove swamp forest environment in those periods. Secondly, the first discernable indication of human impact was at 125 cm of Ikorigho I based on the recovery of pollen of cultivated plants (*Mangifera indica, Blighia sapida* and *Spondias mombin*) as well as those associated with human habitations (*Elaeis guineensis*, cf. *Aspillia africana*, *Chromolaena odorata*, *Vernonia* cf. *cinerea*). Surprisingly, this pollen evidence was not recorded in Ikorigho II. Both cores were very close being separated by 1m. Although it is not very clear why this was so, a likely reason is that sub-samples of Ikorigho I core were studied at 5 cm interval unlike those of Ikorigho II, which were studied at intervals of 10 cm. Perhaps, it was the high resolution palynology of Ikorigho I core that captured the clear pollen evidence of humans there. Thirdly, from 50-0 cm *Rhizophora* continously increased in Ikorigho I but it fluctuated in II. Fourthly, from 30-0 cm, FWSF and FW became abundant in both cores while at 10-0 cm in Ikorigho both cores, *Rhizophora* became dominant. The contrasts in the pollen results of Ikorigho I and II cores show that a single core might not provide adequate details of the palaeoenvironment of an area.

5.6 Holocene vegetation history of the mangrove swamp forest in Nigeria and parts of tropical West Africa

In this section attempt is made to trace the Holocene vegetation history of the mangrove swamp forest using pollen evidence mainly from Nigeria, and parts of West Africa. The early Holocene (13,500-8,500 yrs B.P.) was a period of mangrove re-establishment after the Great Inter-tropical Aridity (GITA) period of ca. 22,000 to 14,000 yrs B.P. Pollen record from the Niger delta core indicated that during the early Holocene period the mangroves were abundant, although some areas had quite extensive freshwater swamp forest (Sowunmi, 1981b). During the mid-Holocene, maximum extension of the mangroves occurred initially between 9,000 and 6,500 yrs B.P. and later between 5,500 and 5,000 yrs B.P. (Sowunmi, 2004; Salzmann and Hoelzmann, 2005). The latter period is commonly referred to as the Nouakchottian sea transgression period. The coast was inundated with marine water and sea level was high. Climate was wet and warm, and the lowland rainforest flourished. Evidence of this favourable climate has come from Bénin (Salzmann and Hoelzmann, 2005; Tossou *et al.*, 2008); the pollen evidence show that the mangroves prevailed between 8,500 and 2,500 yrs B.P. After the wet phase, conditions gradually became drier; there was a gradual decline in the mangroves. This decline was noted in Lac Sélé after 5,000 to 4,500 yrs B.P. (Salzmann and Hoelzmann, 2005) and between 5,600 and before 3,100 yrs B.P. in the Ahanve core (Sowunmi, 2004). In Ahanve, at 3,109 ± 26 yrs B.P, the mangroves completely disappeared, and it was replaced by coastal savannas. Apart from the late Holocene dry climate, geomorphological and hydrological factors were thought to have been contributory to this vegetation change (Sowunmi, 2004). Similarly, after 3,320 yrs B.P. at Lac Sélé, the mangroves disappeared and were replaced by a savanna or open vegetation. This was attributed to the late Holocene dry climate which caused a drying up of the lake. In Southern Bénin (Goho, Yèvié and Dogla-Alago), mangroves also disappeared around 2,500 yrs B.P. and were replaced by freshwater swamp environment dominated by *Persicaria*, *Typha*, *Ludwigia* and *Nymphaea* (Tossou *et al*., 2008). In Ogudu, during this dry phase, mangroves became drastically reduced particularly at 2,620 ± 30yrs BP (Cal BP 2,760-2,730 yrs) but did not completely disappear. They became re-established sometime after the dry phase. This was in contrast to the situation in nearby Ahanve, and the four lake sites in Bénin referred to above. The persistence of the mangroves in Ogudu during this period was due, in part, to the fact that the swamp had (and still has) direct access to the Atlantic Ocean via the Lagos lagoon. This accounted for the occurrence of comparatively wetter conditions there which led to the persistence of the mangroves in Ogudu. Some time around 1,100–1,200 yrs B.P., mangroves at Ikorigho, Nigeria, decreased slightly with a concomitant increase in Poaceae. This vegetation change was registered in Lac Sélé at about the same time i.e. 1,100-1,200 yrs B.P. The decrease is thought to be the result of a brief dry phase. The mangroves recovered and remained dominant in Ikorigho but disappeared from Lac Sélé.

Like the Ogudu swamp, the Ikorigho swamp has direct link with the Atlantic Ocean via the Oluwa River; thus creating a moist environment there. It was this moist environmental condition that sustained the mangroves during the period of environmental stress at Ikorigho. In contrast, the dry conditions led to the cutting off of

River Ouémé, the river which connects Lac Sélé with the Atlantic, thereby depriving the mangroves of marine water. This situation ultimately led to their disappearance there.

In the latter part of the late Holocene, the mangroves at Ogudu had some fluctuations. It was during this period that pollen of weeds such as *Borreria*, *Synedrella*, Asteraceae, and Poaceae became abundant. Furthermore, pollen of freshwater taxa indicative of hydrological disturbances also increased. All these signaled human impact on the mangroves at Ogudu. In southwestern Nigeria, from the mid-Holoecne, the mangroves were dominated by *Rhizophora* except at points where there were general reductions in the mangroves such as the late Holocene dry phase. However, in Ikorigho, in the last few centuries, the mangrove swamp forest was dominated by *Rhizophora* and *Avicennia* at different times. Dominance of *Rhizophora* is associated with higher sea level and frequent inundation of the swamp by marine influence. On the other hand, dominance of *Avicennia* is a characteristic feature of shore-line changes and a possible occurrence of increased influx of freshwater. In addition, within the last few decades, *Typha australis*—a freshwater species—at some point became very abundant while the mangroves decreased in Ikorigho. This indicated continuous infux of freshwater and less marine influence in the area. The reasons for these relatively recent hydrological and vegetation changes at Ikorigho are not well known. So far, what is known from the pol len record is that the mangrove swamp forest in SW Nigeria covering the lattermost part of the last 1,000yrs has been decimated by human activities expecially felling of mangrove trees, dredging the swamp for sand, industrilisation, oil exploration and spills. But they were abundant between the mid to early late Holocene

5.7 Human interaction with the mangrove swamp forest in West Africa with reference to Bénin and Nigeria in the late Holocene

So far, there is yet no concrete evidence that any human groups were present within the mangrove swamp forest of Nigeria before 3,000 yrs B.P. Sowunmi (1981 a& b), on the basis of the increase in the pollen of *Elaeis guineensis*, weeds and concomitant reduction in forest pollen, established that humans were present in the mangroves of the Niger delta area ca. 2,800 yrs B.P. A date of 2,670 ± 60 yrs B.P. obtained from Apa, the Badagry area, indicated that humans existed in the area (Alabi, 1998). Although, pollen analysis has not yet been carried out in Apa, a core from Ahanve, 4.5 km from Apa, indicated that the vegetation of the area during the mid-Holoene to late Holocene was mangrove swamp and lowland swamp forest (Sowunmi, 2004). Pollen evidence from lake sediments in Bénin adjacent to the Badagry area shows that mangroves were also present there from the early-Holocene to ca. 2,500 yrs B.P. (Tossou *et al.*, 2008). Archaeological investigations from coastal sites in Bènin put human occupation in this area at ca. 2510 ± 120 yrs B.P (Alabi, 1998). Therefore, human occupation in the MSF in Bénin and Nigeria is, at present, after 3,000-2,500 yrs B.P. More recent pollen evidence from Ahanve (this thesis) indicated that sometime after 3,109 ± 26yrs B.P. when the mangroves disappeared from there, humans occupied the area. This was based on the phenomenal increase in the pollen of *Elaeis guineensis*, *Alchornea* sp., and the appearance of *Vernonia amygdalina*, *Oldenlandia corymbosa*, *Euphornia hirta* and Asteraceae at 40-20 cm of the Ahanve core. The parent plants of these pollen are associated with human habitation. Unfortunately this part of the Ahanve core was not dated to know the exact period of this human presence.

In Ikorigho, at level 130-125 cm of Ikorigho I core, the recovery and subsequent increase in the pollen of *Spondias mombin*, *Blighia sapida*, *Elaeis guineensis*, *Sida acuta*, *Aspillia africana*, *Ageratum conyzoides*, *Mangifera indica* and *Vernonia* cf. *cinerea* were indications of the earliest record of human occupation of the area. Similarly, in Otolu, Lagos, the appearance of the pollen of *Mangifera indica*, *Anacardium officinale*, *Zea mays*, *Cocos nucifera*, and Asterceae from levels 35-10 cm of the 45 cm core was significant. In addition, the pollen of weeds associated with bush clearance and agriculture such as *Aspilia africana, Synedrella nodifolia, Tithonia diversifolia, Ageratum conyzoides* and *Chromolaena odorata* were recovered towards the top of the core. The occurrence of these pollen especially those of cultivated crops was a direct botanical evidence of farming activities in Otolu. Although the Otolu core and upper sections of the Ikorigho core were not dated, the period of human occupation in these areas is tentatively put at 17th-early 18th century. This is because of the presence of the pollen of exotic plants such as *Zea mays* and *Mangifera indica*; these food crops were introduced to Nigeria during that period. The phenomenal increase in the pollen of secondary forest species, weeds as well as those indicative of freshwater flooding from level 80-40 cm in the Ogudu core are indicators of human impact on the mangrove swamp forest there. The increase in freshwater swamp noted at the top of the core reflected freshwater flooding of mangrove swamp due mainly to the dredging of the swamp. This part of the core is thought to have been deposited during the last 50-60 yrs.

In summary, available pollen evidence indicates that humans first occupied the mangrove swamp forest in the Niger delta area ca. 2,800 yrs B.P. (Sowunmi 1981 a& b), and Bénin around 2,500 yrs B.P. Another occupation period took place between the 17th and 18th centuries in Ogudu, Otolu and Ikorigho areas. It is currently not certain what the human-environment relationship in the mangrove swamp forest of southern Nigeria was like between 2,670 ± 60 yrs B.P. and the 17th century AD but it is assumed to have begun ca. 2,800 yrs B.P., and probably continued into the 18th century. Intensive human impact on the mangrove swamp forest was noted between the 18th and 20th centuries but has been more pronounced in the last 50-60 yrs. There is no direct evidence about the food production levels of the people in the mangrove areas but it can be suggested from the pollen evidence that the people engaged in agriculture. Although some of the common food crops in Nigeria today such as cassava (*Manihot esculenta*) were introduced through the coast after the 16th century, their pollen were not recovered except for *Zea mays*. The absence of the pollen of diverse food crops in the study area could be due to the fact that agricultural sites were far from the locations where sediment cores were obtained. Indeed, as much as possible, coring was done in places where either human presence was not noted or disturbances were very minimal.

