THE LECH KRZYŻANIAK EXCAVATIONS IN THE SUDAN
KADERO

Changes in the natural environment between 8000 and 3000 BC[1]

Lech Krzyżaniak

1. The natural environment, 8000—4900 BC

For about 60 km between the confluence of the Blue and White Nile in Khartoum and the Sixth Cataract, the Upper Nile flows in a flat and gradually narrowing river valley. Finally, it breaks through a barrier of old crystalline and volcanic rocks at Sabaloka, this being the southernmost cataract on the Nile (Vail 1982). Vail (1982:53) emphasizes the rather poor state of research on the geology of the area. One should also mention a map of the geology and geomorphology of the region by Marcolongo and Mascellani (Marcolongo 1983:Fig. 1).

Generally speaking, the maps show vast stretches of sandstone extending on the surface to the east and west of the valley of the Upper Nile; the northern part of the eastern bank features volcanic and metamorphic rock. The sandstone formation includes quartz pebbles, arkose, loamy shale and mudstone, as well as mineralized wood. Numerous sand-filled khors run into the Nile valley from both the east and west (Marcolongo 1983:maps). The old formations of the Sixth Cataract contain gneiss, shale, metavolcanic rock and granite. The quartz pebbles, which were used on a mass scale to produce the stone blades found on late Palaeolithic archaeological sites of central Sudan, Vail (1982:56) derives from the bedrock formation rather than from the eroded Nubian sandstone as suggested by Arkell (1949:41; 1953:25).

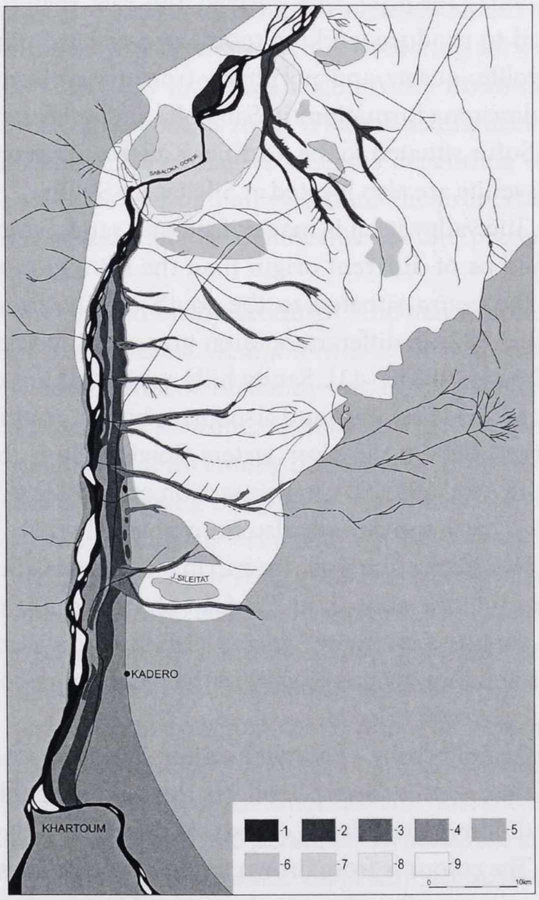

Fig. 1. The geology and geomorphology and hydrography of the Central Sudan (after Marcolongo 1983)
1. Old Nile alluvium, 2. Nile silts and younger Nile alluvium; 3. Wadi alluvial deposits; 4. Gezira Formation; 5. Nubian Sandstone; 6. Younger intrusives, granites; 7. Ryolites; 8. Ring dyke, granites; 9. Gneisses.

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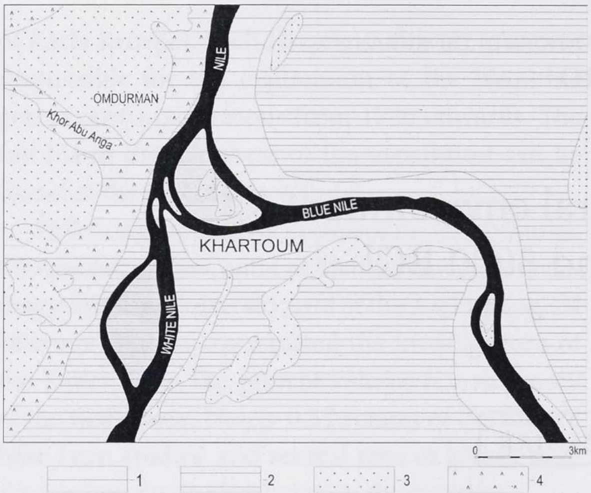

Fig. 2. Soils around the Khartoum (after Worall 1958).
1. riverain soils; 2. high level soils; 3. sands and dunes;
4. eroding Nubian Sandstone soil.

Vail (1982:57) also derived the raw material used to produce working tools, such as hard pink rhyolite, quartz and porphyry, from the volcanic and magma formations in Sabaloka and in Sileitat-es-Sufur situated to the north of Kadero. Outcrops of syenite are also located at Sileitat-es-Sufur.

The valley itself is made of silt and sand, which could be of different origin than the silt and sand of the *gezira* situated to the south of Khartoum (Vail 1982:60; different opinion presented by Marcolongo 1983:41-43). Sandy hills appear on top of the silt and clay; the sand also forms higher ground carved out by the river waters flowing from the south (Vail 1982:52). In this section of the Nile valley paleochannels have also been noted (Fig. 1).

Regarding the soils occurring in central Sudan, the sole source, in the face of an absence of all data, is a study by Worrall (1958) who distinguished four groups of soils in the neighbourhood of Khartoum (Fig. 2).

1. Riverain soils of alluvial origin. The composition of this kind of soil on the Nile is highly differentiated, from coarse sand to heavy clay. The colour is from brown to gray-brown. These soils are often deposited on top of layers of silt and sand intercalated with layers of calcium carbonate which are the result of water evaporating from the soil. The salt and soda content in these soils varies, but the saturation is on the whole much smaller than in the case of soils belonging to the second group. The soils are good, intensively cultivated today with the help of both natural and artificial irrigation. They are quite moist on the whole.
2. Higher-ground soil, mainly to the east of the river bed and covering most of the river valley, that is, the flat bottom which is slightly above water level, but no more than 6 cm above recent flood levels. These soils are sand and clay in composition, the top 30 cm being sandy brown soil, accumulated on top of dark gray or brown-gray clay about 60-90 cm thick, deposited in turn on a hard light brown, clayey or sandy pan. These soils are rich in lime carbonate and gypsum concretions, strongly adhering and rich in soda, especially at a depth of 60-90 cm, but poor in organic nitrogen. They are strongly alkaline and poor in nitrate and phosphates. They are under cultivation today only sporadically, mainly for growing rain-watered sorghum in the summer. They support a thin cover of perennial grasses and isolated acacia trees. The salinity of these soils excludes them from modern agricultural practice.
3. High-ground sand, usually deposited on top of soils of the second group in the form of mostly moving dunes and irregular clusters caused by obstacles in the way of blowing winds (structures, bushes, etc.). The sand in the upper 2 mm of its thickness is very dry and very weakly salinated. Trees grow well in these conditions, but not grasses. Since this soil does not retain humidity, it has no agricultural standing today.
4. Laterite-rich soils, occurring to the west of the river. The prevalent kind is red sandy clay composed of three layers: clay at the top, red sand on top of laterite gravel in the middle, and a layer of sandstone or mudstone detritus coming from the disintegration of Nubian sandstone or alternately beds of lime carbonate nodules. There is little humidity in these soils, and little soluble salts and soda, making them of little use to the modern farmer. Wherever the clay layer appears at the surface, a good harvest of rain-watered sorghum is possible.

All the archaeological sites in central Sudan dating from 11000 to 6000 bp are situated in the valley and it is to be assumed that they were found on the riverbanks of the time. The communities exploiting this region in the Late Palaeolithic must have viewed the river as the most important element of the indigenous ecosystem. To explain the role of the Nile in this environment it is essential to present briefly the river cycle.

The confluence of the Blue and White Nile at the location of modern Khartoum forms the Nile proper. The Blue Nile is a seasonal river with a maximum-to-minimum volume of water at 40:1. The biggest rush comes in August (Williams et al. 1982:119-120), as a result of summer rains in the Abyssinian uplands coming from June to October and peaking in July and August.

The White Nile, which starts in Uganda, is much less of a seasonal river compared to the Blue Nile (the high-water to low-water ratio being only 5:2) and it supplies 35% of the annual volume of water in the Upper Nile, but 83% during the low-water stage (Williams et al. 1982:121-123). According to Allan and Smith (1984:594-600), the Nile is low in Khartoum between January and June. Water levels rise rapidly in early July, peaking in late August (the flow being fifteen times what it was in April), and fall relatively quickly by the end of October and less rapidly until December. Rain is recorded here from July to September, meaning that both sources of water are active at the same time. The annual rainfall rate in Khartoum today is 164 mm (Williams et al. 1982:137-140). Soil humidity in this part of Africa is heavily impacted also by the temperature of the air which initiates evaporation processes (Wiliams et al. 1982:137-138). The present mean annual temperature in the vicinity of Khartoum is 29°C.

Oliver (1965) defines the modern climate of Khartoum province, which includes Kadero, as tropical dry. The river is lowest from mid April to mid May and highest from the end of August to the middle of September.

Nowadays the rainy season starts in Khartoum in July and the dry season in November. The lowest mean temperature for the latter period in Khartoum today, 23.9°C, occurs in January, the highest, 34.2°C, in June. At least three-fourths of the rainfall is due to storms. Less sun radiation, lower ground temperatures and no strong winds during the winter result in much slower evaporation of rainwater at night compared to during the day. Isolated events of heavier rain (7.5—10 mm) bring more water than the ground can absorb, causing runoff down the khors and wadis; this however does not last for longer than a few hours. Air humidity is low from October to June, reaching the lowest in April, and high from June to September, peaking in August. Evaporation of standing water is very intensive, lowest in December and highest in May. Dust storms from February to May are a characteristic feature of the climate.

