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Holocene Evolution of the Mangrove Ecosystem in French Guiana: A Palynological Study*

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Abstract

From palynological analysis and ^{14}C dating of a 22.4 m deep core taken from coastal French Guiana, the evolution of the mangrove ecosystem has been reconstructed as follows: (1) from ca 9000 to ca 5000 years (from the base of the core up to 8 m), the sea-level rising corresponding to the Holocene transgression is characterized by the dominance of *Rhizophora* pollen in the palynological assemblages; the site is located within the mangrove forest; (2) at ca 5000 BP, there is a drastic change in the palynological diagram, the mangrove forest being replaced by a swamp savanna (Gramineae, Cyperaceae, *Typha*). This stage is the result of the stabilization of the sea-level which permits a progradation of the sediments and a seaward shifting of the shore-line; (3) in the upper samples, the pollen spectra are correlative of the present swamp vegetation and of the back-mangrove which has been established after the filling of the lagoon. A decrease in forest representation in recent times may be due to human influence. Our results are in accordance with those obtained in other coastal sediments in British Guiana and Surinam.

INTRODUCTION

French Guiana is situated in the north east of South America, bordered by the Atlantic Ocean to the north, Surinam to the west and Brazil to the east (Fig. 1). The morphology of the coastal plain is very characteristic and is called "the young coastal plain". It is made up of recent alluvial deposits, extending from the mouth of the river Amazon to that of the Orinoco.

Within the framework of a project on the sedimentology and geochemistry of this coastal plain, 7 drillings were made on the Guianese coast. This work concerns the palynological study of one of these drills, GUY 2, bored on the right bank of the river Mana, in the extreme north west of Guiana, close to the present coastline (Fig. 2).

REGIONAL ENVIRONMENT

The north west part of French Guiana is characterised by considerable sedimentary deposits which may be observed from the sea up to the Pre-cambrian socle. This is the beginning of a vast sedimen-

* This paper is a summarized translation of "Evolution de la mangrove en Guyane au cours de l'Holocène. Etude palynologique" by C. Tissot *et al.*, published in: *Inst. Fr. Pondichéry, trav. sec. sci. tech.*, 1988, T. XXV, pp. 125-137.

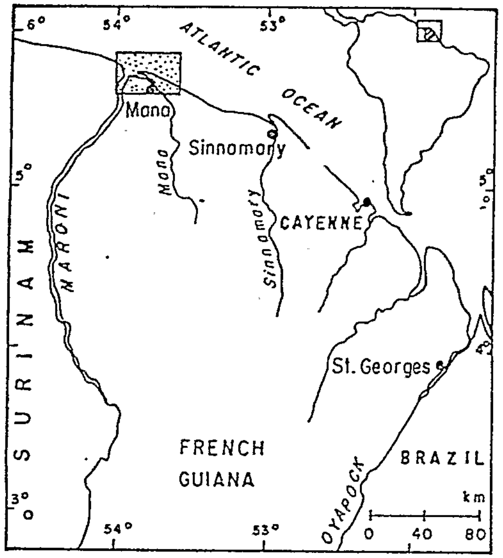

Fig. 1. French Guiana and the region studied.

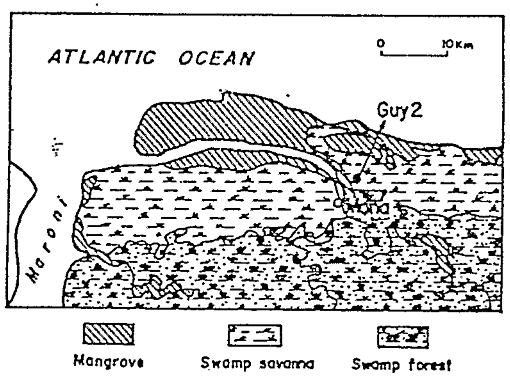

Fig. 2. Location and floristic environment of GUY 2.

tary basin whose maximum width is in Berbice in British Guiana. H. Cruys (1959) has described this region as the "true coastal plain".

The vegetation is represented by *Avicennia nitida* mangrove on the silty side bordering the Atlantic, mangroves with *Rhizophora racemosa* and *R. mangle* on the banks of the Mana estuary and the swampy *Elaeocharis carribea* prairies which have been partly converted into rice fields.

We have used the term swamp savannas to define the low moist formations situated behind the mangrove.