5.8 Development of coastal savannas in southern Nigeria

Several hypotheses have been put forward as to the origin of coastal savannas in southern Nigeria, on one hand and its continued presence/maintenance on the other hand. For West Africa in particular, the origin of the coastal savannas has been linked to two episodes of dry climate. The first climatic episode was during the GITA which occurred between 20,000 yrs B.P. and 14,500 yrs B.P. (Maley, 1996; Dupont *et al.*, 2000). Large patches of savanna and dry forest replaced rainforest during the GITA (LGM). There are indications that coastal savanna vegetation existed in West Africa during that period (Maley and Brenac, 1998; Shanahan *et al.*, 2006). However, when conditions became wet and favourable from ca. 13,500 yrs B.P. to ca 5,000 yrs B.P. forest vegetation recovered and became re-established (Maley, 1991, 1996; Sowunmi, 1981b, 2004; Salzmann and Hoelzmann, 2005). Dupont *et al.* (2000:119) stated that "the Guinean and the Congolian rainforest were probably not separated during the early Holocene". This suggests that coastal savannas did not exist within the rainforest zone in West and Central Africa during that time. In other words, the Dahomey Gap was not in existence from the early to mid Holocene because these times were predominantly wet.

The second episode occurred during the late Holocene dry period. It is believed that during this period, forest vegetation and mangroves were destroyed while savanna and grasses expanded (Sowunmi, 2004; Salzmann and Hoelzmann, 2005; Tossou *et al.*, 2008). However, unlike the situation during the early Holocene when forest became re-established after a dry phase, forest vegetation never fully recovered in Lac Sélé, Southern Benin where after 1,100 yrs B.P., the forest vegetation was replaced by coastal savanna (Salzmann and Hoelzmann, 2005). In Goho, southern Bénin, and in Ahanve, south western Nigeria, the mangroves were completely destroyed after 3,000 yrs B.P.

According to Salzmann and Hoelzmann (2005), the origin and spread of the coastal savanna in Southern Benin was due to a natural cause without any anthropogenic influence. In Ahanve, near Badagry, south western Nigeria, from ca. 9,000 yrs B.P. to 5,500 yrs B.P., the vegetation was dominated by abundant and diverse forest and mangrove swamp forest (Sowunmi, 2004). However from ca 4,500 yrs B.P. to 3,109 ± 26yrs B.P., there was a marked reduction in forest, disappearance of mangroves and a concomitant increase in secondary forest and coastal savanna taxa. In other words, the original forest vegetation was replaced by coastal savanna and secondary forest ca. 3109 ± 26 yrs B.P. This provided the first botanical evidence for the extension of the Dahomey gap into the south-westernmost part of Nigeria. Sowunmi (2004:212) opined that the establishment of the savannas at Ahanve was a natural development but "the subsequent maintenance and expansion of at least the park and derived savanna can be attributed to human action". This was based partly on the marked increase in the pollen of *Elaeis guineensis* and *Alchornea*, and partly on archaeological records of humans in Apa. Alabi (1999; 2002) excavated a test pit 190cm in depth at Apa village, 5.5km from

Ahanve. The artifacts recovered include several pot sherds, a ground stone axe, charred palm kernels and charcoal. A date of 2,670 ± 90 yrs B.P. was obtained from a level above where the archaeological materials were recovered. These artifacts clearly indicated that human occupation of Apa is more than 2,670 ± 90yrs, and is at least 3,000 yrs old. The occurrence of burnt palm kernel and charcoal led to the conclusion that humans felled trees and set fires on the vegetation. Based on palynological and archaeological evidence, Sowunmi (2004) therefore opined that the clearance and continuous burning of the forest had contributed to the maintenance and expansion of the coastal savannas at Ahanve area. However, the views of Salzmann and Hoelzmann, (2005) on the subsequent development of coastal savannas within the Dahomey gap seem to contradict those of Sowunmi (2004).

Coastal savannas have been observed in parts of Lagos and Badagry and parts of Urhobo plains to the east. Those in Lagos and Badagry consist of *Elaeis guineensis, Alchornea cordifolia, Andropogon gayanus, Sorghum arundinaceaum, Panicum, Schizachrium, Cyperus* and *Paspalum vaginatum*. The oil palm (*Elaeis guineensis*) and *Alchornea cordifolia* are the most commonly encountered. The period of rainfall runs from May to October while the dry season runs from November to April. Rainfall is lowest in the west, i.e. in the Badagry areas, and the mean annual value is about 1500 mm/year with monthly average of 60-90 mm (Adejuwon, 1970). Adejuwon (1970) held that coastal savannas originated as a result of series of natural succession processes because the "extreme sandiness of the soil…renders large areas unsuitable for agriculture" (Adejuwon, 1970:7). Therefore, agricultural practices may not have been responsible for the development of the coastal savannas, which is rather thought to be "related to drier climate and the lesser discharge of fresh water from the interior" (Adejuwon, 1970:8). The occurrence of fire, natural and/or human seems to have contributed to the existence and maintenance of the savanna vegetation. The presence of dry leaves especially those of the palms and litter form large quantity of combustible materials which are easily ignited in the event of fire. When there is a fire, younger trees, being more susceptible die out, creating gaps which are invaded by grasses. Adejuwon (1970) concluded that in the time past, the rainforest may have included some patches of natural savanna vegetation. Therefore, the frequent human impacts would have facilitated the spread of human-induced savannas. It is argued that the coastal savannas are not a climax vegetation, but are maintained by frequent fires set by humans. Adejuwon (1970) and Sowunmi (2004) stated that if the coastal savanna is left to fallow for a long period without disturbances, it would revert to the original tropical rainforest vegetation.

Aweto (1980) noted the occurrence of savanna patches in the coastal area of Urhobo plains. These coastal savannas are characterized by abundant grasslands which are similar to those of the Lagos and Badagry areas in physiognomy and floristic composition. The vegetation is made up of trees such as *Albizia adianthifolia, Elaeis guineensis, Anogeissus leiocarpus, Vitellaria paradoxa, Khaya senegalensis, Lophira lanceolata, Cassia sieberiana* and *Isoberlinia doka* but is dominated by grasses (*Imperata cylindrica*, *Psorospermum febrifugum*, *Panicum maximum*, *Ctenium newtonii*), herbs (*Hyparrhenia sporobolus, Cyperus, Centrosema pubescens, Ipomoea muaritiana,*) and shrubs (*Cassia mimosoides, Triumfetta rhomboides, Bridelia micrantha* and *Alchornea cordifolia,* Aweto (1980) opined that the presence and maintenance of savanna taxa are mainly due to bush burning and not agricultural activities because of the extreme porosity of the soil. Dupont *et al.*, (2000) noted that unlike the Dahomey area, dry forest and savanna are not widespread in the north western part of Congo Basin i.e. the Eastern block of the Guinea-Congo rainforest zone. This is not unrelated to the differential amount of rainfall or rainfall variations experienced in the Western and Eastern parts of the rainforests. In the westernmost parts of the rainforest zone of Nigeria, rainfall is usually less than 2200 mm/year and is characterized by longer (about four) drier months. In contrast, the south eastern parts of Nigeria experience two months of dry season and ten months of wet season. In these parts, rainfall reaches 3000-4000 mm/year. Therefore, areas with less amount of rainfall such as Ahanve and the Urhobo plains will, naturally, be more prone to dry climatic conditions. And in the event of the occurrence of extreme and prolonged dry period, the forest in such areas will likely be replaced by savanna.

In the next section, an attempt is made to examine the pollen records of some coastal sites in south-western Nigeria. This is done with a view to ascertaining whether coastal savannas developed at these sites as in Ahanve. The sites to be considered are Ogudu, Otolu and Ikorigho (Fig 52).

Fig 52: Map of Ogudu, Otolu and Ikorigho in relation to Ahanve

Ogudu

At Ogudu where a 6 m core was studied, the palynological results obtained are as follows: From 600-480 cm, the vegetation was characterized by the mangrove swamp forest (MSF), freshwater swamp forest (FWSF) and the lowland rainforest (LRF). The fossil record indicates that the LRF was extensive and diverse because of the many types of forest pollen recovered. Poaceae pollen was present and its occurrence was regular but its values were quite low. At 2,620 ± 30 yrs B.P., there was a peak in Poaceae and moderate increase in savanna taxa but no pollen of weeds or plants indicative of human habitation was recovered. This period falls within the late Holocene dry phase of 4,500-2,500 yrs B.P. which was without any anthropogenic influence. At the top of the core, savanna, Poaceae and secondary forest taxa, and weeds increased significantly while the MSF and LRF decreased. The vegetation at that time became open. But coastal savannas were not maintained in Ogudu. At present, the vegetation at Ogudu is a combination of mangrove swamp forest, some secondary forest species which are the relict of a formerly diverse and extensive lowland rainforest.

Otolu

The vegetation history of the 45cm-core drilled at another coastal site—Otolu, near Epe, Lagos, revealed that from the lowest levels of the core i.e. 50-40 cm, the vegetation was that of mangrove swamp forest (MSF), lowland rainforest (LRF), and fresh water swamp forest (FWSF) taxa. The major species which characterized the vegetation at that time were *Rhizophora, Avicennia,* and *Mitragyna ciliata. Elaeis guineensis, Alchornea,* Combretaceae/Melastomataceae, *Drepanocarpus lunatus* and pteridophytes. From 20 cm upwards, increases noted in *Elaeis guineensis, Alchornea* sp., *Anacardium occidentale* (cashew), *Zea mays* (maize), *Cocos nucifera* (coconut) and Asteraceae indicated vegetation dominated by *Elaeis guineensis* i.e. a secondary forest. In addition, increase in charcoal was also noted at this time indicating increased occurrence of anthropogenic fires and human impact on the vegetation. But there is no evidence for the establishment of coastal savannas at Otolu.