The data collected for this presentation of the natural environment of central Sudan today comes mainly from Wickens (1982) and Mubarak et al. (1982). According to Wickens (1982:35-36), the region today falls within the semi-arid vegetation zone. Summer rainfall in this zone is from 75 to 400 mm annually (compared to 163 mm in Khartoum). The vegetation comprises grasses and herbs exclusively, as well as frequently occurring shrubs which can grow to 2 m in height. A dry savannah stretches south of this zone. Wickens distinguishes five different savannah ecosystems depending on the soil type and rainfall variation. The properties of these zones are of significance for the present study:

1. Thorny and bushy savannah. The main species of tree is Acacia: *Acacia tortilis* subsp. *raddiana* predominates on the sandy soils of the northern part of this subzone, associated with *Leptadenia pyrotechnica* among the shrubs and *Aristida siberiana* among the grasses. The southern part of the subzone is occupied mainly by *Acacia senegal* and *Combretum glutinosum* (*C. Cordofanum*). *Acacia senegal*, the major gum Arabic tree, grows on the dunes. Clay soils with annual rainfall of 400—500 mm provide a proper growing environment for shrubs and smaller trees, including the predominant *Acacia mellifera* growing in dense thickets. The *Schoenofeldia gracilis* and the perennial *Aristida* are the prevalent grass species, especially on shallow lenses of sandy soils overlying the clay. Heavier rainfall favours *Acacia seyal* which associates with *Balanites aegyptiaca* to form stands outside the depressions. They are accompanied by single-species grasses, either *Hyparrhenia anthistirodes* or *Cymbopogon nervatus*, and, interestingly, by wild tropical plants of the *Sorghum*

spp. species, which are present in more humid terrain, where *Acacia seyal* is replaced with *Acacia tistula*. The *Acacia seyal* woodlands of the savannah contain large quantities of fodder for herbivorous game.

2. Leafy savannah. On soils formed of the disintegration of Nubian sandstone, where the rainfall rate is 450—650 mm, the predominant tree species include *Combretum glutinosum*, *Terminalia brownii*, *T. Laxiflora* and *Sclerocarya birrea*, among the grasses probably *Aristida siberiana*. Where the rains are in the 650—800 mm range, *Anogeissus leiocarpus* appears and can even dôm inate in zones with rainfall over 800 mm; the grasses in these zones include *Hyparrhenia* spp., *Andropogon gavanus* and *Ctenium elegans*. The predominant trees on clay soils with rainfall over 800 mm are *Combretum hartmannianum* and *Anogeissus leiocarpus*, usually with a spattering of *Acacia seyal* and sporadic *Sterculia setigera*.
3. Swampy savannah. This includes regular wetlands, as well as seasonally flooded terrain and ground with a high water table that is flooded only occasionally. The swamps on the White Nile may constitute a parallel for the Pleistocene wetlands of the Gezira that existed when the two regions were probably one.
4. Riparian forests on the Nile and its tributaries. Species characteristic of this environment include *Acacia nilotica* subsp. *nilotica* (sunt) and subsp. *tomentosa*. Sunt groves are exploited intensively for timber and fuel. They survive seasonal flooding, but tolerate neither standing water nor a complete lack of natural irrigation. These trees tend to grow in stands occupying depressions of the ground in the vicinity of rivers.
5. Montane savannah. Encountered on isolated hills in this environmental zone, these plant ecosystems are usually richer than the ones from the plains. Since such geomorphological formations are not present on the Upper Nile, they will not be discussed in the present study.

The classification proposed by Andrews (1948: 34-36) is very close to that introduced by Wickens. According to Andrews, Sudan today is in the desert acacia zone. Rainfall is in the range of 5—300 mm annually and the dry season last eight months. Sporadic trees are represented mainly by *Acacia* spp., there are also shrubs and short grasses, but no wild tropical cereal plants from the sorghum group; the sandy dunes are a habitat for wild millet *Panicum* sp., and also *Aristida* spp. Heavy soils in the river valley support the *sunt* acacia which tolerates seasonal flooding, while the upper parts of the khors and wadis are overgrown with the dôm palm. To the south of this zone there is a rather narrow, latitudinal belt taken up by a savannah composed of short grasses, bushes and acacia. Annual rainfall here is in the range of 300—500 mm, and the dry season lasts from four to six months. The predominating tree species is acacia, but it is more differentiated in terms of species; broad-leafed species are also present — willow, baobab and the doleb palm. Among the grasses there is *adar*, that is, wild sorghum (*Sorghum* spp.).

South of this narrow zone in Sudan there is a savannah of acacia trees and tall grasses. The average annual rainfall here is about 500—1000 mm. This zone includes the toich plain which is a flatland seasonally flooded by the White Nile. Numerous species of acacia (including sunt) are accompanied by broad-leafed species like the baobab and the dôm palm. Heavy river soils support, among others, adar, which is the most important component of tall grasses, and *Setaria* spp. representing short grasses; *Aristida* grass grows on the light soils.

According to Andrews (1948:52-53) seasonal river flooding in the *toich* flatlands is sufficient for tree growth, but not for sustaining regular wetlands or sedge overgrowth. In the dry season, these areas form huge ranges that are used today primarily for grazing. The small hills in these plains have supported settlement and small-scale cultivation. They are overgrown with *Acacia* spp., *Celtis integrifolia*, *Randia nilotica*, *Diospyros mespiliformis*, *Combretum* spp. and the doleb palm. When flooded, the *toich* regions have about 30 cm of standing water. The soil here is sandy at the surface and heavy dark clay underneath. The tall grasses growing here consist of fields of pure *Vetiveria nigritana* and *Sporobolus pyramidalis*. Trees are rare in the plains, occurring mostly on termite mounds.

The climate in central Sudan is commonly assumed now to have been more favorable to human settlement in the late Stone Age than it is today. This has been suggested by finds of mollusks (*Pila wernei*, *Lanistes carinatus* and *Limicolaria flammata*) in Late Pleistocene and Early Holocene geological contexts (Tothill 1944; 1946). The mass occurrence of the terrestrial snail *Limicolaria* suggests a savannah environment with acacia and tall grasses, and an annual rainfall over 500 mm, like that existing today in the Gedaref region (Williams et al. 1982:139). This has been confirmed by Arkell's observations on the archaeological sites of Khartoum Hospital (1949) and Shaheinab (1953). Having compared the size of snails from Khartoum Hospital and the neighborhood of Gedaref, Tothill (1948c) came to the conclusion that the climate was less favorable to these mollusks than the present-day climate in Gedaref.

Recent research has shown that the climate in the late Stone Age in central Sudan went through three successive stages (Wickens 1982:30):

1. Cool, dry and windy in the end of the Pleistocene, reaching the latitude of at least 10°—12°N.
2. Moist and warm in the early and middle Holocene. Similar conditions were prevalent in western Sudan, where small lakes and wetlands formed at this time in depressions among the older dunes. At this time the White Nile was flowing to the north.
3. Drier conditions from about the middle Holocene when the rainfall margin started shifting south, drawing with it a recession of vegetation zones and the herbivorous animals dependent on them.

It is currently believed (Williams et al. 1982: 140) that the early Holocene in central Sudan was a wet period with dry intervals, while the middle Holocene was dry with wet intervals. The first of these climatic phases pervaded the plains of the Gezirah south of Khartoum about 8500—5000 bp with a drier interval occurring between 6500 and 6000 bp (Adamson et al. 1982:186, 210, Fig. 9: 21). The neighborhood of Khartoum in the early Holocene could have had a climate approximately like the one that today pervades the area around Kosti on the White Nile about 300 km further south (Williams et al. 1982:138). The humidity content of soils on the Upper Nile, dependent on rainfall, must have been augmented by river flooding which reached higher levels then than at any time in the following five millennia.

The southward shift of environmental vegetation zones during the Holocene is believed today to be the result not only of rainfall variation, but also, although to a lesser degree, of man's impact on the environment through activities such as scorching land under cultivation, animal grazing etc. (Mubarak et al. 1982:158).

In order to describe the natural environment as it might have appeared in central Sudan in 10,000—6000 bp, one must draw on information from the fields of geomorphology, pedology, climatology, botanics and zoology. This environmental characteristic based on current knowledge will then be confronted with data coming from recent investigations on archaeological sites from the period. The above brief presentation of the geomorphology of the Upper Nile region needs now to be complemented with a discussion of current ideas about the evolution of Nile floods and the climate of this part of Sudan in an effort to provide a framework for a dynamic study of the late Stone Age plant cover and the fauna that it supported.

Excavations at the Khartoum Hospital and Shaheinab sites led Arkell to suggest that flood levels in the Neolithic were 5 m higher than presently and even 10 m higher during the Early Khartoum culture phase (1953:8-9). Later surveys on the lower White Nile indicated that high floods during the Early Khartoum phase occurred about 8000—7000 bp (Adamson et al. 1974:120-121). Recent geomorphological and archaeological investigations in the Gezirah (Adamson et al. 1982: 213-219) have suggested that in the Late Pleistocene the climate in central Sudan was dry and the water regime of both Niles very seasonal with the lowest flood levels ever in the Holocene. Around 12,000 bp the climate in the regions of the sources of the two Niles changed to a wetter one, leading in consequence to huge floods on both these rivers in central Sudan, the flood waters carrying enormous accumulations of Holocene silt. It was at this time that the White and Blue Nile started to cut their riverbeds. The Early and Middle Holocene in central Sudan was also characterized by more abundant rainfall than today, although a short dry period occurred in 10,500—9500 bp.

The climatic phases that A. Adamson (1982) distinguished in his synthetic study of the climate of the Gezirah plain should undoubtedly be referred to the neighboring region of central Sudan:

1. Dry and cool climate in the Late Pleistocene (about 20,000—12,000 bp). The water volume in the upper Nile was generally low at this time, the floods average and high but short-lived, and the river level in winter extremely low. The river transported silt, sand and gravel which were deposited on the floodplain.
2. Wet and hot climate in the first half of the Holocene (about 12,000—5000 bp). The expansion of forests and swamps that occurred at this time was caused by heavy rainfall. In 9000—7000 bp the Gezirah was a vast permanent swamp. The volume of water in the Upper Nile was substantial, the floods very high, but in winter the river dropped to a low level. The waters transported silt, clay and sand, flowing in a river bed that started already to be cut into bedrock. River deposits continued to be accumulated on the floodplains during the floods, but to a much lesser degree.

This brief characteristic of the river's water regime and the climate demonstrates that humidity in central Sudan rose rapidly about 12,000 bp. This had to impact the development of the plant cover and a parallel development of fauna in this part of Africa.

In the past, plant dynamics in the environmental zones of central Sudan have been determined mainly by deduction (Wickens 1982: 30ff.), using modern observations of the plant cover to build models for different periods in the past. For this purpose, present gradations of plant complexes are superimposed on different climatic conditions (rainfall and temperature), taking also into account pedological conditions and soil humidity among others. It is assumed that plant complexes have remained practically unchanged over time. It should be noted that there is still no palynological data from central Sudan and archaeological sites have not yielded few plant macroremains.

