THE ARCHAEOLOGY OF AFRICA

Food, metals and towns

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2 *The climatic and vegetational history of the equatorial regions of Africa during the upper Quaternary*

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(Translated from the French by Thurstan Shaw*)

Introduction

For reconstructing the palaeoenvironments and vegetational history of the equatorial zone of Africa during the late Quaternary, we have direct evidence from palynological and palaeobotanical sources. These two fields of research are often complementary, for macro-remains, especially wood, give precise information, essentially for short periods, while pollen analysis, usually carried out on long sequences dated by radiocarbon, allow one to reconstruct the main vegetation changes over a longer time-scale.

Lakes yielding sequences favourable for pollen analysis have been investigated in Ghana (Maley & Livingstone 1983; Maley 1987; Maley 1989), in Cameroon (Maley 1987; Maley & Brenac 1987; Brenac 1988; Maley 1989; Maley, Livingstone, Giresse, Thouveny, Brenac, Kelts, Kling, Stager, Haag, Fournier, Bandet, Williamson & Zogning 1990b) and in the Congo (Elenga 1987; Elenga, Vincens, Giresse & Schwartz 1987), but since the number of such sites is limited, analyses have also been carried out on marine cores from near the coast when their pollen content was sufficient (Caratini & Giresse 1979; Hooghiemstra & Agwu 1988; Fredoux & Tastet 1988; Fredoux, Tastet, Maley & Guilmette 1989). The frequently smaller quantity of pollen in marine cores is compensated by their long chronological coverage.

Indirect environmental evidence is provided both by various kinds of geological research on lacustrine and fluviatile deposits, and by stratigraphical, sedimentological, geochemical, isotopic and archaeological studies of the soils which support the forest today, or the savannas which fringe or are sometimes contained within the forest. Research on the deep-sea fans of large rivers also give important and often complementary information concerning palaeoenvironments (Pastouret, Chamley, Delibrias, Duplessy & Thiede 1978 for Niger; Giresse, Bongo-Passi, Delibrias & Duplessy 1982 for Congo-Zaïre).

Biogeography, that is, the present distribution of different species of flora and fauna, provides other data which contribute to the delimitation of forest areas surviving

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through previous arid periods, or even to the tracing of migration routes (Maley 1987; Maley 1989; Maley, Caballe & Sita 1990a).

The main climatic phases of the late Quaternary in central Africa

Using data from Africa, De Ploey (1965; 1969) was one of the first to produce a chart of the evolution of the palaeoenvironments of central Africa, in particular naming the main climatic phases. This chart has been completed and further refined by geological, palynological, palaeobotanical and pedological research (Giresse 1978; Roche 1979; Delibrias, Giresse, Lanfranchi & Le Cocq 1983; Schwartz, Delibrias, Guillet & Lanfranchi 1985; Maley 1987; Schwartz 1988a; Schwartz 1988b; Maley 1989).

For central Africa (Congo, Gabon, western and central Zaïre, southern Cameroon and southern Central African Republic) the sequence of the main climatic phases has been established as follows:

The *Maluekian*, placed between 70,000 and 40,000 BP on the basis of prehistoric industries, is regarded as a relatively dry period marked by extensive deforestation.

The *Njilian*, with interpolated ages, and sometimes radiocarbon-dated, lasting from 40,000 to 30,000 BP, was a relatively wet phase corresponding to a definite reforestation.

The *Leopoldian*, dated from 30,000 to 12,000 BP, was on the whole relatively dry. This phase culminated around 18,000 BP in a new and marked extension of open savanna environments.

The *Kibangian*, dated from 12,000 BP to the present, was relatively wet until around 3500 BP (Kibangian A), and was drier since (Kibangian B). Reforestation probably proceeded progressively from the beginning of the Kibangian, but with retreat occurring after 3500 BP.