Ikorigho

The palynological results obtained from an 8 m core drilled at Ikorigho show that from 770-780 cm dated to 1190 ± 30 yrs B.P., the vegetation had decreased MSF and LRF and dominance of Poaceae (grasses) and freshwater/aquatics (Cyperaceae and *Typha australis*). This vegetation is similar to a coastal savanna. But this vegetation did not last long. This was because of a return of favourable conditions leading to re-establishment of mangroves. Why then did coastal savanna and secondary forest vegetation develop and still persist in Ahanve? The locations of Ogudu, Otolu and Ikorigho near the Lagos and Lekki lagoon (Fig 52) provides direct access to marine water which would make the establishment of coastal savanna quite difficult. Ahanve on the other hand is located on the westernmost side of the coast. It is currently being watered by freshwaters from the Yelwa River and Badagry creek. There is, at present, no direct link between it and the Atlantic.

Palynological and anthracological evidences show that human history and their impact on the vegetation in Ogudu, Otolu and Ikorigho are probably very recent—may be less than 200 yrs B.P. This was based on the occurrence of pollen suggestive of human presence at the top of all the cores in the three areas; these levels are thought to be of recent age. For instance, in Ogudu, pollen indicative of human habitations became abundant from 40 cm upwards. Although level 40 cm was not dated, level 70-80 cm was dated to about the last 60 yrs. This indicated that level 40 cm where pollen indicative of human presence were noted in abundance was more recent and post-dated 60 yrs. Similarly, in Otolu, charcoal particles increased at a point when pollen associated with human occupation—*Mangifera indica* (mango), *Anacardium occidentale* (cashew), *Zea mays* (maize) and *Cocos nucifera* (coconut)—either appeared and/or increased towards the top of the core (35 cm to 15 cm). These crops are exotic and were introduced into Nigeria sometime between the 17th and 20th centuries. Furthermore, even though the Otolu core was not dated, when compared with the Ogudu core which was dated, the period when levels 35-15 cm were deposited appears recent. For the Ikorigho core, pollen characteristic of human habitation (*Elaeis guineensis*, cf. *Aspillia africana*, cf. *Chromolaena odorata*, *Vernonia* cf. *cinerea*, *Mangifera indica* and *Spondias mombin*) were noted at level 125 cm. According to oral history, the Ikorigho people occupied the area in the last 100 yrs (Segede, Pers. Comm. 2009; 2010). In contrast, as stated earlier, palynological and archaeological evidences indicate that human occupation of the Badagry area where Ahanve is located goes back as far as about 3,000 yrs B.P. (Alabi, 1999). Palynological analysis of the core drilled at Ahanve and studied by the present author revealed unprecedented high amount of charcoal particles coinciding with the period of forest reduction and mangrove disappearance. This further strengthens what had been opined that humans were mainly responsible for the maintenance of coastal savannas in Ahanve

The late Holocene dry phase was very severe particularly in the Dahomey Gap area. Two major characteristics of this gap are the occurrence of abundant grasses and savanna trees, and less amount of rainfall. Rainfall in this area is between 1,000 and 1,500 mm/year. This gap extends from parts of southeastern Ghana, Southern Togo, Bénin to south-westernmost part of Nigeria where Ahanve is located. Ahanve is approximately 20km from the Nigeria-Benin border. In addition, the mean annual rainfall values of Ogudu, Otolu and Ikorigho are 1600-1800 mm/year, 2000-2200 mm/year and 2600-2800 mm/year respectively. The palynological results show that these sites were not severely affected by the late Holocene dry climate except Ogudu which is closest to Ahanve. It is also important to note that the effect of this dry phase at Ogudu was less serious compared to Ahanve. This is because the MSF recovered after the dry phase, and is still present there.

Having established the likely reasons for the maintenance of coastal savannas in Ahanve, could the development of coastal savanna have occurred elsewhere in the tropics bearing in mind that some parts of the tropics have similar climatic and environmental conditions? This is particularly important because the main causes of the coastal savannas in southwestern Nigeria are the Great Intertopical Aridity (GITA) otherwise called Last Glacial Maximum (LGM) in Europe and America, and the dry phase that occurred from 4,500-2,500 yrs B.P. These were global events. For example, decline of hitherto diverse and extensive mangroves due to a dry phase was also noted for Southern Benin from about 5000 yrs B.P. (Tossou *et al.*, 2008).

In a palynological study of the Great Niah cave area Surawak by Hunt and Rushworth (2005), the rainforest was noted to have reduced and was replaced by grasses, Cyperaceae and Asteraceae ca. 6,500-2,350 yrs B.P. This change in vegetation is very similar to that of Ahanve. Apart from the appearance of the pollen mentioned above, that of rice was also identified. This was used as an evidence for increased human activities, cultivation and increased settlement. Therefore, the change from forest to more open vegetation dominated by grasses, sedges and Asteraceae occurred at this period i.e. from 6,500-2,350 yrs B.P. According to Hunt and Rushworth (2005), the reduction in forest was associated with widespread fires and agriculture. Thus coastal savanna vegetation was noted to have developed in the area between 6,500 yrs B.P. and 2,350 yrs B.P. It is important to note that these events fall within the late Holocene dry phase.

In another palynological study of the Great Niah cave in Borneo dated to 45,000-46,000 yrs B.P., the vegetation was dominated by relatively abundant savanna taxa with some rainforest vegetation suggestive of the occurrence of a savanna corridor within the rainforest (Hunt *et al*., (2007). During the LGM, dry *Dipterocarp* woodland and savanna expanded into regions now occupied by humid lowland rainforest in west central and south-central Borneo (Hunt *et al*., 2007). Coastal savanna or open woodland was present before or at the LGM at Sundaland Niah. However, when conditions became more favourable especially from 12,000 yrs B.P, onwards, lowland rainforest became re-established and replaced the savanna and woodland. It should be noted that the present-day vegetation of Sundaland, Niah is forest in spite of the continuous presence of humans there since late Pleistocene times.

At Tiam point, Torres Strait Shelf, Mua Island, Northern Australia, mangrove swamp forest was extensive and well developed at about 6,800 yrs and 6,000 yrs B.P. (Rowe, 2007). Mangrove communities had their maximum occurrence between 6000 and 3000 yrs B.P. At that time, the mangrove swamp forest was dominated by *Rhizophora* spp. Other mangrove species include *Bruguiera*, *Ceriops*, *Avicennia*, *Lumnitzera*, *Excoecaria*, *Xylocarpus*, *Scyphiphora* and *Sonnneratia*. During this time, sea level was high and rose to an estimated 10.8-11.5 m asl (Rowe, 2007). Large expanse of mangrove forest occupied coastal lowlands. The expansion of the mangroves became an even more effective barrier or possible obstacle to the ease of human movement and settlement in the area. The absence of humans in the area during this time is corroborated by archaeological records which states that during this period "human population declined but retained a sporadic visitation between 6000 and 3500-3000 yrs B.P." (Rowe, 2007:927).From 4,000 yrs B.P., *Rhizophora* forest declined and was significantly reduced between 2,300 yrs and 500 yrs B.P. At that time, there was a gradual fall in relative sea level. Mangroves were restricted to shoreline area. After 500 yrs B.P. "the local vegetation was composed primarily of grasses and ferns with sedges" (Rowe, 2007:935). When mangroves retreated there was influx of freshwater into the site indicated by the abundance of *Pandanus* pollen. Similarly, there was also a reduction of lowland rainforest which led to the occurrence of more gaps within the forest and the development of open woodland that concided with increases in macro- and micro-charcoal particles. The presence of these charcoal particles is indicative of forest disturbances by anthropogenic fire. During the late Holocene ca. 2500-500 yrs B.P., the mangroves were replaced by coastal freshwater swamp and followed by complete loss of forest vegetation cover. This change from forest to coastal savanna vegetation was attributed mainly to lowering of sea level and human activities such as increased burning. From Rowe's (2007) work, it is apparent that between 2,500 yrs and 500 yrs B.P. the mangroves became reduced and were eventually replaced by coastal savanna vegetation due to a combination of lowered sea level and human impact on the forest.

Stevenson (2004) studied a 4.2 m core drilled from Luz Saint Louis swamp, New Caledonia located to the east of Australia, and approximately 3 m above sea level (asl). The vegetation also consists of some savanna plants dominated by *Imperata cylindrica, Melaleuca quinqueneruia* and *Eleocharis cylindrimorphus* (Cyperaceae). The vegetation gradually grades into a mangrove swamp forest composed of *Rhizophora* spp, *Bruguiera* sp., *Sonneratia, Avicennia marina* and *Lumnitzera* sp. Rainfall at the site is between 1,300 mm and 1,500 mm/yr. Therefore, the present-day vegetation of Luz Saint Loius Swamp is coastal savanna with some freshwater components. The oldest date obtained for the base of the core was 6,590 ± 110yrs B.P. According to Stevenson (2004), from 6,250 yrs to 3,000 yrs B.P., the vegetation was characterized by mangrove pollen, abundant rainforest and Cyperaceae pollen as well as fern spores. There was a reduction of rainforest and mangrove ca. 3,000 yrs B.P. Marine records from the area show that between 4,000 yrs and 2,500 yrs B.P., there was a drop in sea level indicating the dry conditions that triggered the initial decline in mangroves, followed by a significant increase in grasses and herbs. This latter occurrence was considered to be anthropogenic because this vegetation change occurred when large amounts of charcoal were noted in the fossil record from 3,000 yrs B.P. Although charcoal was always noted in the fossil record, that the magnitude after 3.000 B.P. was unprecedented after 3,000 yrs B.P. Archaeological records of human occupation of the area began ca. 1,100-1,050 yrs B.C. i.e. ca. 3,100-3,050 yrs B.P. (Sand, 1999 In: Stevenson (2004). The archaeological evidence, therefore, indicated that humans were already in the area between 3,100 yrs B.P. and 3,050 yrs B.P. This further supported the suggestion made earlier that the fires at ca. 3,000 yrs B.P. were anthropogenic. The palynological evidence shows drastic reduction in species richness after 2,000 yrs B.P. This coincided with the formation of yam terraces and agriculture in the area.