According to Wickens' theory (1982:39-44), the main plant zones of Sudan in the warm and humid climate of the early Holocene (about 11,000—7000 bp) shifted about 400 km north with regard to the present situation. The 500 mm rainfall isohiet passed through the region near Khartoum. In the light of this theory, the central Sudan covered different environmental zones, starting with a latitudinal belt of dry savannah bordered on the north by a semi-desert zone and on the south, between the Blue and White Niles, by swamps and lakes with papyrus reeds stretching all the way to Khartoum. Fauna in this environment, according to Wickens, included the Nile lechwe antelope, still encountered today in the wetlands on the White Nile, hippopotamus, *kob* antelope, elephant, buffalo, reed rat and ichneumon. Mollusks found in the Gezirah plain, however, point to a more seasonal nature of these wetlands, suggesting that they were more like the present-day *toich* on the White Nile. Trees of the *Acacia seyal* species grew in the plains of the northern Gezirah and the open spaces were overgrown with seasonally flooded grass. The southern part of the Gezirah was a seasonally flooded woodland of *Anogeissus leiocarpus*, *Combretum hartmannianum* and *Acacia seyal*. The dôm (*Hyphaena thebaica*) and doleb (*Borassus aethiopum*) palms could have grown on the higher ground in the Gezirah; both species are resistant to high ground water levels, but do not grow in seasonally flooded terrain. Forests on higher ground were composed of *Anogeissus leiocarpus* and could have been populated by human communities, although numerous insects found in this habitat, including flies of the *Tabanidae* species, could have posed a difficulty, especially during the rainy season. Wickens (1982:41-43) was of the opinion that the presence of the *Tabanidae* flies which spread the protozoan *Trypanosomiasis* that causes sleeping sickness and carbuncle in cattle and humans rather excluded the breeding of cows in the Gezirah. This particular fly does not occur in Sudan north of the 500 mm isohiet. The climatic conditions in the Gezirah at the time could have been difficult for human groups during the maturing and harvesting of wild sorghum at the close of the rainy season when this insect is at the peak of its activity.

In keeping with Wickens' idea, a vast dry savannah as described above should be expected to the west and east of the upper Nile during this period.

1.1. The natural environment in the light of archaeological data

The general idea of the natural environment in central Sudan between 10,000 and 6000 bp presented above can be verified and complemented taking into consideration geomorphological observations made during excavations of archaeological sites as well as the results of analyses of botanical and zoological macroremains identified in the excavated assemblages.

Excavations at the Khartoum Hospital site permitted Arkell (1949:12, 105) to state that the water level in the river during the Early Khartoum occupation of the site was higher than today by at least 4 m. The community returned to occupy the hill repeatedly during the Blue Nile's low-water periods, that is, in winter and spring. Arkell (1953:8-9) went on to modify his earlier calculations based on the Early Khartoum site near the Neolithic camp of Shaheinab. Assuming that Shaheinab was a hill by the river that could be occupied at low-water levels, he measured the difference between the top of the occupational layer (381.14 m a.s.l.) and the present water level in the river during the flood (372.0 m a.s.l.) and found it to be approximately 10 m. Therefore, he concluded that the low-water level of the Nile in the Early Holocene was higher than recent flood levels by about 10 m.

The higher river flood levels must have shaped the natural environment in the valley of the upper Nile in the Early Holocene. The river must have seasonally flooded large parts of the valley, surely the entire flat plains in their entirety. The water may not have been deep, but it ran outside the main riverbed, moving slowly in the shallows, among the thick grasses, bushes and trees.

Perennial flooding was undoubtedly a major source of water in the Nile valley. Rain was the other source, but the huge impact of the river, mainly the seasonal flood, on the degree of humidity in the Nile valley and at its edges makes it difficult to estimate the rate of rainfall in the Early Khartoum period. The flora and fauna that is evidenced in data from archaeological sites was largely dependent on the river flood and the moist soils in the paleochannels and wetlands of the river valley.

Information from Shaqadud specifies the extent of rainfall in this part of Sudan in the older phase of the Holocene. Shaqadud lies just 130 km to the northeast of Khartoum and approximately 50 km east of the Nile, in the presently semidesert Butana uplands. One branch of a long wadi connected this site to the Nile. The environment here was therefore not dependent on seasonal Nile flooding.

At Shaqadud (Marks et al. 1985), the oldest settlement layer yielded remains that testify to the character of the climate in this region about 8000 bp and the flora and fauna that was exploited here by the Early Khartoum population. A natural pool filled with rainwater existed in the wadi at the time. The only plant macroremains discovered were seeds of *Ziziphus*, but the list of animal species attested to in the faunal remains from the site suggest a grassy savannah habitat with clusters of trees, featuring annual rainfall in the range of 400—500 m. The presence of the *Pila* snail and reed-rat suggests seasonal wetlands around the pool. Most of the faunal remains are typical of species inhabiting a dry savannah with access to waterholes: terrestrial snails *Limicolaria* and *Zonitarion*, land tortoise and lizard, wild guinea fowl and ostrich, elephant, giraffe, warthog and porcupine. Game was dominated primarily by big and small antelopes: oribi, kudu, roan, topi and *Alcelaphus*; the African wildcat has also been recorded. Thus, the evidence from Shaqadud clearly points to a dry savannah environment in central Sudan, in the close neighbourhood of Khartoum, in the Early Holocene. Floral and faunal remains found on other Early Khartoum archaeological sites supply further information on the humidity, including rainfall. Of particular value are the remains that existed on the site independently of human activities.

Plant remains were found only in the assemblages from two Early Khartoum sites in central Sudan. Soil samples from test pits at Sarourab 1 (Abbas 1982:82) yielded unidentified grass pollen (*Gramineae* and *Liguliflorea*). One of the hearths from this site contained fruit stones of *Ziziphus* sp., a popular bush in this part of Sudan. Of more importance for this study is the discovery of a few hundred mineralized fruit stones of *Celtis integrifolia*. Arkell (1949:108) believed them to be the remains of fruit collected by the inhabitants outside the settlement. An overview of current research on the ecology of this tree species should prove to be very interesting.

According to Andrews (1948:42-52; 1952:250-252), *Celtis integrifolia* is a component of the wild flora in Sudan from the grassy savannah to the zone with annual rainfall in the 500—1000 mm range. It grows in thickets on the Blue Nile, at some distance from the river, often associated with doleb palms (*Borassus aethiopium*). Sherwood (1948:817) reports it growing also on small hills rising from the seasonally flooded valley of the White Nile, in the company of other trees, such as *Acacia campylacantha*, *A. Sieberiana*, *Randia nilitica*, *Diospyros mespiliformis*, doleb palm (*Borassus aethiopum*) and *Combretum*. *Celtis integrifolia* is a deciduous tree with light-colored bark. It reaches approximately 20 m in height. The leaves are from 4 to 7.5 cm in length and from 2.5 to 5.0 cm in width. The flower is yellow-green in color. Hamilton (1982:281) refers to *Celtis integrifolia* as a tree making up the dry savannah woodlands.

The *Celtis integrifolia* bears fruit that Andrews (1952: 250) refers to as condensed, membranous, dry and having little flesh. They are sweet in taste and remain on the tree through the winter. Kingdon (1971:29) writes that the tree comes to fruit from May to October, that is, during the tropical summer rains. According to Arkell (1953: 9), the presence of this tree is indicative of annual rainfall of at least 500 mm.

Faunal remains also supply data on the natural environment, especially species that lived on the archaeological site and were deposited in the archaeological assemblages without human participation. These are primarily mollusk shells, including terrestrial (*Limicolaria flammata*, *Zootecus insularis* and *Burtoa nilotica*) and palustrine species (*Lanistes carinatus*) not collected by man, as well as those used by human groups.

The terrestrial snail *Limicolaria* (*cailliaudi*) flammata was extremely numerous in assemblages from the Khartoum Hospital site and Saqqai, and were also noted at El-Qoz; at Umm Marrahi there were only a few examples. They were naturally present on these hilly sites and were not exploited by the communities living there. Tothill (1948b: 138-139) says that today the phytophagous *Limicolaria*, which cannot survive in water, is encountered on the grass-and-acacia savannahs featuring rainfall in the 400—800 mm range and no annual river flooding. It feeds exclusively on some species of tall grasses. During the dry season the snail is inactive, waiting buried in the soil for the rain to come. According to Tothill, the smaller size of the shells of this snail found at the Khartoum Hospital site indicates that the climate at the time was less favorable for this species than the present-day grass-and-acacia savannah. Arkell (1953:9) considered the presence of this snail as indicative of annual rainfall of at least 500 mm. At the Khartoum Hospital site the snail existed also in the dry season, during which it was dormant, as indicated by the opercula preserved in some shells. Another terrestrial snail, *Zootecus insularis*, requires similar environmental conditions. It was abundant in assemblages from the Khartoum Hospital site and was also recorded at Sarourab 2; just a few examples were found at Saqqai and Umm Marrahi. *Burtoa nilotica*, recorded at Sarourab 1, is the biggest terrestrial snail to be found in Sudan (Tothill 1948c:197-198). It lives in seasonally flooded terrain, on top of termite mounds, but its regular biotope is well drained, flat or hilly forested ground. The presence of these three snail species, none of them tolerating even seasonal flooding in their habitat, clearly indicates that the hilly sites of the Early Khartoum culture were not submerged by the annual Nile floods.

Phytophagous palustrine *Pila* and *Lanistes* snails, but mainly *Pila wernei* (=*Pila ovata*, *Ampullaria*), all undoubtedly collected by humans (see below), were brought to the settlement from outside. Tothill (1948b:138-139; 1948c:192-197) describes the *Pila* and *Lanistes* as respiring through both lungs and gills. They are said to live in a water habitat and feed on grasses; today they can be found in the grass-and-acacia savannah. During the dry season which lasts seven months, when water reservoirs dry out completely, the snail will dig itself into the mud, seal its shell with an operculum and wait for the rains. *Pila* and *Lanistes* feed in a habitat that has been flooded up to about a meter in depth and for three-four months every year in the tall grasses on the clay plains, sometimes also in seasonal ponds. The *Pila* and *Lanistes* may remain inactive for at least a year (Beadle 1974:106, 274); according to Beadle, the *Pila* live in seasonal wetlands and regular lakes. Bell (1966) believes that only the Pila ovata occurs in Sudan. According to him, the differences in the morphology of this snail are the result of different environmental conditions, but little is actually known about the ecological optimum of this snail and the extent of its habitat. *Pila* and *Lanistes* could have had appropriate conditions on the Khartoum Hospital site at the time that it was functional, the habitat being very much like that around Malakal, in the vicinity of the present-day permanent marshes on the middle White Nile. The similar size of shells of the *Pila* snail from these two environments would stand, in the opinion of this author, in favor of this theory (Fig. 3).