Soil history

The study of soils yields information on palaeoenvironments, in particular because some of the layers which make up the soils were laid down in succession under different environmental conditions. Various publications have shown that stone-lines, which are fairly frequently found near the bottom of pedological profiles, were laid down in certain periods of the Quaternary as a result of a process of intense erosion during which the forest had disappeared (De Heinzelin 1955; Vincent 1966; Vogt 1966; Marchesseau 1967; Stoops 1967; Schwartz 1990). Above the stone-line there is nearly always a sandy-clay colluvium, in which prehistoric industries are found in some places; and in some, actual workshop floors. These industries are often concentrated at the base of the colluvium, resting on the top of the stone-line. This shows that the tools were left on the surface at a time when the stone-line was uncovered.

Two important questions remain concerning these two layers: how old each of them is and how the colluvium was laid down.

As far as the age of the stone-lines is concerned, it is possible that they were formed at more than one time. The main period of formation would have been during the dry phase of the Maluekian, followed by a rapid deposition of the colluvium during the transition from the Maluekian to the wetter Njilian (Lanfranchi & Schwartz 1990). However, a severe erosional phase, occurring at the transition from the Leopoldian to the Kibangian, between about 13,000 and 10,000 BP, at a time when there was a marked increase in rainfall, could also have produced a coarse deposit (Giresse, Kinga-Mouzeo & Schwartz Forthcoming).

It is not yet known how the colluvium was formed. Was it developed in an open environment, of steppe or savanna character, or was it, on the contrary, formed under forest? Marchesseau (1967), in a detailed morphological and mineralogical study in Gabon, inclined towards an allochthonous interpretation for each interfluve. Allochthony would be connected with alluvial or colluvial transport, and would be associated with soil-creep. However, in the north of the forested area, samples of wood charcoal from the base of the colluvium and just above the stone-line, have given ages of 8560 ± 100 bp and 8470 ± 70 bp in southern Cameroon (Kadomura & Hori 1990), and of 11,200 ± 200 bp, 9150 ± 150 bp and 8685 ± 120 bp in Nigeria, at Iwo Eleru not far from Ife (Shaw & Daniels 1984; Thurstan Shaw, *pers. comm.*). These data seem to show that a stone-line would have been formed towards the end of the Pleistocene and that the colluvium would have been deposited subsequently in a forest environment, since the recolonization of the forest began progressively in these areas from about 13,000 to 12,000 years BP. Nevertheless it is clear that further research, accompanied by precise dating, must be carried out in other areas of the African forest zone before we shall be in a position to reach any definitive conclusion on this subject.

Forest refugia and holocene forest expansion

Various biogeographic data showing the vast wealth of flora and fauna in certain parts of the African forest zone have led to the conclusion that this wealth, particularly localized in certain well-defined areas, is evidence for ancient forest refugia which would have survived the great arid phases of the Quaternary, the last of which took place between 20,000 and 15,000 years BP (Van Zinderen Bakker 1976; Hamilton 1976; Maley 1987; Maley 1989).

Pollen studies recently carried out on lacustrine cores at two forest sites, one in Ghana and the other in western Cameroon, covering a period extending back from the present to about 25,000 to 30,000 years BP, have yielded precise data on this question. The Ghanaian site (Lake Bosumtwi) is situated in a sector where aridification is clearly shown between 20,000 and 15,000 BP by the disappearance of the forest, while western Cameroon benefited from a climate far less dry, attested by the survival of islands of forest forming one of the principal refuges of the African forest block (Maley 1987; Brenac 1988; Maley 1989). Data on the primates of the central Zaïre basin indicate that a 'central refuge' must have existed along certain portions of the great rivers of this basin (Colyn 1987), apparently confirming palaeobotanical surveys conducted in the Congo (Dechamps, Lanfranchi, Le Cocq & Schwartz 1988).

In the Lake Bosumtwi area of Ghana, the forest was completely restored about 9000 BP (Maley 1987; Maley 1989), but pollen results show that in this area the first stages of reforestation became apparent from 13,000 to 12,000 BP.