From the foregoing it is apparent that the establishment of coastal savannas and secondary forest with concomitant decrease in mangrove and lowland rainforest taxa at NW Caledonia is remarkably and strikingly similar to that which occurred at Ahanve even though the two locations are approximately 17,000 km apart! Furthermore, Athens and Ward (2004) noted that in the Island of Guam, between 9,300 yrs and 4,300 yrs B.P (a period of 5,000 yrs) charcoal particles and pollen and spore indicative of forest disturbances (*Gleichenis* and *Lycopodium*) were absent. But it was only at 3,900 yrs B.P. that pollen of species indicative of forest clearance and charcoal slightly increased, and the pollen and charcoal had marked increase at 2,900 yrs B.P. These two events were occasioned by drastic reduction in forest and occurrence of large extent of savanna. The expansion of the savanna was synonymous with the occurrence of coastal savanna particularly at 2,900 yrs B.P. and it had an anthropogenic influence.

Coastal Savannas—the causative factors

In all the palynological studies discussed above including those at Lac Sélé, Bènin (Salzmann and Holzmann, 2005) and Ahanve (Sowunmi, 2004), Nigeria, the development of coastal savannas in the late Holocene (4500 yrs and 2500 yrs B.P.) was initiated firstly, by the dry climatic conditions was due to a redistribution of solar energy occasioned by a southward shift of the position of the Inter-Tropical Convergence Zone (ITCZ). This resulted in the pronounced weakening of the south west monsoon winds and led to increased drier conditions in Africa (Marchant and Hooghiemstria, 2004; Wanner *et al.*, 2008; Ngomanda *et al*., 2009). During that period, one common factor noted in some of these sites (Ahanve, SE Asia and Australia) was the increase in Poaceae and monolete spores at about 3000yrs B.P. when mangroves and forest taxa became reduced or disappeared. This is represented in the Table 22 below

Table 22: The late Holocene dry phase and associated vegetation changes in the tropics

Author (s)	Event yrs B.P.	Site	Pollen noted to increase during or after event	Pollen noted to decrease or disappear after event
Elenga *et al.*, 1994	ca.3000-2850	Congo, Central Africa	Poaceae, Cyperaceae monolete spores	Sapotaceae, Combretaceae, *Alchornea*
Athens& Ward, 2004	2900-2300	Guam, Pacific Islands	Poaceae, monolete spores, ferns	*Barringtonia, Pouteria, Piper, Randia*
Stevenson, 2004	4000-3000	NW Caledonia, Australia	Psilate monolete spores, Cyperaceae	Mangroves, Elaeocarpaceae/Cunoniaceae
Sowunmi, 2004	3109 ±26 yrs B.P.	Ahanve, SW Nigeria	Poaceae, *Elaeis guineensis, Alchornea,* monolete	*Rhizophora, Avicennia*, forest taxa
Salzmann& Hoelzmann, 2005	4500-3320	Lac Sèlé, Southern Bénin	Poaceae *Cyclosorus*, Cyperaceae	*Rhizophora, Nauclea, Celtis,* Sapotaceae
Tossou *et al.*, 2008	ca 3000-2500yrs B.P.	Southern Bénin	Freshwater swamp forest,monolete spores	*Rhizophora*, forest taxa
This study	ca. 3100	Ahanve, SW Nigeria	Poaceae, monolete spores	*Rhizophora,Avicennia, Laguncularia*, forest taxa

As can be noted from Table 22, when high amounts of Poaceae pollen and monolete spores coincided with reduction in either forest, mangroves or both, a dry phase could be inferred. This is because grasses and ferns have higher capacities for surviving drier conditions. But when this phenomenon i.e increase in Poaceae and monolete spores, occurs with pollen, anthracological and archaeological evidence in a particular area, such changes reflect human impact on the vegetation.

This human factor in or at about the same period that coastal savannas occurred in the late Holocene or after in the areas highlighted above is significant. As discussed above, there is sufficient evidence that human activities contributed to the sustenance of the coastal savannas in those areas. Salzmann and Hoelzmann (2005) stated that the spread of savanna (coastal savanna) in the Dahomey gap at the beginning of the late Holocene cannot be attributed to human activities. Rather, the occurrence and spread of the coastal savanna in Lac Sélé was due to the appearance of a little dry season. This dry season, which was associated with cold-water upwelling in the Gulf of Guinea, "was clearly the driving force which caused a rapid deterioration of the closed semi-evergreen rain forest which covered the Dahomey Gap during the early and mid-Holocene (Salzmann and Hoelzmann, 2005:198). Similarly, in Ogudu, where the late Holocene dry phase was noted in the pollen record, there are no indications that humans were present there at that time. However, there are areas, already mentioned above, with unequivocable pollen and archaeological evidences indicating that humans contributed to the establishment of coastal savannas there.

5.9 Antiquity of Humans in the tropical forests of Bénin and Nigeria

Evidence from archaeological excavations from from the hinterland forest region of Nigeria (Shaw and Daniels, 1984) on the one hand, and southern Bénin and southern Nigeria indicates that humans were present in these areas after ca. 3,000 yrs B.P. (Allsworth-Jones and Wesler, 1998; Alabi (1999) on the other hand indicates that humans were present in these areas about 11,000 years ago and sometime after ca. 3,000 yrs B.P., respectively. Furthermore, palynological evidences from Ahanve, Nigeria indicate human impact on the vegetation after 3,109 ± 26 yrs B.P. (Sowunmi, 2004; this study).

Schwartz (1992), Kadomura (1995), Kadomura and Kiyonaga (1994) and Elenga *et al.*, (1994) postulated that the occurrence of a savanna corridor within the foest of southeastern Nigeria-southwestern Cameroon would have enhanced the movement of Bantu people from the ancestral home ocated somewhere ih that forested region to the eastern and southern parts of Africa. The period of this human movement coincided with the time of forest reduction in Congo due to the prevalence of drier climatic conditions dated to ca. 3, 000 yrs B.P. (Elenga *et al*., 1994). This period roughly coincided with when ceramics appeared ca. 2,800-2,700 yrs B.P. Similar reasons were given by Scwartz, (1992), Kadomura and Kadomura (1995), Kiyonaga (1994) and Elenga *et al.*, (1994) to have enhanced the easy movement of Iron-Age Bantu people from their ancestral home located somewhere in the forested southeastern Nigeria-southwestern Cameroon to eastern and southern parts of Africa. The period of this human movement which coincided with drier climatic conditions and forest reduction in Congo was dated to ca. 3,000 yrs. Elenga *et al*., (1994) suggested that the Bantu people would have taken advantage of the savanna corridor created within the forest as a result of drier climatic conditions. This period roughly coincided with the period of the appearance of ceramics (ca. 2,800-2,700 yrs B.P.) in the area. It has been suggested that the Bantus brought with them the art of pottery. Thus savannas appear to have played a significant role in the dispersal of humans especially within forest vegetation. Similarly, palynological study of samples recovered from the Great Niah cave excavations in Borneo indicated that around 40,000 yrs B.P., there were dry conditions suggestive of the occurrence of a savanna corridor within the rainforest. This savanna corridor is thought to have facilitated the dispersal of the earliest modern people in Borneo ca. 40,000 yrs B.P. (Hunt *et al*., (2007). The abundance of pollen of *Justicia* sp—a plant which, according to the authors, colonises recently burnt forest area. Thus the presence of *Justicia* sp (although the particular species of *Justicia* was not indicated) was taken as evidence for the occurrence of fire and burning (Hunt et al., 2007). Although this is a much earlier evidence of human occupation of tropical forests that than from West Africa as outlined here the evidence of burning is significant. There are indications that there were movements of peoples from southern Bénin into Badagry areas in Nigeria and vice versa. This will be discussed in detail in Chapter Five (Discussion II).

DISCUSSION II (ARCHAEOLOGY)

5.9 Archaeology of Ahanve

From oral history and information provided by the elders of the village, the people of Ahanve migrated from Ile-Ife more than about 200 yrs ago, that is early 19th century. The leader of this group of migrants was a man named *Igbereh*. He stole one of the oracles of the town. It was believed that anyone in possession of this oracle became very powerful. Thus, in order to excape the wrath of the Ile-Ife people, *Igbereh* took his people and fled from their ancestral home and one of their places of rest was Apa, a settlement located about 4.5 km east of Ahanve. At Apa, after they had rested for a while, the oracle directed them to move further until they came to the small village which they called Ahanfe. The village was so named because they had left their ancestral home in an unfriendly manner; consequent upon this, the oracle asked them to show love anywhere they went. Thus, the actual name of the village is AHAN-IFE; Ahan-Ife in Yoruba means "show love". Ahanfe was later corrupted or anglicized to AHANVE (Fig 4). Till date the people of Ahanve share strong ties with the Apa people; they even have a home there (Toyon Jimoh, 2008: pers comm). The people also claim they or their ancestors never engaged in pottery making but got pottery from neighbouring towns. As stated in Chapter Four, two periods of human occupation, Phases I (Figs 18 and 20) and II (Fig 19 and 21) were recognized in the archaeological investigations in Ahanve. This discussion will follow this trend: Subsistence economy, origin of the people and interactions with neighbouring peoples.

5.10 Subsistence Economy of Ahanve

At the beginning of Phase I, apart from pottery, the African giant snail (*Archachatina achatina*), catfish (*Clarias gariepinus*), charcoal, hearth and iron slag were the first and most abundant materials recovered. These were later to be followed by animal bones, bivalves and palm kernels. Based on these materials therefore, it can be deduced that the early Ahanve people utilized a combination of aquatic (catfish), bivalves (*Anodonta* sp.) and terrestrial food resources (snail) which they prepared using fire over a hearth. The abundance of large *Archachatina achatina* shells whose natural habitat is the rainforest zone, suggests that the vegetation might have been that of a rainforest. But the occurrence of mostly charred kernels of the oil palm (*Elaeis guineensis*), though not in abundance at this early stage, suggests that the vegetation might have been a secondary forest. The nature in which the palm fruits were recovered indicates that they were exploited for food and oil. It was during this phase, precisely at 90-100 cm of TPII that a lamp (*Atupa* or *Fitila*; Fig. 25) was recovered. Although, this lamp is unusually thick (2.1 cm) for its kind, it would have served the same purpose. In using this lamp, a good amount of palm oil is poured into it to serve as fuel and a cotton wick put in the oil. The wick is then lit to give some light. Alternatively, the husky remaining part of palm kernel is compressed into a strand and then soaked in the oil to serve same purpose as the cotton wick. Furthermore, the catfish (*Clarias gariepinus*) prefers shallow waters and burrows in mud during dry periods (Van Neer, 2004) while bivalves (*Anodonta* sp.) naturally prefer salt (marine) and freshwater environments. The village of Ahanve is bounded to the north by the Badagry creek and Yewa River, and south by the Atlantic Ocean. Therefore, the reconstructed environment of Ahanve, in the early stages of this phase, consisted of secondary forest and freshwater swamp (Yewa River); these deductions are consistent with those of the palynology of Ahanve.