The wild game species composition in the vicinity of the Early Khartoum settlements can be reconstructed from assemblages found at these sites. The bones represent fish, reptiles, birds and mammals, for the most part remains of food consumed by the inhabitants of the sites. It is commonly assumed today after Arkell (1949:110; 1953:9) that the presence of a few highly specialized species typical of the swamp biotope suggests the existence of such a habitat in the vicinity of Khartoum during the Early Khartoum Culture phase. These wetland species include the Nile lechwe antelope (*Kobus/Onotragus megaceros*), water or mud mongoose (*Herpestes ichneumon/Atilax paludinosus*) and extinct reed-rat (*Thryonomys arkelli*). Recent examination of the assemblages from Saqqai and repeated study of the faunal remains from the Khartoum Hospital and Saqqai sites have shown (Peters 1986) the presence of, respectively, four and 20 skeletal fragments belonging to the marsh rat, the identification now revised to *Thryonomys swinderianus* (Greater Cane Rat). Six fragments at Khartoum Hospital and 21 at Saqqai represented the water or mud mongoose (*Herpestes ichneumon/Atilax paludinosus*). Four bone fragments of Nile lechwe antelope were found at Khartoum Hospital as well as, more importantly, two parts of the skeleton of *sitatunga* antelope (*Tragelaphus spekei*), which is another marsh species.

These species clearly demonstrate close ties with a marshy environment existing around Khartoum Hospital and Saqqai, exploited by the indigenous hunters. The marsh rat is a very large rodent weighing 4.5—8.8 kg (Kingdon 1974:700-701). It

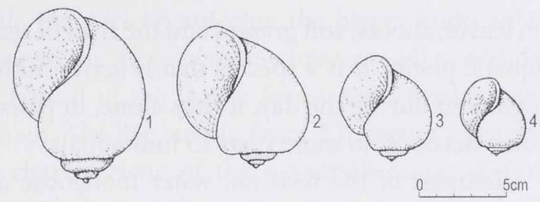

Fig. 3. Shell size of the *Pila ovata*.
1. shell found in 1977 near Fashoda, 2. shell from the Khartoum Mesolithic site in Khartoum Hospital, 3. the biggest shell found on the Neolithic settlement at Kadero, 4. medium size of the shell from the Neolithic site at Kadero

is widespread in Africa, living on the banks of rivers and lakes, in the reeds and water grasses, and in seasonally flooded grassland. It is a semi-aquatic species and a good swimmer. It feeds on reeds and aquatic grasses, as well as nuts, fallen fruit and tree bark. According to Bate (Arkell 1949:22), a fossil reed-rat which she identified as *Thryonomys arkelli* occurred in the assemblages at Khartoum Hospital. Bigger than the *Thryonomys Swinderianus* and an excellent swimmer and diver, it typically inhabited the wetlands, rushes and thick jungle.

The mud mongoose (*Atilax paludinosus*) is a predator of the marshes of Africa (Kingdon 1977: 206-213). It can live in open water, but prefers marshy biotopes, edges of rivers and lakes, and is particularly well adapted to papyrus rushes. It hunts river crabs, clams and water snails, reptiles, birds, large insects and larvae, eating also different fruit and bird's eggs. It scrounges around fishing villages, waiting for discarded food leftovers. It can reach a weight of 2.5—4.1 kg.

The Nile lechwe antelope (*Kobus/Adenota/Onotragus megaceros*) inhabits the marshes and wetlands on the White Nile and the Bahr el-Ghazal with tributaries (Dorst and Dandelot 1980:214-215). Big herds of 50 and more animals graze on grasses and other aquatic plants. It is a medium-sized antelope which can reach approximately 86 kg in weight.

Sitatunga (*Tragelaphus spekei*, *marshbuck*) belongs among the big antelope of central Africa with a body weight of 45—110 kg (Dorst and Dandelot 1980:196-198). It is a highly specialized species living in marshy habitats composed of seasonally flooded reeds and papyrus rushes. It is an excellent swimmer and is physically well adapted, its long legs allowing it to wade safely through the marsh and its ability to submerge itself completely except for the nostrils a good precaution. It feeds on leaves, shoots, soft grasses and the fruit of semi-aquatic plants. It is a species that is active both at night and during the day. It lives alone, in pairs or small herds of no more than 15 individuals.

Remains of the reed-rat, water mongoose and two species of marsh antelope at the site indicate that there was a permanent swamp within reach of the Khartoum Hospital and Saqqai hunters. Marshes were thus an important element of the natural environment on the upper Nile in the 10th—7th millennium bp. Yet the region around these sites was not all wetlands as demonstrated by the full list of game and other animals represented in the faunal assemblage, as well as the frequency of fragments representing the different species of interest for the purposes of the present study.

The four species of palustrine fauna are represented by about 57 skeletal fragments in the Early Khartoum assemblages, while the full list of hunted mammals (that is, disregarding mollusks, reptiles and birds) counts some 3000 skeletal fragments (about 600 from the Khartoum Hospital site and about 2500 from Saqqai) representing 36 species. Therefore, the palustrine mammals constitute only a small part of the faunal remains. A general classification of these species by habitat gives a good idea of what the hunting zone of the Early Khartoum population looked like in its entirety.

The river is inhabited typically by certain mollusks, fish, reptiles, birds and some of the mammals. Among the mollusks one should mention Nile clams and snails: *Aspatharia*, *Corbicula*, *Bellamya*, *Etheria* and *Mutela*. The deeper and rapidly flowing waters are home to *Etheria*, while the *Aspatharia* and *Mutela* prefer the quieter shallows. The Nile oyster (*Etheria elliptica*) lives on the rocky river bed, while the Nile mussel (*Aspatharia*) can remain inactive in the dry Nile with a sealed shell for more than two years (Beadle 1974:304, 275).

Among the twelve fish species, the remains of which were found in Early Khartoum deposits, there are mainstream fish and those encountered in the shallow waters on the floodplain (Bridge 1904: 586-593, 659, 671). Mature barbel (*Lates*), tiger-fish (*Hydrocyon*) and Nile catfish (*Synodontis* and *Bagrus*) come from the deep, well oxygenated waters of the river. Species that are characteristic of poorly oxygenated shallow waters and closed pools of standing water left from seasonal river flooding include the catfish *Clarias* as well as *Tilapia*, *Barbus* and *Protopterus*. The *Clarias* and *Protopterus* can absorb oxygen from the air (*Clarias* have lungs along with gills). If the water evaporates, the *Clarias* can even bury itself in cracked clay but still requires a minimum of water and oxygen to survive. Only the *Protopterus* does not die with the receding and evaporation of all water from a flood terrace. Remains of this fish, not very numerous, were found in the settlements at Khartoum Hospital and Saqqai. This fish is equipped with lungs and takes 98% of the oxygen from the air; it lives in large lakes and rivers, but if the water dries up completely, it can bury itself in the soft mud at a depth of about 45 cm, forming a small cocoon around itself and leaving a small channel to the surface to respire through (Bridge 1904:511-515). Swimming, it comes up to the surface periodically to take a breath of air. In the dry season it can be dormant even up to six months, waiting for the next rainy season. It then builds a kind of nest in the shallow waters overgrown with grasses near the bank and deposits its spawn. It feeds on small larvae and insects, but also decaying plants, frogs and fish.

There does not seem to be enough data to resolve the question whether either of the these two river ecohabitats, the deep waters and the shallow waters, are represented more numerously among the ichtiofaunal remains in the studied assemblages.

Reptilian remains include species typical of both the river waters and the dry regions situated in the vicinity of the former. Water reptiles are represented by the crocodile (*Crocodylus niloticus*) and carnivorous water turtles, of which there are six species: two *Peluios*, two *Cyclanorbis*, *Trionyx* and *Cycloderma* (Gadow 1909:463-464, 404-407). The crocodile feeds in the river waters. The young hatch from eggs laid at the beginning of the flood season in deep, dry riparian sand. The water turtle Trionyx lives in shallow muddy rivers, feeding on the bottom on various water creatures like fish, frogs and mollusks. It takes to dry land only for the purpose of laying eggs in the sand.

Quantitatively, the faunal material is dominated by the remains of terrestrial reptiles such as the rock python, the great Nile monitor and the terrestrial turtle (Gadow 1909:365, 545, 597,601). The rock python (*Pyton sebae*) is a typical snake constrictor from tropical Africa. It lives most commonly in a forest ecohabitat where it can lay in wait for its prey entwined around tree branches; it hunts mainly small mammals like rats and birds. Rock pythons also occur in marshy, aquatic and sandy environments. The terrestrial turtle (*Testudo*) is a herbivore, but also feeds on larvae, mollusk and insects. In the hot and dry season, it is dormant. The Nile monitor (*Varanus niloticus*) is a lizard encountered in different biotopes, from forest through sandy and dry, to semi-aquatic.

Bird remains in the studied assemblages represent the avifauna of different biotopes. The geese *alopochen aegyptica* (?) and *Plectropterus gambenis* (?) belong among aquatic fauna; shallow waters with papyrus and reeds are their preferred habitat. The small African bustard, a small fragment of the skeleton of which was found at Saqqai, is a species that is characteristic of a dry environment, like the ostrich which is represented in the Early Khartoum site assemblages by nothing more than beads made from ostrich eggshell. This biggest of the birds is a typical dry savannah species (Evans 1900:27-30) and lives in dry sandy areas overgrown with low bushes. It usually feeds in the company of herds of zebra, hartebeest and other antelopes. It consumes different grasses and herbs, including seeds and fruit, but also small mammals, birds, reptiles and insects. Ostrich may go without water for a very long time, but they have the habit of bathing in the river by submerging their bodies up to the neck.

The game species in the studied assemblage, apart from the wetland species already discussed above, represent fauna from different savannah biotopes. Using Jewell's classification (1980: 362), one can distinguish the fauna of a number of ecohabitats based on the ecology of particular species as given by Kingdon (1971; 1974; 1977; 1979), MacDonald (1984a; 1984b) and Dorst and Dandelot (1980).