PALYNOLOGY

Optical aspect and origin of organic matter

Throughout the sequence analysed, the organic matter is characterized by an abundance of plant debris, some of them big in size (several mm). No clear cut changes can be distinguished in the evolution of the organic matter. However, there is distinct "opaque" debris (carbonised plant debris?) in samples below 8 m, as well as a lightening in the colour of the other elements. The presence of amorphous organic matter which generally indicates a marine origin is not noticed here.

These observations seem to prove that the organic matter is mainly of continental origin and are in accordance with Berthois & Hoorelbeck's (1968) conclusion on the origin of coastal sediments of French Guiana.

^{14}C dating

Two carbon datings of wood samples taken at the bottom of the core indicate a Holocene age: 7680 ±320 BP at 19.60 m; 7740 ±640 BP at 20 m*.

Palynological study

Palynological studies were carried out on 23 samples taken at about 1 m intervals. All the sediments were found to be fossiliferous. For each sample, about 200 pollen and spores were counted. The percentages were calculated from the sum total of the pollen and spores observed, including the unidentified and unidentifiable ones (broken or damaged pollen). The marine (dinoflagellate cysts and testa of foraminifers) and fresh water (*Botryococcus, Concentricystes*) elements have not been included in the total count.

As the sediments and palynological residues are not very homogeneous, only relative percentages were taken for constructing the diagrams. Taxa observed only occasionally, as well as those which are very few in number, are not represented in the diagrams but their relative values are given in Table 2.

Different groups

The taxa have been grouped according to their ecology, geography or floristics (Table 1) following the plant associations defined by Marius & Turenne (1967).

* The datings have been made in the Laboratoire des Séries Sedimentaires of ORSTOM in Bondy (France) by M. Fournier.

TABLE 1. Different taxa recorded

Mangrove	Swamp savanna	Swamp forest	Allochtonous	Other NAP	Miscellaneous
Rhizophora	Amaranthaceae/ Chenopodiaceae	*Alchornea*	*Alnus*	*Abutilon*	Apocynaceae
Avicennia nitida	Compositae	Anacardiaceae	*Podocarpus*	Acanthaceae	Capparidaceae
Acrostichum aureum	Cyperaceae	Annonaceae	*Hemitelia*	*Borreria*	*Commiphora*
Conocarpus erectus	Gramineae	Bombacaceae	*Myrica*	*Euphorbia*	Euphorbiaceae
Laguncularia racemosa	*Hedyosmum*	Caesalpiniaceae	*Ephedra*	Geraniaceae	Labiatae
Sesuvium portulacastrum	*Hibiscus tiliaceus*	*Calophyllum*		*Hypoestes*	Monocotyledons
	Jussieua	*Cassia*		*Indigofera*	Oleaceae
	Nymphaea	*Cassine*		*Phyllanthus*	Rubiaceae
	Polygonum	*Cassipourea*		*Polygala*	Solanaceae
	Potamogeton	Celastraceae		*Solanum*	Sterculiaceae
	Ranunculaceae	*Celtis*		Umbelliferae	Urticaceae
	Sagittaria	*Clusia*			
	Typha	Combretaceae			
	Pteridophyta	*Eperua*			
	Ceratopteris	*Eugenia*			
	Isoetes	*Euterpe*			
	Lycopodium cernuum	*Ficus*			
		Ilex			
	Monoletes	*Malpighia type*			
	Pteridaceae	Malvaceae			
	Stenochlaena palustris	*Mauritia flexuosa*			
		Meliaceae			
	Triletes	Mimosaceae			
		Palmae divers			
		Parinari			
		Proteaceae			
		Pterocarpus			
		Randia			
		Rauvolfia			
		Rutaceae			
		Sapotaceae			
		Symphonia			
		Zizyphus			

TABLE 2. Relative values (per cent) of different taxa observed in the GUY 2 borewell