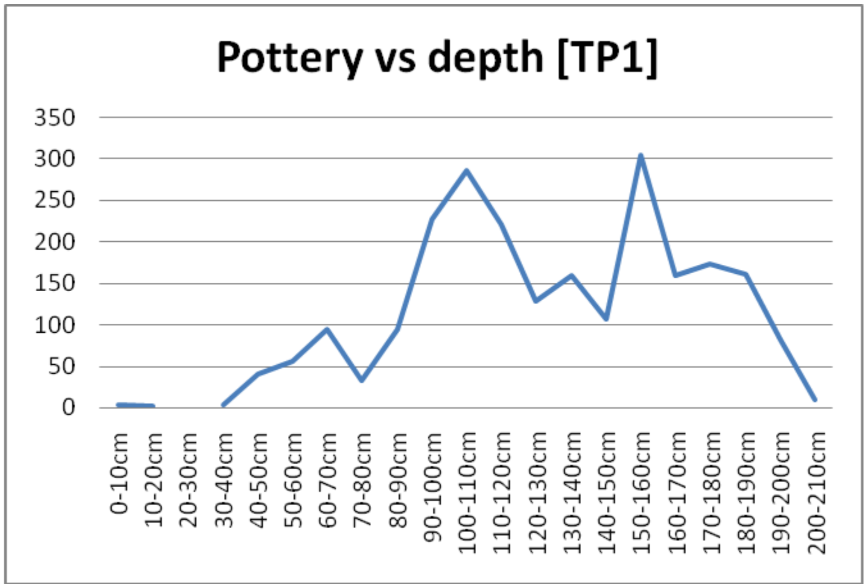


Fig 53: Graph showing number of pottery (y axis) recovered from TPI

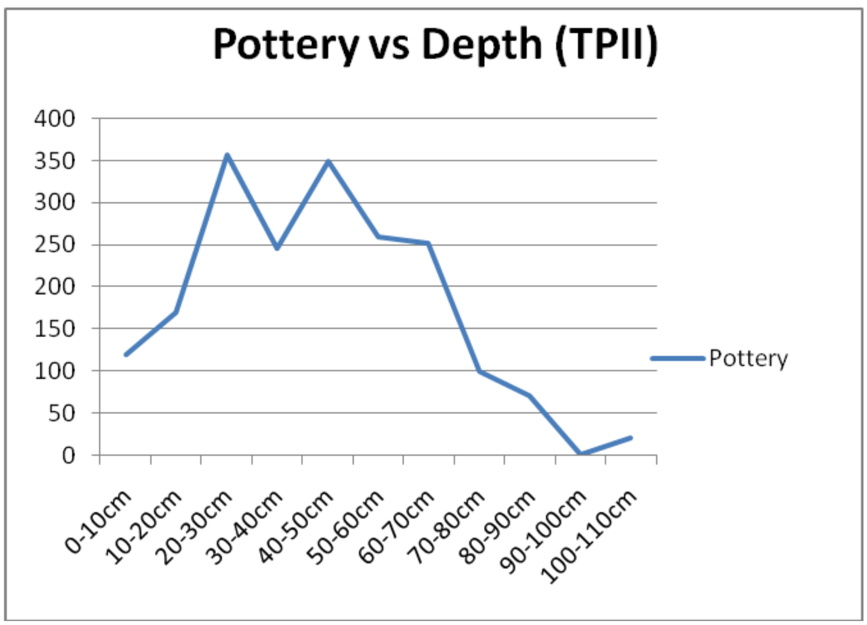


Fig 54: Graph showing number of pottery (y axis) recovered from TPII

Subsequently, charcoal particles, iron slag and animal bone increased and became abundant. The bowl of local smoking pipe appeared at the end of this phase. The abundance of these materials suggests increased use of fire, possibly iron working and/or increased population. The latter is supported by the increase noted in the amount of potsherds as can be seen in Figs 53-54. The abundance of archaeological materials around this period indicated intensive human activities in Ahanve, and in the entire Badagry area. Dates obtained from Ganyingbo sea beach, Apa II and Ahanve center around the 15^{th}-16^{th} centuries for the time of high human population. The greatest commodities of interest then were mostly slaves and salt. The Badagry area was the center through which slaves were taken to Bahia (Brazil) and other areas in the new world while salt was an essential economic and domestic commodity. It was produced from boiling sea water, or ashes of mangrove plants or both (Allsworth-Jones and Wesler, 1998).

It seems plausible that, in order to support the increasing human population, more food resources were obtained. This is reflected in the increased abundance of food remains such as animal bones (some were charred), bivalves and palm kernels compared to the amount recovered from the early stages. In addition, charred animal bones recovered from this phase suggest that games might have been hunted and roasted. Iron slags occurred regularly alluding to the deduction made above about increased use of fire but they were few in number and small in size (8 cm, max. length). Based on the absence of tuyeres and furnace, it is difficult to suggest or infer that Ahanve people engaged in iron smelting or smithing. Till date, no iron smelting/smithing site has yet been reported from the coastal areas of SW Nigeria.

a

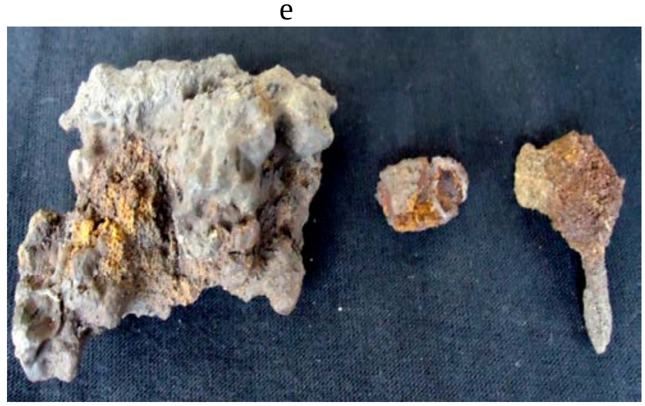
b

c

d

e

f



g

h

Fig. 55: Materials recovered from Ahanve:
Legend: a. African giant snail *Archachatina achatina*, b. head bones of catfish (*Clarias gariepinnis*), c. Pieces of Gin bottle, d. Mandible of a baboon (?), e. Animal bones, f. bivalve (*Anodonta* sp.), g. Iron slag, and h, Set of vertebrae.

The reconstructed vessels from the recovered potsherds included dishes, (*Awo kutupu*); small and medium-sized water storage pots (*Amu*), and large pots (*Ikoko*). With reference to the latter category, Alabi (1998) recovered large potsherds from Gberefu and Agorin sea beaches which would have been used in salt production. The sizes of the Gberefu and Agorin potsherds are comparable with those recovered from Ahanve. These large pots have diameter ranging from 60 to 80 cm and constituted 14.5 % of the reconstructed forms. In contrast however, the residue from salt production, containing sodium (Na) and chlorine (Cl) recovered by Alabi was not found in Ahanve. Thus, although the trade of salt was very popular in the West African coast during the 16th-19th century, Ahanve may not have been involved. More so, unlike other places in the Badagry area (where salt making was practised) which have direct link with the Atlantic Ocean, and contain mangroves, Ahanve has none of these factors, having lost its mangroves 3,100 yrs ago. These made it a disadvantaged site for the trade. Therefore the recovered large pots might not have been used in salt production but in storing and/or boiling water or oil. However, Dr R. Alabi of the Department of Archaeology and Anthropology, University of Ibadan, who has worked in the Badagry area, has advised that a chemical examination of the iron slags should be done because the salt residue is very difficult to distinguish from iron slags. If some of the 'iron slags' turn out to be salt residue, then it might be that Ahanve was involved in salt production. For salt production, water is collected from the Ocean and boiled for many hours afterwhich the recovered crystal residue is left to cool (Allsworth-Jones and Wesler, 1998). Gberefu, a well known salt production site is located 0.75 km from the Atlantic Ocean; collecting water from such a distance would not be difficult. In contrast, Ahanve is at least 5.4 km from the Atlantic Ocean; if salt was produced, collecting saltwater from such a distance would have been no easy task.

The bowl of a locally-made smoking pipe occurred at the end of this Phase (120-130 cm in TPI). Its recovery at a level below the occurrence of any of the foreign products suggests that it may have preceded foreign pipes in Ahanve. Furthermore, it indicates that, perhaps, smoking might have been practised before the coming of Europeans in Ahanve. The occurrence of foreign smoking pipes in Nigeria has been linked to the Portuguese who first arrived in West Africa during the 15th century

(DeCorse, 2001). In contrast, Aribidesi (2012) recently suggested that smoking pipes were autochthonously produced in the hinterland and transported to the coast for use in barter trade before those of European origin. Locally made smoking pipes were known in Ghana (Buipe) in AD 1640 ± 90 yrs B.P. (York, 1973) indicating that local smoking pipes are not very recent products in West Africa. This Ahanve smoking pipe was recovered from a level directly above that which was dated to 360 ± 40 yrs B.P. (Cal AD 1440-1640) in TPI. This shows that local smoking pipes were present in Ahanve, at least, in the late 17th century. However, if it is agreed that smoking was autochtonous to West Africa before the arrival of the Europeans, what plant product were West Africans smoking before the former introduced tobacco? The tobacco plant is a native of South America (Hutchinson and Dalziel, 1963) and was possibly introduced by the Portuguese (DeCorse, 2001; Ogundiran, 2010). It is either Africans were smoking (a)-now-lost-plant(s) or tobacco plant (*Nicotiana tabacum*) was present before the Europeans. Neither of the two possibilities is, as yet, supported by facts. Still on this locally made pipe, it must be stated that it was recovered from the same stratigraphic layer (i.e. layer 3 of TPI) as those of the foreign pipes. It may therefore mean that both kinds of pipes were used side by side during that time.