Generally speaking, almost all the game species hunted by Early Khartoum community groups could be found in different savannah biotopes from the floodplain through riparian forests, to bushy and forest savannah and the open savannah grasslands. Today these species tend to concentrate in the vicinity of waterholes. Of these only the guenon monkey and the true civet are typical of the riparian forest, and the bushy and forest savannah, while the African anteater, the bigger kudu antelope and the *Alcelaphus* antelope, as well as equids, are typical of the bushy, forest and grassland savannah. The big buffalo from Khartoum Hospital are characteristic of the savannah fauna (Peters 1986:22). It is striking that the kob (*Kobus kob*) and oribi (*Ourebia ourebi*) antelopes, which are the most numerous species among hunted game represented in the studied assemblages, are both typical of a seasonally flooded plain, while the bohor reedbuck (*Redunca redunca*) is characteristic of this kind of habitat but also occurs in the open grassland savannah. Hippopotamus feeds in rivers, marshes and on the floodplains. No specimens of fauna specific to a montane habitat were recovered from the faunal assemblages in question.

Caution is recommended in forming conclusions concerning the natural habitat in the neighborhood of a given site based on nothing more than the species distribution suggested by the site assemblage. Several different factors can impact both the actual number of the remains and the list of identified species. These factors include potential hunting specialization, quartering locations and methods, transport of the carcass or its part to the village, dumping of bones etc. Nonetheless, the studied remains of mammalian game are of relevance for a study of the natural environment exploited by the Khartoum Hospital and Saqqai populations.

Summing up the information on the environment exploited by Early Khartoum communities contained in the species composition recorded for the different site assemblages, we find different biotopes in ecological niches of a riparian habitat: deep river waters and shallows, permanent and seasonal wetlands, riparian forests, as well as vast grassy floodplains dotted with isolated mounds covered with bushes and trees and with seasonal marshes. Judging by the number of mammalian remains, hunting must have been especially intensive on the seasonal floodplains, where the kob and oribi antelopes, buffaloes and Nile monitors could be found.

1.2. General reconstruction of natural environment characteristics

The floral and faunal macroremains from archaeological assemblages support a general reconstruction of the central Sudanese environment

Fig. 4. Molluscs shells from Kadero. *Limicollaria* (right column), *Pila* and their opercula (left column).

between approximately 8000 and 4900 BC (10,000–6000 bp). Taking into account the ground relief of the region, the river cycle and the climate (rainfall and temperatures) during this period, data on humidity (river flooding and rainfall), the nature of the floral and faunal cover and comparative data with today's dry savannah zone, we can distinguish three ecological habitats in the local savannah ecosystem, all three exploited by the hunting and fishing Early Khartoum communities:

1. Riverbank and the margin of permanent riparian marshes. Soil in this niche was composed of young alluvial silt. The Nile flowed in its paleochannel until about 7500 bp, hence the floodplains were regularly flooded with shallow waters; the low Nile was at least 10 m higher than the recent river levels in winter. Even so, it is clear from the abundant presence of the terrestrial snail *Limicolaria* which does not survive under water that the settlements were not flooded (Fig. 4). This narrow ecological niche ran along the entire upper Nile and was home to the Early Khartoum camps which occupied the low hillocks. The tree cover included *Celtis integrifolia* as well as presumably other tree species, such as the *doleb* palm, *Ziziphus* bushes and grasses. The permanent riparian wetlands were composed of papyrus and reeds, similarly as on the middle White Nile in modern Sudan. On the western bank and at the northern end of the eastern bank where extensive floodplains do not exist, this niche neighbored directly with a zone of higher flats composed of sand and gravel, cut by wadis which connected the two niches. Typical fauna in this niche included aquatic species: water and marsh mollusks, fish, reptiles, water turtle, crocodile and goose. Mammals in this niche fed both in water and at the water edge (hippopotamus, sitatunga antelope, reed-rat, water mongoose). The fauna must have concentrated wherever this narrow zone connected with the wadis down which the herbivores came to the watering places. This must have been especially true in the dry season when herds of herbivores moved here from the other two ecological niches in search of food and water.
2. Flat river plain. It is composed most probably of silt and clay similar to the terminal Pleistocene upper layers of the Gezira Formation situated south of Khartoum. In the northern part of the region in question, north of Wadi el-Garwada to the Sixth Cataract, it is narrow and was cut in the Early Holocene by the bed or beds of the Nile and its paleochannels, as well as khors connecting the river with the third ecological zone. To the south of Wadi el-Garwada the plain widens gradually to join the vast Gezira plain in the vicinity of Khartoum. The isolated hills in this plain could have hosted hunting camps during the wet season. There were also shallow ground depressions which turned into seasonal marshes during the river flooding or as a result of heavy rains.

The flat plain, which was wider at the southern end, used to be flooded by the Nile in the summer. It seems to have had a rich growth of grasses and sunt acacia trees which take well to seasonal floods. The rich plant vegetation in this zone must have supplied excellent feeding ground for different herbivores and predators, especially in the wet season and right after its end. Numerous herds of herbivores would have included the elephant, giraffe, rhinoceros, buffalo, antelope, gazelle, warthog, hippopotamus and beasts of prey. The seasonal marshes were inhabited by terrestrial reptiles, that is, big Nile lizards, turtles, pythons and undoubtedly numerous birds. This animal population was complemented by numerous palustrine mollusks and lungfish species. A huge concentration of floral and faunal biomass characterized this zone.

3. Wadi-carved plateau. This extensive ecological niche stretched to the east and west of the Nile valley (Butana). It was composed of sand and gravel from eroded sandstone and in the northeastern part of the valley of volcanic and magmatic rock. Wadis cut through it reaching the Nile. The plant cover was obviously richer in the wadis and consisted of grasses, bushes and acacia (*seyal* ?)trees. Acacia trees, bushes and grasses could have also grown sporadically on the gravel plateau itself. Here rainfall was the only source of humidity, hence the dry season had to be long. Rock crevices and depressions in the ground must have served as natural water reservoirs, similarly as in Shaqadud (Marks et al. 1985:265). In the dry season and shortly thereafter, it provided good foraging also for many species of fauna living in the second ecological niche, while in the dry season only for the more environmentally specialized species of gazelle, antelope, ostrich and selected predators.

Of significance for the present study is the issue of the abundance of food in particular ecological niches from the point of view of populations characterized by a non-productive economy and the kind of technology that the Early Khartoum Culture possessed. As indicated above, the central Sudan in the Early Holocene lay in an environmental zone, most of the characteristics of which were akin to those of the dry savannah situated in modern Sudan approximately 400 km further to the south.

The tropical savannah is classified depending on the duration of the dry season. According to the criteria used by Harris (1980a:3-18), the central Sudan in the Early Holocene lay in a latitudinal zone of medium-humid savannah characterized by annual rainfall between 500 and 1000 mm and a dry season from five to seven-and-a-half months long.

The two types of the savannah are characterized by an irregular rainy season. Natural (either sparked by lighting or volcano eruptions) and human-related fires threatened the plant cover, causing the expansion of grasslands at the cost of trees (Harris 1980a:12; Moss 1969:220–222). Indeed, uncontrolled burning of savannah grasslands was the work of hunters, not farmers (Moss 1969: 222).

The savannah is exceptionally rich in biomass (Harris 1980a:17–18). Most of this biomass is consumed by mammals, mainly big herbivores, as well as rodents, marsupials and insects (locust, mosquito, tse-tse and black fly). It is not homogeneous and is often quite varied in the plant cover: trees, bushes, grasses, herbs (Harris 1980b:31). Human settlement always preferred the marginal zones between savannah and water because the presence of water and availability of food of aquatic origin reduced the seasonal environmental tension caused by fluctuations in rainfall and related plant vegetation, as well as the habits of terrestrial fauna. In the dry season most herbivores cluster around water and in the shade of trees (Kingdon 1971:40). With the coming of rains these animals scatter to more widely spread feeding grounds. Human communities inhabiting the savannah ecotones characteristically make us of the whole range of resources (Harris 1980b:31). Therefore, the richness of the ecotone between the water and the savannah on the upper Nile must have been much bigger than in other parts of this great environmental zone, although there is no data to support more specific estimates in this respect.

It is believed that the fauna of the primal savannah was composed of great populations of ungulates and other grass-eaters, as well as the predators that preyed on them. Grass burning as a hunting technique (to force animals into traps or toward a line of hunters) had serious impact on the development of plant vegetation and the fauna that forages on it (Moss 1969:220-222). Hunting-fishing-foraging groups regularly burned grass and bushes in the savannah in order to stimulate the growth of young plants, thus raising their attractiveness as feeding ground for herbivores, especially the big species (Clark 1980b: 64-65). According to Clark, palynological data is proof of grass burning as a technique; pollen diagrams from the banks of Lake Victoria show a sharp increase in the share of grass. There are also extensive layers of charcoal in the Kalahari region and numerous ethnographic examples to support this idea. The technique was used consciously to increase the richness of the exploited environment, especially with regard to the hunted fauna.

2. The natural environment, 4900-3800 BC

The early phase in the development of the Khartoum Neolithic falls in the Middle Holocene. It is currently held that the climate in Sudan began to deteriorate in the Middle Holocene compared to the conditions present there in the Early Holocene. Annual rainfall rates decreased in this part of Africa, causing environmental, climatic, floral and faunal zones to shift gradually toward the south; the destructive impact of human economy on the natural environment also began to be felt (Wickens 1982:30).

According to Wickens, the vegetation zones in Sudan in the Middle Holocene were about 250 km further to the north than they are today. Middle Sudan was then at the northern edge of a latitudinal belt of dry savannah. To the west of the upper Nile and in the region of the Sixth Cataract there was in this period a semi-arid zone with acacia and bushes, while to the east of the river there was a thorny savannah. The permanent marshes of the Early Holocene around Khartoum dried up, although they continued to exist on the lower White Nile, about 100 km further to the south, or else gave way to seasonal marshes. A migratory pastoral economy (cattle, goats and sheep) did not disturb the balance of this natural environment, unlike migratory plant cultivation and the inherent burning of vegetation in areas intended under cultivation. Even so, the concentration of herds of domesticated animals in the neighborhood of human settlements could have already posed a threat, through excessive grazing, for example, and the elimination of predators attacking the herds. Perennial Nile flooding was also reduced in the Middle Holocene compared to the earlier period. A lowering of overall humidity levels due to less abundant rainfall and lower river flooding caused the climate of upper Nubia to become drier than in the times of the Early Khartoum Culture (Wickens 1982:41, 45-46, Figs 3, 5-C).

In the Middle Holocene, the conditions around Khartoum were dry with a wet interval encompassing the rainy season and flooding by the river. The change of climate resulted in a change of the vegetation and fauna present in the region.

2.1. The natural environment in the light of archaeological data

Arkell's investigations at Shaheinab (Arkell 1953:7–9) have provided data on the ancient river flood levels. Comparing altitudes for the bottom of the occupational layer on the site, the neighboring Early Khartoum settlement and the flood level of 1946, he arrived at the conclusion that the river flood levels for the Early Neolithic were about 5 m lower than in the times of the Early Khartoum Culture and about 5 m higher than the flood of 1946. He assumed that human camps occupied sites not much higher above the waters of the river at the current ordinary flood level.