	Level (m)											
	0.10	0.22	2.02	3.14	4.11	5.27	6.28	7.18	7.76	8.32	11.16	11.46
Mangrove												
Rhizophora	3.9	0.9	13.3	10.3	11.0	12.1	18.9	18.2	26.5	83.2	70.1	75.3
Avicennia	40.7	3.2	1.5	4.0	1.4	0.4	2.5	3.0	1.1		3.9	5.6
Others	2.7		3.0		1.0	0.4	3.0		1.7	1.0		1.0
TOTAL	47.1	4.1	17.9	14.3	13.3	13.0	24.4	21.2	29.3	84.2	74.0	81.9
Swamp Savanna												
Gramineae	23.0	34.1	16.9	10.3	10.3	9.0	8.2	3.0	6.6	3.2	1.3	1.9
Cyperaceae	0.8	34.1	3.1	6.3	6.8	7.2	6.9	7.3	5.5	0.5	1.3	
Amaranthaceae/ Chenopodiaceae	0.8		1.5	1.1		3.6	0.6	3.0	1.1			0.6
Compositae	0.8	0.5	2.1	4.0	2.7	4.0	2.5	1.8	1.7			0.6
Typha	9.3	10.6	0.5	0.6					0.6			
Spores	7.8	7.4	21.0	25.7	19.2	22.0	21.4	25.5	15.5	2.6	5.8	4.9
Others	0.4	1.5		1.1	0.7	0.4	0.6	2.0				
TOTAL	42.8	88.1	45.1	49.1	39.7	46.2	40.3	42.6	30.9	6.3	8.4	8.0
Swamp forest												
Alchornea	0.4		2.6	5.1	6.2	4.5	2.5	2.4	2.8	0.5		
Ilex		0.5	1.0			0.9	2.5				0.6	
Malpighiaceae	0.4		1.0	0.6	0.7	0.4	0.6	4.2	1.1		1.9	
Mauritia			0.5	1.1	2.7	3.6	1.3	1.8	3.9		0.6	
Palmae div.	0.8	1.4	2.6	5.1	5.5	2.7	3.1	2.4	3.9		0.6	1.9
Others		0.5	5.1	3.0	7.0	5.4	4.4	1.8	5.5	1.6	2.6	1.2
TOTAL	1.6	2.3	12.8	15.0	22.1	17.5	14.5	12.7	17.1	2.1	6.5	3.1

TABLE 2. Relative values (per cent) of different taxa observed in the GUY 2 borewell (*contd.*)

	Level (m)											
	0.10	0.22	2.02	3.14	4.11	5.27	6.28	7.18	7.76	8.32	11.16	11.46
Allochtones												
Alnus				1.1	0.7			0.6				
Podocarpus			0.5		0.7	0.4		0.6				
Others			1.0	0.6	0.7	0.9		0.6				
TOTAL			1.5	1.7	2.1	1.3		1.8				
Other NAP	2.3		2.1	2.3	2.1	2.7	2.5	1.8	2.8	0.5	1.3	
Miscellaneous	0.8	0.5	4.6	1.1	2.1	5.4	2.5	3.6	5.5	1.6	0.6	0.6
Unidentified	1.2	2.8	8.7	8.6	9.6	7.2	11.9	10.3	7.2	2.1	5.2	1.2
Unidentifiable	4.3	2.3	8.2	8.0	9.6	7.6	4.4	6.7	7.2	3.7	3.9	5.6
Marine												
Dinoflagellates	1.1		1.0			1.7	2.4	0.6	1.1	0.9	1.2	
Foraminifers	0.4		0.5	1.7	0.7	1.7	1.2	1.2		10.7	8.8	8.5
TOTAL	1.5		1.5	1.7	0.7	3.5	3.6	1.8	1.1	11.6	9.9	8.5
Fresh water												
Botryococcus	0.4					0.4	0.6	0.6				
Concentricystes			1.0	1.7								
TOTAL	0.4		1.0	1.7		0.4	0.6	0.6				
Pollen count	257	217	195	175	146	224	159	165	181	190	154	162

TABLE 2. Relative values (per cent) of different taxa observed in the GUY 2 borewell (*contd.*)

	Level (m)										
	12.17	13.39	14.28	15.34	16.37	17.39	18.95	20.35	21.03	21.04	22.4
Mangrove											
Rhizophora	76.8	81.3	75.0	81.1	75.2	90.4	87.2	72.2	63.8	80.6	77.6
Avicennia	5.6	2.9	4.6	2.2	4.1	0.4		1.7	2.9	1.4	0.7
Others						0.4		0.6	1.0	0.7	
TOTAL	82.4	84.2	79.6	83.3	79.3	91.2	87.2	74.4	67.6	82.7	78.4
Swamp savanna											
Gramineae	2.1	1.0	0.7	0.6	2.1	0.4	1.1	5.6	2.9		3.0
Cyperaceae	0.7	0.5	2.0	0.6	0.7	0.4			2.9	1.4	0.7
Amaranthaceae/ Chenopodiaceae											
Compositae					1.4		0.6				
Typha					0.7						
Spores	2.8	6.7	6.6	8.9	7.6	2.2	3.9	7.2	11.4	4.3	3.0
Others										0.7	
TOTAL	5.6	8.1	9.2	10.0	12.4	3.1	5.6	12.8	17.1	6.5	6.7
Swamp forest											
Alchornea			0.7								
Ilex			0.7								0.7
Malpighiaceae				0.6		0.4	0.6	1.1	1.9		
Mauritia		0.5			0.7						
Palmae div.	1.4					0.4	0.6	1.7	1.0		2.2
Others	2.1	0.5	0.7	0.6		0.4	0.6	1.1	1.0	0.7	2.0
TOTAL	3.5	1.0	2.0	1.1	0.7	1.3	1.7	3.9	3.8	0.7	5.0