The holocene forest expansion went far beyond its present boundaries, as can be inferred from the biogeography of the western forest zone. Thus the relatively great taxonomic homogeneity on either side of 'the Dahomey Gap' (which nowadays breaks the east–west continuity of the forest zone in the Republics of Togo and Benin) shows that this sector was probably invaded by forest in the course of the Holocene. This break in the east–west forest zone probably only came into being again from about 4000 to 3000 BP (Maley 1987; Maley 1989).

In central Africa (Fig. 2.1), the beginning of Kibangian A (about 12,000 BP) corresponds to a phase of forest recolonization (Maley 1987; Brenac 1988; Maley 1989), accompanied in Congo by a resumption of podsolization (Schwartz 1988a; Schwartz 1988b). It seems that it was only in the course of the middle Holocene that the forest expanded far beyond its present limits. Thus, near Pointe-Noire, in the coastal zone which is at present covered with savanna vegetation, the bases of tree-trunks of species belonging to rainforest have been observed *in situ* on palaeosols and dated from 6500 to 3000 BP (Dechamps, Lanfranchi, Le Cocq & Schwartz 1988; Schwartz, Delibrias, Guillet & Lanfranchi 1985). This forest extension into what is now savanna, sometimes included in, or adjacent to, the forest zone, indicates that these savannas probably disappeared or were reduced in extent during the second part of Kibangian A (*c.* 7000–3500 BP).

Diverse data for this period have led to the conclusion that there was an increase in rainfall (Giresse and Lanfranchi 1984; Maley 1987; Dechamps, Lanfranchi, Le Cocq & Schwartz 1988), caused above all by a shortening of the southern dry season (Maley 1989). Later, during the Kibangian B (about 3500 BP to the present), the annual dry seasons began to lengthen again, with a corresponding new extension of savannas in, or adjacent to, the forest (Giresse and Lanfranchi 1984; Maley 1987; Maley 1989). The Bantu, who originated from western Cameroon and the neighbouring regions south of the Benue and spread across central and southern Africa in the course of late Holocene times (Vansina 1984), may well have taken advantage of this retreat of the forest, beginning abruptly around 3500–3000 BP, to penetrate certain sectors of the forest. It is