Relatively lower flooding must have seriously impacted the natural environment in the Nile Valley. Less of the valley was flooded, the volume of the flood was smaller and it lasted for a shorter time, hence lowering the overall levels of humidity. This must have resulted in changes of the indigenous flora and fauna.

Data on rainfall, the other source of humidity in the Nile Valley, can be garnered from the floral and faunal macroremains found in Early Neolithic assemblages on sites situated in the near vicinity of the Nile, but outside the reach of the river floods. The Neolithic settlement in Shaqadud is excellent in this respect. The site was tested with a trench located in a midden situated at the bottom of a local wadi (site S1-B), overlying remains of Early Khartoum habitation. Neolithic layers appeared at a depth of approximately 1.50 m (Marks et al. 1985:270-277). An approximate date for the beginning of Neolithic settlement on the site is about 5700 bp. A permanent pond continued to exist in the wadi during this period.

Peters (personal communication) believes on the grounds of an analysis of the faunal remains from the Neolithic midden that the natural environment in this period was slowly changing into a dry savannah with annual rainfall of 350 mm already possibly around 3600 bp. Neolithic layer III on site S1-B still contained remains of mammals representing wild fauna typical of a rather wet savannah, such as *Pila* snails living in seasonal ponds and marshes, terrestrial snails *Limicolaria cailliaudi*, numerous amphibians and terrestrial turtle(?) (*Kinixys* sp.), savannah monitor (*Vara-*

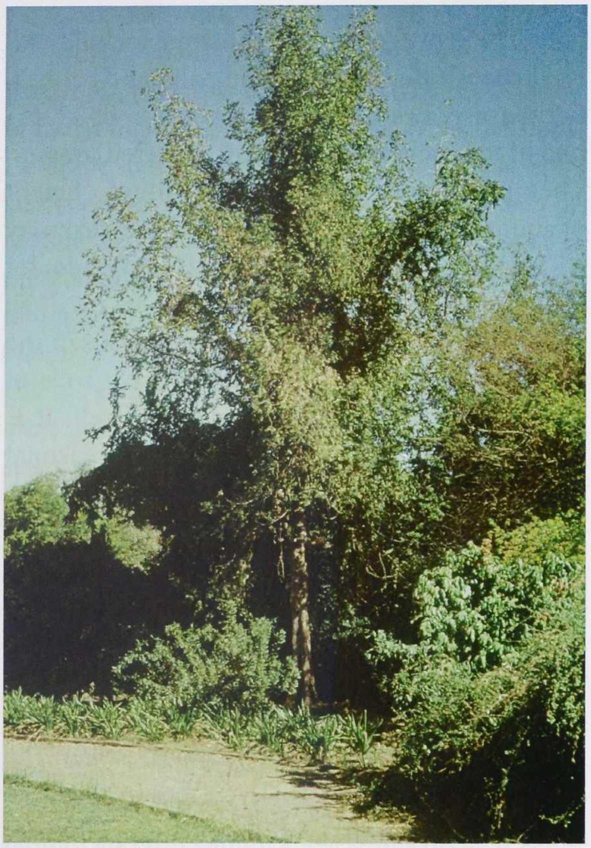

Fig. 5. *Celtis integrifolia* tree in the Botanical Garden in Khartoum.

Fig. 6. Seeds of the *Celtis integrifolia* found in the Kadero.

nus exanthematicus), pelican (*Pelecanus* sp.), genet (*Genetta* sp.), warthog (*Phacochoerus aethiopicus*), giraffe, oribi antelope (*Ourebia ourebi*) and the larger kudu antelope (*Tragelaphus strepsiceros*).

In the light of currently available data there is no doubt as to a general decrease in humidity in the upper Nile Valley during the Early Neolithic as compared to the times of the Early Khartoum Culture. The phenomenon seems to be due to lowered levels (and consequently extent) and duration of seasonal river flooding as well as decreasing and probably more and more irregular annual rainfall. A drier environment is clearly suggested by the list and frequency of plant and animal species recorded in Early Neolithic site assemblages. Similarly as in the case of the previous period, species that inhabited the site regardless of human volition have the greatest usefulness for analyses of ecological conditions.

Plant remains were found on four archaeological sites. At Shaheinab there were numerous charred seeds of *Celtis integrifolia*, pieces of shell of the oil palm (*Elaeis guineensis*), charred wood from an unspecified species of acacia (*Acacia* sp.) and *Ziziphus* sp. bushes. *Celtis integrifolia* stones were also found in the settlement at Umm Direiwa 1, and wild sorghum (*Sorghum verticilliflorum*) was identified among the impressions on ceramic sherds found on the site. Impressions of this wild grain were also identified on pottery from the settlement in Zakiab 1, where *Celtis integrifolia* stones were also found.

To date, Kadero has been the most prolific source of floral macroremains for analysis. These include an abundant set of *Celtis integrifolia* stones (Fig. 5 and 6), two stones of dôm palm (*Hyphaena thebaica*) fruit from a Neolithic grave and impressed seeds of cereals on potsherds. No pollen was recorded in soil samples from the site and its neighborhood (Krzyżaniak 1979a:69). M. Klichowska (1982; 1984) noted impressions of seeds of grasses (*Gramineae*) on potsherds from the site. Nine tropical cereal species (*Cerealia*) represented include four varieties of sorghum and five of cereal grasses from the millet group. According to Klichowska, sorghum (*Sorghum bicolor*) and African millet (*Eleusine coracana*) could have been cultivated by the inhabitants of Kadero (see below).

The ecology of plant species identified from Early Neolithic sites throws more light on the possible natural conditions on the Upper Nile in this period. The *Celtis integrifolia* is typical of savannah grasslands and dry savannah woodlands, occurring all the way to the zone of annual rainfall in the range of 500–1000 mm. It grows on hillocks, occasionally in thickets, often together with the doleb palm (*Borassus aethiopicus*), *Acacia campylacintha*, *A. Sieberiana*, *Randia nilotica*, *Diospyros mespiliformis* and *Combretum*.

The *Ziziphus* is even today a popular bush in central Sudan. The dôm palm is also not very specialized in terms of its environment. It grows today in central and northern Sudan, also in the desert, reaching about 16 m in height (Andrews 1952: 304). It is a frequent component of forests growing in the savannah grasslands (Andrews 1948: 4). It also grows in the beds of the seasonally drying rivers Atbara and Gash (Mackinnon 1948:704), and groves of this palm occur also in seasonally flooded areas (Phillips 1959:210).

The oil palm (*Elaeis guineensis*), identified by a nutshell fragment from Shaheinab, is a different case altogether. Arkell (1953: 105) believed it to be foreign in central Sudan (import ?), but Andrews (1952: 301) found it to grow today in southern Sudan, in the Equatoria province, and considered it as likely autochthonous in a humid tropical forest environment composed of broad-leafed trees and characterized by annual rainfall in excess of 1000 mm (see also Andrews 1948:34, Fig. 1; Ireland 1948:69, Fig. 26). The tree must have thus been a component of riparian flora in central Sudan in the Early Neolithic.

Species of tropical cereals identified at Kadero are typical of a dry savannah environment in modern Sudan. As regards their wild forms, both sorghum and African millet are among the most frequent grasses growing today in a grasslands environment in central and southern Sudan. The inhabitants of Kadero seem to have collected the seeds of these cereals growing in the wild rather than cultivating the species in any way.

Wild sorghum (*Sorghum verticilliflorum/arundinacaeum*) can be observed today in the zone of the open savannah with annual rainfall in the 300–500 mm range and a dry period lasting 4–6 months. Broad-leafed trees, baobab and doleb palm predominate; tall grasses and bushes are also abundant. Wild sorghum grows also in the more southerly environmental zone, which is the forest savannah with tall grasses and annual rainfall of 500–1000 mm, including also the seasonally flooded flats (*toich*) on the White Nile. The groves of trees in this zone include acacia, broad-leafed species, dôm palm and baobab. Sorghum grows here on the heavy soils and is one of the most frequently encountered grasses. The riparian areas are flooded usually to a height of about 30 cm; they are made of thick dark clay with sand on the surface. Termite mounds dot the landscape (Andrews 1948:38–46, 52–53). Wild sorghum also grows on the margins of the marshes and on the thick, dark, heavy soils of the river valleys, which retain water well. It is perfectly adapted to humid conditions, seasonal flooding, for example. A well developed root system reaching a depth of 1–1.8 m lets it grow to heights of 4 m (Doggett 1970:191–192). Cattle grazed in the savannah will eat wild sorghum (wild *durra*) (Snow 1948:686).

Wild millet (*Eleusine indica*) is also a frequent component of the tall grasses growing on the thick, dark clay soils of central and southern Sudan. The cultigen (*Eleusine coracana*) reaches a height of about 1 m (Andrews 1952: 445; Snow 1948: 686; Bacon 1948: 320).

The *Setaria* and *Digitaria* grass species, identified from impressions of seeds preserved on the pottery from Kadero, are a typical component of the flora present in an open savannah with tall grasses and annual rainfall in the range of 500–1000 mm. This zone also includes seasonally flooded territory irrigated by the waters of the White Nile as well as by rain. *Setaria* spp., for example, grows there today (Andrews 1948: 40–46, 52–53).

An analysis of the environmental needs of plants found in Early Neolithic assemblages, mainly *Celtis integrifolia* and grasses, indicates that in most of the cases, the species in question are characteristic of two of today's environmental zones in Sudan:

1. Open grassy savannah with annual rainfall of 300–500 mm and a dry season lasting from four to six months. Acacia predominates, but broad-leafed species also occur.
2. Savannah with tall grasses, acacia and some of the broad-leafed tree species, annual rainfall of 500–1000 mm and a shorter dry period than in the previous zone. Territories seasonally flooded by the White Nile also belong in this zone.

A drier environment compared to the Early Khartoum period is also suggested by the ecology of fauna identified in the remains from the Early Neolithic sites. It is striking that practically no species specialized in exploiting regular wetlands or shallow waters is present on the lists. Missing is the sitatunga antelope (*Tragelaphus spekei*), striped mongoose (*Mungo mungo*), Greater Cane rat (*Tryonomys swinderianus*), bushbuck antelope (*Tragelaphus acriptus*) waterbuck (*Kobus ellipsiprymmus*) and whitenosed rat (*Rattus coucha*), that is, specialists in exploiting aquatic environments that were recorded in the Early Khartoum assemblages. Kadero 1 yielded a single fragment of the skeleton of a water/mud mongoose (*Herpestes ichneumon/ Atilex palodinosus*), a mammal living in an aquatic and marshy environment.