A date of 360 ± 40 yrs B.P. was obtained from 130-140 cm level of Ahanve TPI. A second date of 260 ± 30 yrs B.P. obtained from level 170-180 cm of Ahanve TPI is younger, and is a reversal. This reversal is thought to be due to some stratigraphic disturbance. Since the date obtained for 130-140cm is older, the earliest period of human occupation in Ahanve will be before 360 ± 40 yrs B.P. If the people's oral account of their Ile-Ife migration is accepted, and this writer has no reasons not to believe so, then aspects of Ile-Ife culture would have been brought by the people to Ahanve. The evidence of this Ife connection lies in the name of the village and in the pottery, details of which will be discussed shortly. However, the date of this first settlement in Ahanve will be after the 9th century because the oldest date yet obtained for Ile-Ife is the 9th century (Garlake, 1974). From the foregoing therefore, it can be inferred that the Ahanve people had quite a wide range of food resources (catfish, bivalves, snails, forest games and the oil palm fruits) which they sourced from their immediate environment. They, unlike their neighbours, might not have engaged in the salt trade that boomed during the 16-19th century due to the disadvantaged location of their village for salt production. The village was settled after the 9th century but few centuries before 360 ± 40 yrs B.P.

In Phase II, there were several significant changes in the material culture of Ahanve (Figs 56 and 57). The first was the appearance of foreign smoking pipes (bowls and stems) along with more local ones.

Fig 56: Locally made bowls of smoking pipes from Ahanve

Fig 57: Foreign stems and bowls from Ahanve, extreme left stem has '*milled rim*'.

These locally made bowls were characteristically bigger in size (ca. 5cm) and thicker (1.5 cm) than the European ones. Diverse prominent decorations (basket weaves, deep incisions and bosses) are on their surfaces; two of them are plain (Fig 56). In contrast, the European ones (stem and bowl) are mainly plain except for some incisions on the topmost part of the bowls (Fig 57) and decoration on one of the stems. As can be noted, due to the thick nature of the locally made ones, they would be more durable. Unlike the foreign ones, their stems were not recovered. Perhaps, the local pipes were made of wood or of less durable clay. Since foreign smoking pipes were known to have been imported from Europe, about what period, and through which routes could they have reached West Africa and Nigeria?

Walker (1975) reported that England, France, Denmark and Sweden exported Dutch pipes to West Africa during the 17th and 19th centuries. In a 1969 rescue excavation in the Kainji Resevoir Area, 57 African and one foreign smoking pipes were recovered (Breternitz, 1975). The foreign pipe from this excavation had "Scotland" inscribed on it. The tentative date for this stem is late 19th century. Breternitz (1975) stated that the "Scotland" inscription was the registered trade mark of McDougall of Glasgow whose company manufactured smoking pipes and was in business from AD 1846-1967 when many of his pipes were shipped to West Africa. In fact, Calvocoressi (1975) stated that Glasglow pipes were first produced around AD 1680 but were not exported to West Africa until the late 19th century (1880). Similarly, a pipe with this 'Scotland' trade mark was recovered from Apa (Alabi, 1998). This indicates that this type of smoking pipe was one of the widely used pipes in the coast and hinterland of West Africa in the 19th century. However, the pipes recovered from Ahanve have no marks or inscriptions except that they have a feature like a "milled rim" on the surface and a "delicate cog-wheel-like denticulation round the bowl rim" (Walker, 1975:185). These are characteristic features of Dutch smoking pipes. Furthermore, all the imported pipes recovered from Ahanve have a "superior finish obtained by polishing and stroke-burnishing" (Walker, 1975:185). These, according to Walker (1975), are trade marks of Dutch pipes. In addition, the Dutch were among the first to build forts in Ghana (DeCorse, 2001) in the late 16th century enabling them to import smoking pipes and other products into West Africa. Most importantly, the Dutch established a trading post in Apa prior to 1734 till 1736 when it was moved to Badagry by Hendrick Hertog for economic reasons (Alabi, 1998). It is stated that smoking pipes "were shipped in very large quantities to the Guinea coast in the eighteenth century as part of the slave trade" (Duhamel du Monceau, 1771, In: Walker, 1975: 186). Since the Badagry area was a well known slavery depot during this period, it is most likely that the Dutch smoking pipes reached Ahanve via slavery.

Towards the top of both test pits, smoking pipes disappeared while pottery decreased. The reduction in pottery is linked with its reduced importance and use, while the disappearance of smoking pipes could be linked with the abolishment of slave trade and the subsequent replacement of Badagry by Lagos, as a preferred economic capital after its annexing by Britain in 1861.

The second notable change in this phase was the rare occurrence of animal, bivalve and fish remains (Tables 1 and 2), which were hitherto very abundant. In fact, the latter was not recovered from TPII. Coupled with this was the irregular occurrence of snail shells (Tables 1 and 2) but charcoal and palm kernels were abundant. Iron slag occurred moderately. These suggest that there was more reliance on plant food resources particularly the oil palm. Although vegetal food crops would have been utilized and planted, no botanical remains of these kinds were recovered. But the increase in the pollen of weeds and those associated with agriculture in Ahanve (already discussed in Chapter Five, Discussion I) indicate that the people would have engaged in subsistence agriculture. The abundant macro and micro-charcoal particles indicated intensified use of fire and significant human impact on the vegetation.

The third change was noted in the pottery particularly in the abundance and decrease or disappearance of some decoration types. The first of such was in the appearance and subsequent abundance of a new decoration type named the Comb-Teeth Impression; (CTI) [Tables 6 and 7]. This decoration appeared for the first time in Phase I but increased significantly in Phase II. It is significant to note that this decoration type became abundant after the recovery of foreign smoking pipes which reached Ahanve through trade contacts. Therefore, it is inferred that the abundance of the CTI decoration on pottery was influenced by the Europeans who brought combs to West Africa.

The fourth change was that the number of pottery with (aquatic) snail shell (?*Biomphalaria* sp.) impression [Tables 7 and 8], being one of the first decoration types recovered from the two test pits, decreased in abundance from Phase I to Phase II (Tables 7 and 8). The decrease of this decoration was perhaps because the ?*Biomphalaria* snail became scarce in Ahanve suggesting that, perhaps, its habitat, which is freshwater, (the Badagry creek and Yewa River), might have been disrupted at some point.

The fifth was the occurrence of pieces of broken gin bottle at the topmost levels of this phase II (Fig 55). These are recent materials which served as containers for dry gin being one of the products brought by the Europeans. The sixth change was the appearance of two glass beads; beads were only recovered from TP II (Table 2; Fig 58]). The first glass bead (Fig 58a), which occurred at 50-60 cm, is white (l, 2.1 cm x w, 0.7 cm) and cylindrical in shape with perforation at both ends. This glass bead is similar to that described by Alabi (1998).

a  b

Fig 58: Glass beads from Ahanve; a, white and b, 'Venetian' beads

The second (Fig 58 b) which occurred at 40-50 cm has black and white stripes arranged in a parallel fashion but is actually black opaque glass, oval in shape with perforation at both ends. This bead is very similar to what was found in Buipe, Ghana (York, 1973) and Falemma, Senegal (DeCorse *et al*., 2003). Lamb and York (1972), York (1973) and DeCorse *et al.,* (2003) stated that it is a Venetian trade bead i.e. it is from Venice, Italy. Decorse (1989) opined that the correct date for the Venetian beads is the 19th century. Therefore, its presence in Falemma, Senegal indicates that it was brought there through trade relations with the Mediterranean via North Africa. This type of bead was also recovered from deposits in Kissi, Burkina Faso, dated to between the 1st and 7th century AD (Magnavita, 2003). But the Kissi beads, in contrast to Asian beads, contain very low soda and potash. For instance, majority of the glass beads recovered from excavations in Mahilaka, NW Madagascar, contained mineral soda and plant-ash, which are characteristic of South Asian glass (Robertshaw *et al.,* 2006). Therefore, based on the similarities in the chemical composition of the beads with those from south Asia, Robertshaw *et al.,* (2006) were confident that the Mahilaka beads from this site (i.e. Mahilaka) were of South Asian origin particularly, from Indonesia, India and China.

The Kissi dates show that this type of bead has been in West Africa for about 1000years. This probably predates the period of its production in the Meditteranean. Furthermore, that it has been recovered from several countries such as Ghana (Buipe), Senegal (Falleme), Burkina Faso (Kissi) and Nigeria (Ahanve) attests to the fact that it was indeed a trade bead. As Magnavita (2003:134) opined an "incipient trans-Saharan trade network linking North with West Africa was active throughout the first millennium AD". At this point an attempt is made to ascertain if the Ife account can be supported by the ethnographic and archaeological records.

5.11 Origin of the Ahanve People

The first point, which is ethnographic, is in the similarity between the suffixes in the original name (before it was anglicized) of Ahanve i.e. Ahan***Ife*** and Ile-***Ife***. Although the suffixes in the two names have different meanings, Ahan***Ife*** meaning "to 'show love', and Ile-***Ife*** meaning "land of expansion**,** the towns seem to have some connection. This is evident in the second point which is in the potsherds recovered from the early stages of Phase I. There were two of such potsherds with the groove and incison decoration. This decoration is regarded as the "*Classical Ife decoration*" (Fig 60). Alabi (1998) reported the occurrence of a similar decoration on Apa II pottery. The vessels from Ife have "horizontal incised lines in-between two vertical grooves in the shape of ladders "(Alabi 1998:249). Those from Apa II were slightly different in the sense that they have "vertical or inclined incised lines in-between horizontal grooves" (Alabi 1998:251). This decoration was the most abundant on potsherds in the lowest levels from a recently excavated pit at Igbo Olokun, Ile-Ife. This pit dated to ca. 900 yrs B.P. produced over 9, 000 glass beads (Babalola, Pers Comm. 2012).

Based partly on the similarities in the vessels obtained from Ile-Ife and Apa II, and partly on white glass bead and glass bead crucibles recovered from the latter, Alabi (1998) established that Apa people, in support of their oral traditions, migrated from Ile-Ife, although no possible date for this migration was provided.

The decoration on the Ahanve pottery (Fig 59) is strikingly similar to the Woji Asiri, Ile-Ife vessel described in Alabi (1998). The occurrence of this decoration type on vessels from the lowest levels of this phase is significant because it sheds light on the people's origin. These potsherds with similar decoration like those of Ile-Ife, and the original name of the village support the people's claim of their Ile-Ife connection.
This brings us to the issue of relationship the Ahanve people had with their neighbours.