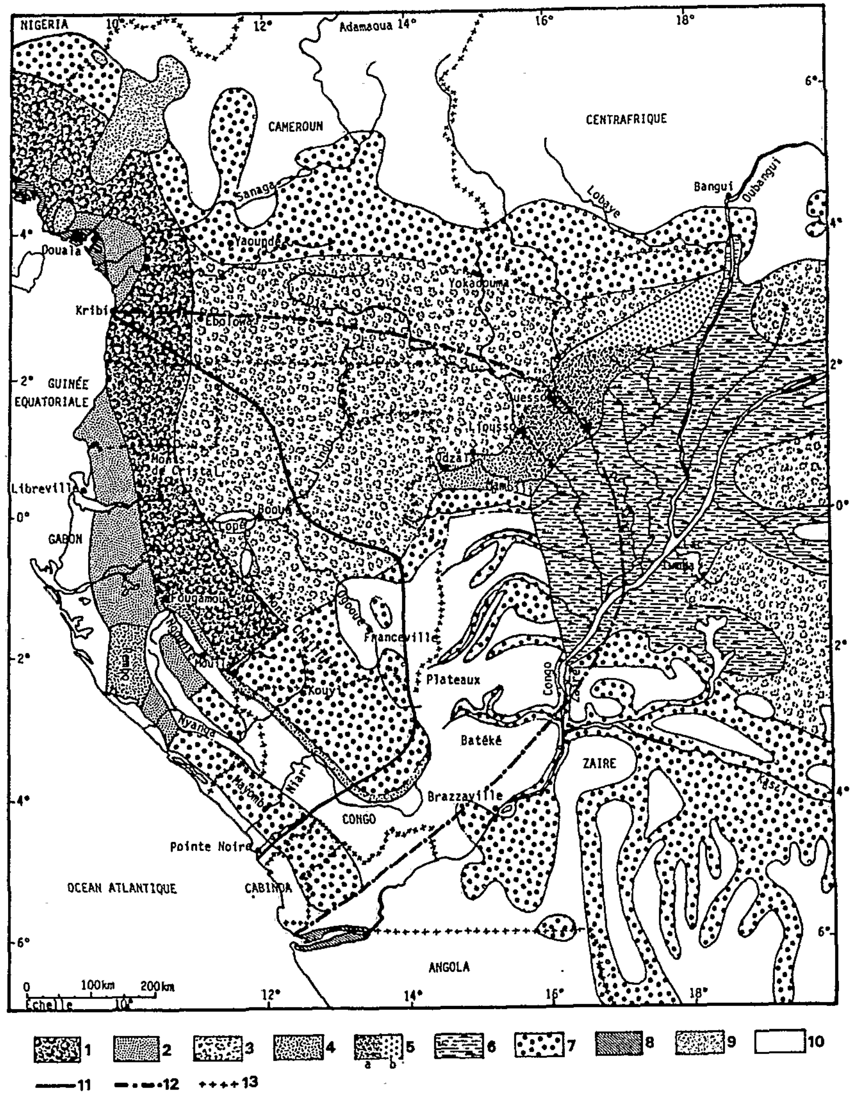

Figure 2.1 Schematic map of the forest vegetation of central Africa (adapted from Letouzey (1968; 1985), White (1983) and Maley (1990)).

1 Evergreen forests of southern Cameroon and Gabon with numerous Caesalpiniaceae
2 Atlantic coastal forests with *Sacoglottis gabonensis* and *Lophira alata* in Cameroon, but replaced in Gabon by *Oukoumea klaineana*
3 Congo-type forests characterized by the alternation or mixing of evergreen and semi-deciduous species
4 Open-growing forests with Marantaceae and Zingiberaceae
5a Mixture of forests of types 4 and 5b
5b Evergreen forests with *Gilbertiodendron dewevrei* (*Caesalp.*)
6 Zone almost permanently flooded, with evergreen forests, raphia palms and other moisture-loving species
7 Semi-deciduous forests
8 Mangroves
9 Various montane groups
10 Savannas
11 Limit of *Aukoumea klaineana*
12 Maximum extent of cooler air during the southern dry season (about four months, from June to September)
13 State boundaries

possible, then, that this climatic change – synchronous with comparable changes occurring in the more northerly savannas (Maley 1981; Maley 1982; Maley 1983) – initiated the Bantu migration.

Temperature variation and the extension of montane biotopes to low altitudes

There is now a whole body of data which shows that at the time of the great glacial advances in higher latitudes, culminating around 20,000–15,000 BP, there was also in lower latitudes a marked lowering of temperature. As far as the African forest zone is concerned, various data show montane taxa to have spread to low altitudes, an indication of the lowering of temperature.

First, on the Congo side of the Chaillu massif the existence of a surviving low-altitude (approximately 600–700 m) population of montane taxa (Fig. 2.2), in particular *Podocarpus latifolius* (Maley 1987; Maley, Caballe & Sita 1990a) shows that in the past montane biotopes extended to a low altitude in the forest zone, implying a lowering of temperature of at least 3–4°C. For the Congo sector, this conclusion has been confirmed by pollen analyses carried out by Elenga (1987) and Elenga, Vincens, Giresse & Schwartz (1987) on a short core taken in a depression on the Batéké Plateau at an altitude of 600–700 m. With more than 60 per cent of pollen from montane taxa (mainly *Podocarpus*, *Ilex* and *Olea*), it is clear that a local montane phase continued until about 10,000 BP. Given the altitude at which *Podocarpus* are living today, a minimum temperature drop of 3–4°C may be inferred.