A comparison of the wild game list for Early Neolithic sites with the contents of Early Khartoum assemblages also reveals a higher frequency of species typical of a drier environment. Mollusks, reptiles and fish cannot suggest this because samples are incomparable due to a lack of frequency data for Early Khartoum sites, but the trend can be observed in the case of bird and mammal remains. Almost always, however, the remains belong to specimens hunted, brought to the settlement and consumed. The composition and frequency thus reflects the specific hunting strategies of a given social group which could have preferred to hunt selected species of local wild game.

The bird sample is dominated by species common to the savannah, such as wild guinea fowl (*Numida meleagris*), which constitutes, for example, 80% of all bird remains in the large collection from Shaheinab (111 remains). Moreover, the assemblage included the bones of an unspecified form of great bustard, vulture and buzzard. Water species, like wild duck and goose, stork and crane, are definitely in the minority in this sample.

A similar tendency can be observed in the case of wild mammals. Compared to the Early Khartoum period, the Early Neolithic is characterized by the appearance of new species: hare (*Lepus capensis*), fringe-tailed gerbil (*Tatera robusta*), desert jerboa (*Jaculus jaculus*), genet (*Genetta* sp.), gazelles *Gazela rufifrons* and probably also *Gazela dama*. As far as preferred environment is concerned with regard to these new species, hares occur in a more open and dry savannah (Kingdon 1974:344-352), while the fringe-tailed gerbil is present in unforested sandy dry savannah; both species can last longer periods of time without water (Kingdon 1974:518), but the genet already prefers a forested niche, regardless of whether dry or wet (Kingdon 1977: 136-155; Macdonald 1984 I:136). The *Gazela rufifrons* is typical of a semi-desert environment, that is, open steppe with thickets of thorny bushes and isolated acacia trees, similar to the present-day sahel in northern Sudan (Dorst and Dandelot 1980:245). The *Gazela dama* prefers a similar environment, that is, grassy clearings in the desert and on the northern edges of the sahel in northern Africa; it can last without water for a long time (Dorst and Dandelot 1980:236-237).

Compared to the Early Khartoum group, the Early Neolithic assemblages also demonstrate a distinct increase in the number of remains of species typical of rather drier conditions, but with regular waterholes: ground squirrel (*Euxerus erythropus*), jackal (*Canis Arens*), honey badger (*Mellivora capensis*), white rhinoceros (*Ceratotherium samum*), black rhinoceros (*Diceros bicornis*) and giraffe (*Giraffa camelopardalis*). Comparing the two samples, one also notices a lesser frequency in the Early Neolithic of species typical of seasonally flooded terraces or flats and with waterholes nearby, such as the kob (*Hippotragus equinus*) and oribi (*Ourebia Ourebi*) antelopes, the buffalo (*Syncerus caffer caffer*) and roan antelope (*Hippotragus equinus*).

In summary, the Early Neolithic wild fauna composition lacks species typical of regular wetlands and is characterized by an increased, compared to the Early Khartoum period, presence of species common to the drier savannah environment. The evidence is still strong for the existence of seasonal wetlands in the valley of the Upper Nile, presumably formed in effect of river flooding. Keeping in mind the obvious impact of the hunting strategy of a social hunting group on the faunal assemblage found on any given site, one can be sure that the new situation observed in the Early Neolithic in central Sudan had its source largely in a different wild animal structure which followed from a changing environment.

2.2. Changes of the natural environment

In the light of the available data one can present the major changes occurring in the natural environment of central Sudan between 4900 and 3800 BC (6^{th} millennium bp, Middle Holocene). Compared to the situation that existed in the times of the Early Khartoum culture, the new ecosystem was characterized by dropping humidity which triggered changes in the floral and faunal cover. The impact of human economy on the environment must have also increased during this period. In effect, the combined impact of the two factors seriously affected the local natural environment and the adaptation strategies of the oldest communities applying a productive economy.

Decreased humidity in the valley of the Nile was caused by lower levels of seasonal river flooding as well as diminished rainfall, which could have also demonstrated more variability. In the end effect, the part of the river valley that was flooded during the rainy season when the river flood partly connected with the rains was smaller and the flooding shallower and shorter than in the Early Khartoum period. This had to affect the humidity of soils in the different ecological niches and lead in effect to changes in the floral and faunal cover.

It is not easy to estimate the impact of human economic activity on transformations occurring in this environment, but it was undoubtedly greater than before as a result of intensive animal husbandry (cattle, sheep. goats) and cultivation of tropical cereal plants or even regular harvesting of wild cereals, as well as continued traditional hunting.

The introduction of domesticated animals and plant cultivation is believed to have been a kind of revolution in man's relations with the natural environment in Africa. These new economic forms were accompanied as a rule by regular burning of the savannah to foster grass growth for grazing purposes and increase the fertility of cultivated fields. Grass burning during the dry season causes a faster and more abundant growth in the rainy season, significantly increasing the foraging resources, as well as feeding ground for wild game. Burning is used also today in Africa to remove the vegetation from fields before loosening the soil and seeding. Regular burning of the vegetation increases the share of annual grasses at the cost of bushes and trees. This phenomenon is observed today, for example, in terrain seasonally flooded by the White Nile that is being exploited for pasturing by the Nilotic tribes of the Dinka, Nuer and Shilluk. Burning of the savannah may have also stimulated an increase in the share of fire-resistant species in this environment. Traditional use of fire for hunting (driving game toward the hunters) or to collect honey from wild beehives may have continued in use as well. This could have led to a broader distribution of the dôm palm (Hyphaena thebaica), the fruit stones of which were found in a Neolithic tomb in Kadero (Krzyżaniak 1978:166). The dôm palm, which Purseglove (1975:425) describes as resistant to fire, reaches heights of 15 m and is extremely common in the drier parts of tropical Africa. Its seeds (stones) are carried by man, who collects the fruit today for consumption. The fruits and stones are eaten also by elephants and baboons, thus also aiding in the spreading of the species. More intensive pasturing and burning of the vegetation cover can also cause soil erosion in the savannah. On the other hand, it is believed that moderate pasturing in the savannah is favorable because it favors species differentiation and stimulates more intensive plant growth. Grazing that reduces only 15–51% of the biomass of the savannah (it is most efficient right after the rainy season) also helps to retain the environmental balance, much more so than harvesting cultivated plants, which exploits 87–89% of this biomass (Hamilton 1982: 256, 260, 261; Singh and Joshi 1979:217-218; see also Harris 1980a:12; Moss 1969:220-222). Burning grass in the savannah seems also to have been used to increase harvests of wild tropical cereals.

It is an interesting suggestion that bred animals can be less economic than herbivore species living in the wild in the African savannah in terms of the conversion of fodder into food for humans (Coupland 1979:351).

Based on the available evidence, the changes that occurred in the three ecological niches distinguished on the Upper Nile between 4900–3800 BC (6th millennium bp) can be characterized as follows:

1. River bank and riparian margins of floodplains. The permanent marshes disappeared in favor of seasonal ones, the existence of which is indicated by large numbers of *Pila* snails on Early

Neolithic sites located in this ecological niche. Vegetation in this zone undoubtedly included abundant grasses, including wild tropical cereals, bushes (*Ziziphus*) and trees (different species of acaccia, dôm palm, *Celtis integrifolia* and other usually associated species). The river shallows could have been overgrown with papyrus rushes and reeds, forming an excellent habitat for water fowl, which would have included, as today, wild ducks and geese, as well as reptiles (crocodile, water turtle species) and mammals (hippopotamus), not to mention aquatic mollusks and fish. Similarly as in the Early Khartoum period, wild animals presumably were concentrated in the transitional zone between this niche and the wadis of the third niche, especially during the dry season. Pressed by conditions, the herbivores would have gathered at the waterholes, moving in from the other two niches, and would have been followed there by predators. The settlements at Shaheinab and probably also Nofalab were situated in this niche.

2. River valley flats. The vast river valley flats continued to be seasonally flooded, similarly as in the times of the Early Khartoum culture, but the floods were shorter in duration and lesser in volume. The depth did not exceed a few dozen centimeters on average, as demonstrated by calculations for the neighborhood of the Kadero 1 village (Krzyżaniak 1978:161). Numerous finds of *Pila* snail shells in Early Neolithic assemblages prove the existence of seasonal marshes on the river valley flats where the settlements were situated. As for the vegetation in this niche, in this period it was probably composed of species growing on the heavy silt and clay soils of the vast river valley and the sand and silt hillocks on which the settlements were located. The soils of the first morphological zone are excellently adapted to growing wild tropical cereals, sorghum and African millet, as well as undoubtedly other species of grasses common today on the clay soils and in the seasonally flooded habitats on the White Nile. The species composition of flora in this zone must have been close to that of the modern savannah with tall grasses and acacia, and annual rainfall in the 500–1000 mm range. Right after the rainy season this terrain must have provided rich grazing and foraging grounds exploited by the human groups which hunted, grazed animals and harvested either cultivated or wild-growing cereal plants. This environment easily provided for numerous herds of cattle and small ruminants, as well as for wild game, mostly of the herbivorous type. The hillocks in this ecological niche, which were now for the first time occupied by relatively regular settlement, were appropriate for small fields like the ones found even today in seasonally flooded areas on the White Nile; the vegetation there could have included the dôm palm and broad-leafed trees like the *Celtis integrifolia* and commonly associated species. Species characteristic to these hillocks included the terrestrial snail *Limicolaria*. It may be assumed that during the dry season, as waterholes dried out in this zone, the grazing herds and wild game moved gradually toward the river.
3. Sand and gravel plateau cut by wadis. The environmental conditions in this extensive zone stretching out on either side of the flood terraces, were much like those observed for the Neolithic Shaqadud. Rainfall was the only source of humidity in this zone; at Shaqadud in this period rainfall was estimated at approximately 350 mm annually. This level of humidity is noted in modern Sudan in the open savannah zone with acacia and short grasses, where the dry season lasts about six months. Beside the most common acacia species, the zone is also home to broad-leafed trees, the baobab and doleb palm. The fauna in this zone in Early Neolithic times also resembled closely that observed for Shaqadud, where the local permanent pond hosted palustrine *Pila* snails, terrestrial snails *Limicolaria*, amphibians, mud turtles, monitor lizards, genets, warthog, giraffes, oribi and kudu antelope. In areas deprived of permanent waterholes, the composition of the local fauna could have been similar to that found today in the semi-desert zone. There were good pastures and foraging ground in this zone, during and after the rainy season. The considerable environmental differences between the rainy season and the long dry season must have prompted most of the wild animals to migrate periodically to the first and second niches.