5.12 Interactions with neighbouring peoples

It should be noted that part of the fact that the people of Ahanve had contacts with some of their neighbours has already been discussed above. The black opaque glass bead, discussed above, also show that Ahanve possibly had contacts, through trade, with other West African groups. Other lines of evidences indicating Ahanve relations with their neighbours are based on language and archaeology. The first is that *Ogu* (corrupted to *Egun*), a dialect (and its variants) of the Yoruba language is a common language spoken in southeastern Bénin and southwestern Nigeria. In fact, most people living in these areas speak both Ogu and Yoruba fluently. Furthermore, the names of some spiritual beings in Aja-Fon of Southern Bénin are similar to the Yoruba names for such beings. A few examples include *Sakpata* or *Cankpana* (god of earth and smallpox), *Xebioso* or *Cango* (god of thunder), *Gu* or *Ogun* (god of war and iron) (Bénin Embassy Report, 2009). The Yoruba names for these same deities are *Sopona*, *Sango* and *Ogun* respectively. Owing to the absence of written record, the exact time for the first period of interactions cannot be accurately determined. However, the evidence suggests that these interactions are not recent. These can be deduced from the second evidence as discussed below.

Fig.59: Early Ahanve pottery showing the *Classical Ile-Ife* decoration

The earliest decoration types on potsherds in Ahanve included plain and burnished, punctate, snail shell (?*Biomphalaria* sp.) impression and carved wood roulette (CWR) (Tables 7 and 8). Of these, the lattermost became the predominant decoration type in the archaeological record. That it occurred in the lowest levels in the excavations is an indication that it is among the oldest decorative forms in the area. It has been identified from pottery in 12th -17th centuries of Begho, Ghana; Bénin (14th-19th centuries), Sudan, Benue-Congo and Senegal-Muaritania area (Alabi, 1998). Most importantly, this decoration type is still found among the Fon, Adja, Gun and Bariba of southern Bénin; vessels from Kwesu market, Bénin Republic with this decoration type were observed in Badagry market, Nigeria (Alabi, 1998). Therefore, the existence of this technique in modern pottery shows continuity in this decoration design among the people of Badagry and southern Bénin. This carved wood roulette would have been transfered by humans who travelled between southern parts of Bénin and Nigeria in the past. In addition, the zig-zag roulette pattern on the rim area of the potsherd in Fig. 58 (photograph to the left) above is characteristic of the Ijebu. In fact, this zig-zag roulette pattern is very common in the coast particularly Lekki area (Ajala and Orijemie, 2013). It was also recently recovered in abundance from excavations in the Ijebu town of Oke-Eri, near the Sugbo-Eredo earthwork in Ogun State (Ogiogwa, Pers Comm., 2013). Thus its presence in Ahanve indicates interaction between them and the Ijebu people. A good number of the latter live in the coast of southwestern Nigeria (Ijebu waterside) and were known to have been actively involved in the Atlantic slave trade with the Europeans. In summary therefore, those with whom Ahanve had interactions were mainly the Badagry people, the Ijebus and those in southern Bénin, Togo and as far as Ghana.

Fig 60: A view of the entrance into Ahanve Village

CHAPTER SIX

6.0 SUMMARY AND CONCLUSIONS

In this section, objectives for embarking on this research will be reiterated and the major findings highlighted. These will be followed by recommendations.

This research work is a follow-up on the author's M.Sc. work titled *Late Holocene Vegetation History of the Mangrove Swamp Forests in Lagos and Badagry areas.* One of the aims of that work was to compare the vegetation history of the mangroves at Ahanve (Badagry area) and Ogudu (Lagos area), 60 km from Ahanve. The major findings, based on the pollen analyses of the sediment cores drilled at those sites, were, firstly, that the lowland rainforest decreased, and the mangroves declined and disappeared at Ahanve about 3,100 yrs B.P. These two vegetation types were subsequently replaced by secondary forest and coastal savannas respectively. Secondly, pollen of plants associated with human occupation in Nigeria increased after the mangroves disappeared. Some of the factors responsible for the vegetation changes at Ahanve included a change to a drier climate (4,500-2,500 yrs B.P.), geomorphological and hydrological changes, and probably humans (Sowunmi, 2004). Archaeological evidence from Apa, a site located about 4.5km from Ahanve indicated human occupation of the former site at ca. 3,000 yrs B.P. (Alabi, 1998) Therefore, one of the main reasons for embarking on this research is to ascertain, through archaeological excavations at Ahanve, the evidence of human occupation as far back as 3,100 yrs B.P., and whether humans could have contributed to the vegetation changes. Thirdly, the mangroves at Ogudu became drastically reduced at some point but recovered afterwards. Because the core was not dated, it was not possible to determine whether or not this drastic reduction was contemporaneous with the decline and disappearance of the mangrove at Ahanve. Thus, another major reason for embarking on this research was to find whether the disappearance of mangroves at Ahanve was contemporaneous with their decline and subsequent recovery at Ogudu.

In addition, it was also important to study the vegetation history of the mangroves in other areas in southwestern Nigeria, particularly where the mangrove swamp forest still exists. Finally, this research hopes to shed more light on the poorly-known late Holocene vegetation history of the lowland rainforest (LRF) in Nigeria and human interactions with it.

6.1 Antiquity of Humans at Ahanve, near Badagry

The archaeological excavations at Ahanve were conducted on two test pits. These test pits were 210 cm and 110 cm deep respectively. Archaeological materials were recovered from all the levels of the two test pits which indicated that there was continuity of human occupation in the area. Two phases of human occupation were identified in the two test pits namely Phase I and Phase II. The first of the two phases was characterised by the presence of pottery, fish and animal bones, snail shells, iron slag, charred palm kernels and charcoal. The subsistence economy during this phase was basically gathering of snails, bivalves and palm kernel fruits, and possibly fishing and hunting. Evidence from pottery and burnt animal bones suggests the use of fire in food preparation. The second phase was characterised by the appearance of locally-made and foreign smoking pipes, iron objects (rusted nails) and pieces of gin bottles. These materials indicate that the people had interaction with Europeans. Pottery increased from the lowest levels upwards but decreased towards the top of the test pits. This may be indicative of decreased use of pottery.

Pot sherds recovered from some levels of TPI have similar decoration styles with some of those recovered from excavations in other parts of the Badagry area and in southern Bénin. These indicate the possibility of socio-economic relationships between these peoples. The original name of this village AHAN-IFE, (anglicized to Ahanve) and the occurrence of a decoration with parallel incisions in-between two grooves on pottery recovered from the lowest levels of TPI seem to strengthen the people's claim of their Ile-Ife origin. This is because, this decoration style is characteristic of Ile-Ife pottery (Garlake, 1974). The dates obtained from the archaeological excavations show that there was human occupation there by 360 ± 30 yrs B.P. This date is not the earliest occupation of the site because it was obtained from charcoal and charred palm kernels recovered from level 130-

140 cm of TPI which was 210 cm deep. Therefore, the earliest date of occupation in Ahanve is probably a few centuries before 360 ± 30 yrs B.P. which does not indicate that the present set of humans contributed to the vegetation changes. The antiquity of humans in the Badagry area and in southern Bénin Republic, according to archaeological evidence, is between 2,670 ± 90 yrs B.P (Apa, Nigeria) and 2,510 ± 120—2,930 ± 130 yrs B.P. (Djegbadji and Ojegbame, Bénin). These dates suggest that the earliest humans might have had impact on the LRF particularly after the MSF disappeared.

6.2. Botanical composition of the Lowland Rainforest in SW Nigeria in the Holocene

During the mid Holocene, i.e. the earliest period covered by the Ahanve core, the LRF and MSF were abundant. The LRF was characterised by an abundance of *Daniellia ogea, Irvingia gabunensis, Canthium subcordatum, Tabernaemontana crassa, Hildegardia barteri, Bosquiea angolensis, Anthonotha microphylla, Dombeya buettneri, Scaphopetalum, Mansonia altissima, Alstonia booenii, Pentaclethra microphylla, Piptadeniastrum africanum,* and *Sacoglottis gabunensis* along with few species of dry forest such as *Tetrorchidium didymostemon, Canthium setosum, Morus* sp., *Celtis* sp., *Pycnanthus angolensis, Newbouldia laevis* and *Ceiba pentandra.* The MSF was characterized by *Rhizophora, Avicennia africana, Laguncularia racemosa* and *Acrostichum aureum.* During the late Holocene ca. 3,100 yrs B.P. in Ahanve the LRF reduced to secondary forest and the mangroves declined and subsequently disappeared. Coastal savannas replaced mangroves. The coastal savannas were characterised by Poaceae, *Borassus, Bridelia* cf. *ferruginea, Dichrostachys cinerea, Grewia bicolor* and *Entada abyssinica* while the pollen of LRF included *Parkia bicolor, Tetrorchidium didymostemon, Triplochiton scleroxylon, Newbouldia laevis, Celtis* sp., *Ceiba pentandra, Hymenostegia afzelia* and *Pycnanthus angoloensis*. In the latter part of the late Holocene, pollen of *Elaeis guineensis* and *Alchornea* had phenomenal increases dominating the secondary forest whose only forest taxa were *Tetrorchidium didymostemon, Hymenostegia afzelia* and *Pycnanthus angolensis*. The coastal savannas are currently being maintained by continuous bush clearance and burning.

In Ogudu, the mangroves, which had been abundant, had drastic reductions at 2,620 ± 30 yrs B.P., while the LRF only slightly decreased. The LRF at that time was dominated by species of dry forest such as *Pycnanthus angolensis, Tetrorchidium didymostemon*, *Gaertnera paniculata*, *Celtis*, *Ceiba pentandra,* and *Nelsonia* sp. Savanna plants such as *Parkia biglobosa*, *Acacia* sp., *Morelia senegalensis*, *Bridelia* cf. *ferruginea, Parinari* sp., *Phyllanthus discoideus* and *Lannea microcarpa* were also present. These were indicative of the dry climate at that time and showed that the forest had changed from predominantly primary and wet to secondary and dry forest by 2620 ± 30 yrs B.P. Subsequently, when conditions became favourable, the mangroves and LRF experienced increase; the latter was dominated by wet forest plants. In recent times, the LRF and MSF have decreased. While the mangroves are still present, though fragmented, in Ogudu, the LRF is now almost absent there. The pollen of LRF recovered from the top levels of the core were *Pycnanthus angolensis, Berlinia, Syzygium guineense, Sacoglottis gabunensis, Acanthus montanus, Ceiba pentandra, Newbouldia laevis, Gaertnera paniculata, Paullinia pinnata, Celtis, Mimusops warneckei* and *Alstonia booenii*. Only *A. booenii* and *N. laevis* are present there today showing recent human destruction of much of the forest.