Pollen analyses carried out in western Cameroon and in Ghana, at two low-altitude sites, have also shown the presence of a montane element characterized by *Olea hochstetteri*. From this a minimum lowering of temperature of 3 to 4°C has also been deduced (Maley & Livingstone 1983; Maley 1987; Maley 1989). Furthermore, in the core from Lake Bosumtwi where pollen of *Olea hochstetteri* was identified, Palmer (in Talbot, Livingstone, Palmer, Maley, Melack, Delibrias & Gulliksen 1984) identified many Gramineae fragments as belonging to the Pooideae. Today this taxon is found only in tropical areas on the highest mountains (Clayton 1976; Livingstone & Clayton 1980) such as Mt Cameroon where they grow only above 2000 m (Letouzey 1968; Letouzey 1985). The presence of Pooideae on the hills surrounding Lake Bosumtwi therefore implies a temperature drop which could be of the order of 6°C, a figure comparable to that estimated for east Africa at the time of the last glacial maximum.

Thus, before 9000 BP the rainforest was absent, being replaced by a montane type of grassland with sparse clumps of trees. These trees belonged on the one hand to the montane type of vegetation such as *Olea hochstetteri*, and on the other, not to species of the sudano-guinea savanna but in most cases to the flora of semi-deciduous forests. Today, in fact, it is the montane prairies of the guinea zone at medium altitudes which provide examples of clumps of trees of typically montane species, including numerous ones belonging to the forests of low altitudes, especially semi-deciduous species (Letouzey 1968; Schnell 1977).