The richness and appeal of particular niches should be estimated from the point of view of the earliest farmers in central Sudan. The above description of particular habitats shows that the second niche had the greatest advantages for a pastoral economy. The conditions in this niche would have been perfect for long-term grazing of herds in the extensive grasslands amid seasonal ponds and wetlands left in depressions of the river valley flats after the river flood had subsided. These water reservoirs functioned as waterholes. Intensive animal grazing would have been possible starting after the flood had subsided and the ground dried somewhat through the period of grass vegetation until the drying out of the waterholes in the region. Human settlements at this time were relatively stable, situated in the second niche, population numbers changing probably depending on the season and the nature of economic activities. In the dry season the scattered herds could have been accompanied in the grazing grounds by smaller groups which set up seasonal camps. In the wet season, the Neolithic pastoralists would have herded the animals from the valley bottom onto the alluvial hillocks found in this niche where the Early Neolithic settlements were located. The animals could have been driven also into the third niche, but so far there is no archaeological data from this zone.

In the African savannah today, moving herds of cattle have supplanted the original fauna, that is, the huge herds of herbivores and preying predators. Their place has been taken by man and his herds, causing at the same time a fundamental transformation in the species composition of savannah vegetation. It is believed, for example, that intensive cattle grazing combined with sporadic burning of the grass can lead to increased forest growth. Grass burning is still used today by the farmers of the savannah in the case of fallow cultivation of sorghum and millet (Moss 1969:222, 250).

In presenting ecological conditions in the Early Neolithic one should briefly describe the requirements of tropical cereals cultivated today in this part of Africa, assuming that these cereal grains were quite probably among the plants cultivated by the earliest pastoralists of central Sudan. In Gedafer, which lies in the Blue Nile province, to grow sorghum (*durra*) or millet on the heavy soils one needs a minimum of 450 mm of rain annually; on the sands of western Sudan 300 mm annual rain is enough. The plant's root system allows sorghum to tolerate both shortages of water and short-term flooding of the fields (Norman et al. 1984:125, 129).

Sleeping sickness could have been a key factor impacting human activities in this period. *Trypanosomiasis* attacks both humans and animals. According to Lambrecht (1970), it is caused by a blood parasite, the *Trypanosommiasis* protozoan, which is carried by the tse-tse fly (*Glossina* sp.) only at a certain stage in the development of this parasite. There are two ecological groups of this fly species: one inhabits the humid tropical forests, the other the drier forests of the savannah. In a forest environment the *Trypanosoma gambiense* sickness is carried by the G. *Palpalis* fly which attacks humans. It is endemic in the neighborhood of regular settlements and riparian camps, of fishermen, for example. The tse-tse fly of the savannah occurs today in northeastern Africa to the south of the 15°N latitude, that is, the latitude of modern Khartoum, in a zone of annual rainfall in the range of about 500 mm. Comparing a map published by Lambrecht (1970:97, Fig. 4), one observes the tse-tse fly of the savannah to be more active today on the southern fringes of the country, in the neighborhood of the humid tropical forests. The savannah species (e.g. *Glossina morsitans*, typical of the open forest) causes sleeping sickness (*T. Gambiense*, *T. Rhodesiense*) in cattle alone, since wild animals today have developed a natural immunity.

In seasonally flooded terrain the tse-tse fly is much rarer, as its chrysalis form perishes in seasonally flooded soil. The *G. Palaidipes* fly which inhabits the denser vegetation zones of the savannah causes *T. Rhodesiense*. It can thus be assumed that the environmental conditions in central Sudan in the Middle Holocene were more favorable to the development of species of tse-tse fly characteristic of the savannah rather than wet forest habitats, and that its activity could have been much weaker in the seasonally flooded river valley. Lambrecht (1970:87-88) has also assumed that, generally speaking, the Upper Pleistocene man inhabiting the closed forests of Africa could have suffered more excessively from *T. Gambiense*, while the groups living in the savannah fell victim to *T. Rhodesiense* only sporadically; wild fauna was the most affected at the time. Human groups may have knowingly avoided settling in areas where the tse-tse fly was more active, similarly as in the case of areas touched by malaria, although in the latter case man in Africa has acquired some degree of immunity to this illness.

Lambrecht (1970:89-90) believes sleeping sickness to have had a significant impact on the rate and direction of the spread of animal husbandry in Africa. For example, in eastern Africa, the southward diffusion of pastoralism at the end of the Stone Age took place on either side of the central section of the great tectonic rift, undoubtedly in an effort to avoid regions occupied by the tse-tse fly, passing through territory fee of this species. In the dry and cooler season the tse-tse fly is dormant, hence it was probably inactive around the campsites and settlements inhabited during this time of the year (Clark 1980b:63).

The river valley flats of central Sudan thus seem to have been free of the sleeping sickness epidemic attacking cattle. The chrysalis form of the tse-tse fly in the soil could not survive the seasonal flooding episodes. The absence of concentrations of dense vegetation in which this fly lives was also not conducive to its development. This could explain the obvious concentration of Early Neolithic settlement based on animal grazing in the river valley where the fly was exterminated by seasonal flooding, as well as suggest at least in part why pastoral settlement did not develop in the central Sudan savannah where, because of the absence of seasonal flooding, the fly would have been insufferable to domestic animals.

In the Early Neolithic, as in the previous period, it was possible to exploit seasonally a whole range of resources found in different biotopes and niches of the central Sudan savannah. This clearly refers to the economic traditions observed in all of tropical Africa. Pastoralism is treated here as a method of production that preceded European colonization and developed independently of it (Harris 1980b:31, 37). The seasonal translocation of social groups to different niches and biotopes is a characteristic feature of the economic exploitation of savannah resources (Graham 1969:427).

3. Changes in the natural environment: 3800-3000 BC

There is practically no data for a reconstruction of food-acquiring strategies of the Late Neolithic population of central Sudan as no settlements of this period are known and only four cemeteries associated with this population have been discovered and explored. These are Omdurman (Arkell 1949:99-106), Shaheinab (Arkell 1953:82-91), Geili (Caneva 1984:355-356) and Saggai (Caneva 1983b:24-28). The assemblages from these cemeteries permit only limited research on Late Neolithic communities, their production and goods exchange, as well as social structure.

Neither is there any evidence of the evolution of the natural environment in central Sudan in the Late Neolithic. One should note the discovery of some stones of *Celtis integrifolia* on the Gereif site near Khartoum (Arkell 1949:110, note 1) associated with Late Neolithic pottery; the site could have been a camp from this period.

The Late Neolithic falls at the end of a wet climate phase in the Sahara lasting from 6500 to 4500 bp (Williams 1982:19). This period was characterized by a great expansion of Neolithic pastoral peoples in North Africa. According to Wickens (1982:44-47), the beginning of the desertification of this part of Africa in the Middle Holocene falls about 5000–3000 bp. Exploration of the settlement at Jebel Tomat on the lower White Nile, situated about 300 km to the south of Khartoum and dated to around 4000 bp (Wickens 1982:28-29, Pl. 3.1 and 45-47), demonstrated the existence of a thorny savannah with thickets of *Acacia seyal* on the clay soils and *Acacia senegal* on the sands and dunes. It was a dry environment, although not as dry as today. The regular lakes and swamps of the Early Holocene, situated deep inland to the west of the White Nile, had dried up by this time, but the riparian marshes still existed. Environmental change was due to rainfall zones shifting southward; an appropriate shift in floral and faunal zones followed. The end effect of the process was a lowering of annual rainfall rates in central Sudan, the extent of which is impossible to estimate at the present stage of research. About 4000 bp the hunters from Jebel Tomat on the lower White Nile were hunting *dorcas* gazelle, Klipspringer antelope, forest boar, reed-rat, mongoose, but also Nile monitor and genet. They also fowled, fished and grazed cattle, sheep and goats. They could have also cultivated sorghum.

The humidity in the valley of the Upper Nile depended not only on rainfall, but also on seasonal river floods which in turn were determined by fluctuations in rainfall at the sources of the Blue and White Niles, mainly however at the source of the Blue Nile in the Abyssinian uplands. About 5800 bp the levels of lakes dropped, this process peaking about 4000 bp (Gasse et al. 1980:389). The Late Neolithic in central Sudan could have fitted into a relatively short period of stable lake levels and Nile flooding briefly before 4000 bp. A short-lived period of low floods at the turn of the sixth millennium was followed by an equally short period of high floods in the first half of the fifth millennium, followed in turn from the second half of the fifth millennium bp by a longer period of low floods lasting through the second half of the fourth millennium bp (Williams and Adamson 1980:301, Fig. 12:10). According to this diagram, the early phase of the Late Neolithic in central Sudan (about 5000–4300 bp) would fall rather in the brief period of high floods. The actual height of flooding in this period cannot be calculated.

The only source of data on environmental change in central Sudan in the Late Neolithic is, for lack of floral and faunal finds from settlement sites, the assemblage from the cave site of Shaqadud, dated to the third-second millennium BC (about 4200–3600 bp), that is, the post-Neolithic period. According to this data, the Butana uplands featured a dry savannah or steppe landscape with annual rainfall around 350 mm. This is an obvious deterioration of natural conditions compared to the seventh millennium bp (Abbas and Marks 1984:58, Marks et al. 1985:272, 277). Finds included remains of *Zizyphus* sp., grasses and domesticated millet, dated about 2500 BC. The faunal remains from the site were identified as belonging to the *Pila* snail, clams, terrestrial snails, tortoise, Nile monitor, guinea fowl, ostrich (egg-shell fragments), hare, ground squirrel, mountain squirrel (*Hystrix cristata*), wildcat (*Felis silvestris*), anteater, savannah boar, giraffe (numerous), gazelle (*Gazella rufifrons*) and medium and greater antelope. The top layers of the midden inside the cave also yielded remains of domesticated cattle, sheep, ovicaprid, dog and probably also donkey.

At Saggai, no lime concretions were observed on human bones from the Late Neolithic burials. This is noteworthy as such deposits were a characteristic feature of human bones from Early Khartoum burials made at a similar depth on the same site. The difference can be explained by the lower ground-water table in the Late Neolithic period as compared to Early Khartoum times, resulting from lowered river flooding (Caneva 1983:24)

Current data are insufficient for a reconstruction of rainfall amount and river flood levels in the Late Neolithic. It seems probable, however, that the overall humidity of the climate in central Sudan continued to drop, causing further changes in the plant cover and the species composition of wild game.