Majority of the forest pollen recovered from Ikorigho were those of dry forest such as *Morus*, *Syzygium*, *Pycnanthus angolensis*, *Celtis*, *Canthium setosum*, *Flabellaria paniculata* and *Tetrorchidium didymostemon*. This indicated that the LRF at Ikorigho was a secondary forest. Today, forest plants are absent from Ikorigho. At the lowest level of the core, the MSF was abundant but had a slight decrease at ca. 1,190 ± 60 yrs B.P. after which it increased and is abundant there till date. The LRF pollen recovered from the lowest levels of Otolu core i.e. 35-50 cm were those of dry forest (*Celtis* cf. *brownii*, *Gaertnera paniculata*, *Canthium setosum* and *Syzygium guineense*) and riverine forest (*Mimusops warneckei* and *Pterocarpus santalinoides*). In addition, the abundance of the pollen of *Elaeis guineensis*, *Alchornea* and those of cultivated plants at the upper levels (35 cm-0) of this core shows that the LRF was also a secondary forest. Although the Otolu core was not dated, it seems to have been deposited in recent times particularly with the recovery of the pollen of exotic plants such as *Mangifera indica*, *Anacardium officinale*, *Zea mays* and *Cocos nucifera* at levels 35 to 0cm.

6.3 Human impact on the Rainforest in Southwestern Nigeria.

In this work, the evidence of human impact on the rainforest is drawn from palynology, anthracology and archaeology. The high resolution pollen analysis at Ahanve shows that after 3,000 yrs B.P. when the mangroves had disappeared, pollen indicative of human impact such as *Elaeis guineensis, Alchornea* sp., *Vernonia amygdalina, Oldenlandia corymbosa,* Asteraceae, and *Cocos nucifera* increased while forest pollen continuously decreased. The parent plants of these pollen are associated with natural and/or human disturbance of rainforest. The concentrations of charcoal particles which hitherto were not more than 95 particles/ cm^3 (200-50 cm) increased to 933 particles/ cm^3 (20 cm), 1020 particles/ cm^3 (10 cm) and 1272 particles/ cm^3 at 0cm. This is evidence of possible human impact on the Ahanve environment. Charred palm kernels and charcoal recovered from the archaeological excavations in Ahanve suggest that human impact on the forest there is at least about 400 yrs old.

In Ogudu, human impact was noted at 60 cm of the core when the LRF reduced with concomitant increase in *Elaeis guineensis, Alchornea* sp. and Asteraceae. Level 190-200 cm was dated to recent indicating human impact. Similary in Ikorigho and Otolu, human impact on the LRF vegetation is also recent. Pollen of cultivated plants such as *Mangifera indica, Blighia sapida, Spondias mombin, Anacardium occidentale*, *Zea mays* and *Cocos nucifera,* and those of weeds such as *Aspillia africana*, *Ageratum conyzoides, Vernonia* cf. *cinerea* were recovered from 125 cm in Ikorigho I and 35 cm in Otolu. The occurrence of these pollen indicate the practice of agriculture in these two sites.

6.4. Palaeoenvironment of the tropical rainforest in SW Nigeria in the Holocene

The palaeoenvironmental conditions of the tropical rainforest in the mid Holocene included the prevalence of predominantly wet and warm climate and high sea levels in Ahanve and Ogudu. Drier environmental conditions occurred between 4,500 yrs and 2,500 yrs B.P. in the two sites. In the late Holocene period, due to extreme dry and perhaps cold conditions, sea level dropped. Subsequently, there was an influx of fresh water from surrounding rivers into the Ahanve swamp which lowered its salinity. In Ogudu, conditions were different. Although there was a fall in sea level, the swamp still had access to marine water; this condition sustained the mangroves.

In Ikorigho, the MSF was abundant throughout the core; this indicated continued access of the area to marine water, but the LRF was not abundant. Towards the top of the core, there were fluctuations in the dominance between *Rhizophora* and *Avicennia*. These fluctuations were indicative of alternating periods of increased wetness (when *Rhizophora* was dominant) and slightly dry conditions (when *Avicennia* was dominant). The MSF and LRF in Otolu were initially dominant indicating that the sediments were deposited under warm and wet climate. Subsequent reductions in the MSF and LRF coupled with evidence of cultivars noted in the pollen record signaled anthropogenic activities particularly agriculture.

6.5 Holocene vegetation history of the mangrove swamp forest in SW Nigeria

During the mid-Holocene, the mangroves were abundant and extensive. It was during this period, 5,500-5,000 yrs B.P., that a maximum extension of the mangroves was reached (Sowunmi, 2004). After 5,000 yrs B.P., conditions gradually became drier until the late Holocene dry phase of 4.500-2,500 yrs B.P. The changing environment led to the decline and subsequent complete disappearance of the mangroves from Ahanve at 3,109 ± 26 yrs B.P. The mangroves started decreasing sometime before 2,620 ± 30 yrs B.P. at Ogudu. This indicated that the decline in the mangroves at Ogudu was contemporaneous with that at Ahanve. But, in contrast to those at Ahanve, the Ogudu mangroves did not disappear but recovered afterwards. The mangroves, after the late Holocene dry phase increased reaching levels that were not attained during pre-late Holocene times. This indicated that a wet period occurred after the dry phase. The

Ikorigho mangroves, which were hitherto fairly abundant, experienced some decrease by 1,190 ± 30 yrs B.P., the result of a brief dry phase. The mangroves are abundant and are still present in Ikorigho.

In the latter part of the late Holocene, mangroves in all the sites experienced reductions, except those at Ahanve which had disappeared. Reductions in mangroves at Ogudu occurred concomitantly with increase in the pollen of weeds such as *Borreria*, *Synedrella*, Asteraceae and Poaceae. These were evidences of anthropogenic impact on the Ogudu MSF. Towards the top of the Ikorigho cores, *Rhizophora* and *Avicennia* fluctuated alternatively with that of low and high river competences. In addition, pollen of *Spondias mombin, Blighia sapida, Elaeis guineensis, Sida acuta, Aspillia africana, Ageratum conyzoides, Mangifera indica, Vernonia* cf. *cinerea* and *Blighia sapida* increased from 130 cm upwards. Similarly, in Otolu, pollen of *Mangifera indica* (mango), *Anacardium officinale* (cashew), *Zea mays* (maize), *Cocos nucifera* (coconut), *Aspilia africana, Synedrella nodifolia, Ageratum conyzoides* and *Chromolaena odorata* increased between levels 45 cm and 10 cm. All these are signals of recent human activities impacting on the vegetation in these areas. The human activities include bush clearing and felling of forest trees, agriculture and dredging of the swamps for sand.

6.6 Contribution to Knowledge

The following are the contributions of this research work to knowledge: Firstly, this work has established that Ahanve, a village in the easternmost extent of the Dahomey Gap, records the first archaeological excavations conducted in this important village. It has also provided the first evidence of human occupation and subsistence economy of the village.

Secondly, results from these excavations show that human settlement there dates to perhaps sometime between 400 and 500 yrs ago. Consequently, the present people did not contribute to the vegetation changes which occurred after the disappearance of the mangroves (ca. 3,100 yrs ago) until 500 yrs ago. However, there are indications that earlier people in the Ahanve area might have contributed to the vegetation changes from ca. 3,000 yrs B.P. Thirdly, the decline of the mangroves at Ogudu was contemporaneous with that at Ahanve but was transient. Fourthly, the history of the mangrove vegetation from Ahanve westwards is very different from that eastwards, i.e. towards and in the Niger delta. Hence Ahanve marks an important mangrove boundary. Fifthly, the Holocene history of the LRF in Nigeria is better known. It was a primary forest, abundant and diversified in the mid-Holocene, began to decrease in the late Holocene, becoming drier and more open. It has been further degraded in the last 500 yrs. This decrease and degradation occurred first in the west (Ahanve) and much later eastwards. Sixthly, there are strong evidences that factors that led to the reduction and degradation of the LRF during the late Holocene were natural, and subsequently, human. The traditional method of obtaining a single sediment core for an area needs a review. This is based on contrasting results obtained from the two Ikorigho cores located within 50 cm from one another.

6.7 Limitations

Firstly, funds were the greatest limitations particularly for the radiocarbon dating, as a result, only few samples from two cores were sent for dating; Ahanve, Ikorigho I and Otolu cores were not dated. Secondly, few sites located within the rainforest had suitable sediments from where cores could be obtained, thus limiting coring to few sites. Thirdly, electric power in the University of Ibadan Campus was another major challenge; it was very epileptic particularly for many months between 2008 and 2010. This contributed to delay in completing the programme on schedule. Fourthly, a good number of the fossil pollen and spores recovered from the cores, could not be identified, and in some cases those identified were only to family or generic level. This was because they were not contained in the comparatively few (3600) reference slide collection of African plants available in the Palynology Laboratory, University of Ibadan. The African Pollen Database Website, which could have helped with this problem, was difficult to use. Similarly, the animal bones recovered from the excavations could not be identified. The identification of the bones would have provided information about the kinds of terrestrial fauna that existed in Ahanve thereby adding some value to the archaeological aspect of this work. Unfortunately, neither the

Department of Zoology nor that of Veterinary Anatomy, University of Ibadan, Ibadan, could help in this regard.

6.8 Recommendations

The first point is that this work has provided further evidence of human disturbances of forest during the late Holocene becoming more intensified in the last 500yrs in southwestern Nigeria area. Deforestation and burning of the felled trees are contributors of CO_2 into the atmosphere. Therefore, West African States, particularly, Nigeria, needs to have government-backed programmes involving relevant non-governmental agencies to save the LRF; this cannot be over-emphasized.

Secondly, mangrove swamp forest should be protected by all means possible. Appropriate laws concerning mangrove swamp forest reserves should be reviewed and strengthened. The Federal and State governments, whose areas have mangrove swamp forests, should collaborate and adequately fund University research in this area. Results of such works should be integrated into a Mangrove for Sustainability Project.

Thirdly, environmental awareness programmes should be carried out in communities located within forest environments on how best to interact with the forest. Such programmes can also be introduced to pupils in primary schools. Finally, more archaeological excavations should be carried out in Ahanve with a view to ascertaining the earliest possible period of human occupation there.

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