Towards the bottom of the Lake Bosumtwi core, dated to around 28,000–27,000 BP,

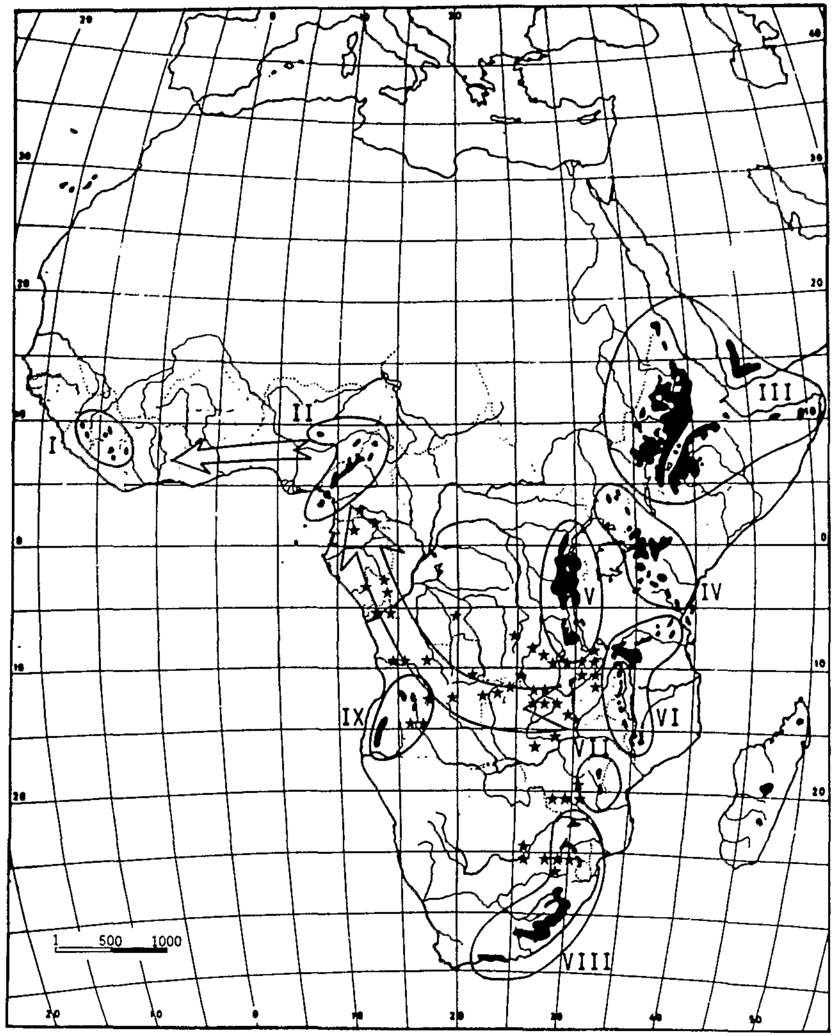

Figure 2.2 Distribution of the nine African regional montane systems.
I West African
II Cameroon-Jos
III Ethiopian
IV Imatongs-Kenya-Usumbara
V Ruwenzori-Kivu
VI Uluguru-Mlanje
VII Chimanimani
VIII Drakensberg
IX Angolan
The stars indicate populations of Afromontane plant species outside the large mountain systems, represented by black areas (adapted and completed from White 1981). The two arrows schematically represent a possible migration path of Afromontane taxa from east Africa to Angola, and subsequently via Cameroon to west Africa (Maley 1989).

the proportion of arboreal pollen reaches about 50 per cent, which is an indication of the presence of a montane forest environment. This tallies with similar data gathered in east Africa.

Pollen data recently obtained from a marine core off the coast of the Ivory Coast (Fredoux & Tastet 1988; Fredoux, Tastet, Maley & Guilmette 1989) show that *Podocarpus latifolius* was present on 'the Guinea Ridge' (in Ivory Coast and Republic of Guinea) during Isotope Stage 5 (in part Eemian) but disappeared towards the very end of the Pleistocene. Today this montane tree no longer exists anywhere further west than the Cameroon mountains, where its spread began in pliocene times (Maley 1980).

Comparison of the African forest zone with east Africa

East Africa, particularly the area between the two branches of the Rift Valley, is relatively rich in lakes and bogs, which have been cored for pollen analysis since the 1960s. Various syntheses have already been published for this region (Van Zinderen Bakker & Coetzee 1972; Hamilton 1973; Livingstone 1975; Flenley 1979; Hamilton 1982; Van Zinderen Bakker & Coetzee 1988).

It should be noted that, since the majority of sites are at altitudes above 1000 m, the results of the pollen analyses apply particularly to montane types of vegetation.

Three principal sites have yielded results from before 30,000 BP: Sacred Lake in Kenya (Coetzee 1967); the peat bog of Kamiranzovu in Rwanda (Hamilton 1982); and Kashiru in Burundi (Bonnefille & Riollet 1988). From these three sites the main stages in the history of the vegetation and the climate are as follows:

Stage 1
This stage began before 40,000 BP and lasted until 33,000–31,000 BP. It was characterized by a climate considerably colder and drier than at present. Sacred Lake, situated at a height of 2400 m and nowadays surrounded by montane forest, was then situated in the Ericaceous zone; as this is nowadays located at a height of 3400 m, this represents a lowering of 1000 m, from which one can infer a lowering of temperature of around 6°C (Van Zinderen Bakker & Coetzee 1988). In Burundi, the Kashiru bog, in which Ericaceae as well as the genus *Cliffortia* (Rosaceae) were dominant, must also have been surrounded by the Ericaceous zone (Bonnefille & Riollet 1988).

Stage 2
From 33,000–31,000 BP to about 28,000 BP there was a wetter fluctuation accompanied by a certain increase in warmth. Montane forest re-established itself around Sacred Lake (Van Zinderen Bakker & Coetzee 1988). At Kashiru in Burundi, Bonnefille and Riollet (1988) deduce a wet, cool climate for this period.

Stage 3
From about 28,000 BP to around 12,000–10,000 BP, the climate was in general considerably colder and drier than today. On the whole, the herbaceous plants, especially the Gramineae and the Cyperaceae, dominated the pollen spectra, corresponding above all to a major extension of the Afro-alpine savannas. The Ericaceous zone again surrounded Sacred Lake. The coldest and driest period occurred between 21,000 BP and 17,000 BP at Sacred Lake, and between 21,000 and 14,500 BP at Kamiranzovu (Hamilton 1982). The temperature drop must therefore have been between 6 and 9°C. The beginning of the retreat of the Ruwenzori glaciers occurred around 14,750 BP (Livingstone 1967).

Stage 3b
Around 24,000–22,000 BP a brief wet episode has been recognized in various places in east Africa by Perrott & Street-Perrott (1982); it has also been detected at Kashiru (Bonnefille & Riollet 1988) and in other parts of tropical Africa (Maley 1981).

Stage 4
From 12,000–10,000 BP to 4000–3000 BP the climate became considerably wetter and progressively warmer; everywhere the forests began to expand. At Kashiru, Bonnefille & Riollet (1988) observe that before 6700 BP (Stage 4a) the climate was cooler than at present, to become warmer later (Stage 4b).

Stage 5
From 4000–3000 BP modern conditions became established, marked by a decline in rainfall and reduction of the rainforest. Associated with this decline, a marked increase in pollen of *Podocarpus* has been observed at the beginning of this stage, a phenomenon which has continued at certain sites (Mt Kenya) until today (Hamilton 1982; Perrott 1982).

One site north of Lake Victoria, at an altitude of about 1135 m, is worth special mention. In fact, to the north and west of the lake, there are still several extensive areas of evergreen and semi-deciduous forest today. These forests constitute advanced outposts of the wet rainforests of lowland Zaïre (White 1983). An 18 m core taken in Pilkington Bay, not far from the outlet of Jinja, was studied by Kendall (1969). By means of pollen analysis this author was able to reconstruct the forest history of the region:

- After the great dry stage (Stage 3), of which only the final stage is represented, forest recolonization began about 12,000 BP with a certain number of semi-deciduous species.
- Around 9500 BP the forest was completely re-established in the region.
- From 9500 BP to about 6500 BP the forest vegetation had a more evergreen character, indicating high rainfall well distributed throughout the year, with a dry season of no more than two months.
- From about 6500 BP to about 3000 BP the forest vegetation took on a more semi-deciduous character, shown in particular by a marked increase in the pollen of *Celtis* and *Holoptelea*. The dry season was therefore probably extended to three months; the climate was relatively warmer than today.
- From about 3000 BP to today, the forest declined as a result of the climate becoming drier. The widespread character of this decline across tropical Africa shows that, above all, we are dealing with a climatic phenomenon and that the human role in it was much less important than some authors have tried to suggest (for a discussion of this topic, see Hamilton, Taylor & Vogel 1986; Perrott 1987).

In conclusion, the principal climatic phases correlate well between the African forest zone and east Africa, especially after 20,000 BP. Before 30,000 BP the comparison seems more difficult, but the apparent lack of correspondence before this date could be the result of inherent errors in radiocarbon dating operating at the limit of its reliability.

Conclusions: comparisons between equatorial Africa and dry tropical Africa

In the course of the last twelve millennia, the main transgressive and regressive stages of the equatorial rainforest seem to correlate chronologically with lacustrine deposits and vegetation evidence in northern dry tropical Africa (Servant 1973; Maley 1981; Maley 1982; Maley 1983). With regard to the climatic mechanism involved, this correlation could indicate that the moisture-laden air of the monsoon, producing rain north of the forest right up to the central Sahara, derives not only directly from the Gulf of Guinea, but largely also from a recycling of the moisture already precipitated on the equatorial forest and then carried on by evapotranspiration. This repeated recycling of moisture-laden air has been demonstrated for the present period by several isotopic studies (Baudet & Laurenti 1976); from this follows the system elaborated by Monteny (1986; 1987) and well illustrated by the detailed study of an annual cycle by Cadet & Nnoli (1987). Because of this recycling every important change in the African forest block must have had an important effect on adjacent climatic zones.

Acknowledgements

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