TABLE 2. Relative values (per cent) of different taxa observed in the GUY 2 borewell (*contd.*)

	Level (m)										
	12.17	13.39	14.28	15.34	16.37	17.39	18.95	20.35	21.03	21.04	22.4
Allochtones											
Alnus											
Podocarpus					0.7						
Others											
TOTAL					0.7						
Other NAP	1.4							0.6	2.9	0.7	
Miscellaneous	0.7	1.0		1.1		0.4	0.6	3.3	2.9	2.2	0.7
Unidentified	4.2	3.3	3.3	3.3	4.8	1.8	1.7	0.6	1.9	2.9	5.2
Unidentifiable	2.1	2.4	5.9	1.1	2.1	2.2	3.4	4.4	3.8	4.3	3.7
Marine											
Dinoflagellates	1.4	0.5	0.6		0.6		1.6				
Foraminifers		5.4	9.5	11.3	6.4	1.7	1.6			0.7	
TOTAL	1.4	5.9	10.1	11.3	7.1	1.7	3.2			0.7	
Fresh water											
Botryococcus		0.9					0.6				
Concentricystes											0.7
TOTAL		1.0					0.6				0.7
Pollen count	142	209	152	180	145	228	179	180	105	139	134

Mangroves

Rhizophora: Mangrove pollen are mostly represented by *Rhizophora* (*R. mangle* and *R. racemosa*) which sometimes account for 80 per cent in some levels. Although it is not always easy to differentiate the fossil pollen of these two species (Muller & Caratini 1977), they seem mostly to belong to *R. mangle*.

Avicennia: The only species reported in French Guiana is *Avicennia nitida* (white mangrove). The percentages observed in our sediments are relatively low (1-6 per cent) except in the upper level where they attain 40.5 per cent. They are present throughout the core except at 8.32 m and 18.95 m.

Other mangrove pollen: All the other taxa characteristic of the peripheral zones of the mangroves and which are poorly represented or absent in the sediments, are grouped in this category: *Conocarpus erectus* and *Laguncularia racemosa*, considered as pioneer shore line species, and *Sesuvium portulacastrum* which likes sandy soils but may also be observed along the estuaries colonised by *Rhizophora*. The golden fern, *Acrostichum aureum*, which in French Guiana grows behind the belt of tall mangrove trees, is also included in this group.

Swamp savannas

The main species of this formation belong to Gramineae and Cyperaceae. *Typha angustifolia*, pollen of Amaranthaceae, Chenopodiaceae and tubuliflorous Compositae are found associated with these herbs. Other pollen characteristic of these habitats but which are observed only occasionally are grouped under "Others". They are mostly the pollen of *Jussieua, Nymphaea, Polygonum, Hedyosmum, Potamogeton* and *Sagittaria*, and generally represent less than 1 per cent.

In coastal Guiana, fern spores always constitute an important element of swamp savannas. The most commonly observed spores are those of Blechnaceae, Polypodiaceae and Lycopodiaceae. *Isoetes* (common in fresh water) and *Ceratopteris*, as well as spores of *Stenochlaena palustris*, have also been observed occasionally.

Swamp forest

The swamp forest is located in the sub-coastal zone, particularly along the estuaries. It is quite poor in species except in transitional zones which are frequently inundated and whose constituents are mingled with the species of the dry land forest (de Granville 1978). On vegetation maps, the same symbol is generally used to denote the two formations. Often called "swamp palm groves", it owes this name to the large number of palms growing there, including *Euterpe oleracea, Mauritia flexuosa* and several other species grouped under "Other palms". Many other tree species are also found, and are listed in Table 1.

The taxa of this group which were observed periodically and in very low percentages (less than 1 per cent) were just grouped under "others". Only taxa of fairly regular occurrence (1-5 per cent) have been listed in Table 2. Among the important genera are *Alchornea* (which sometimes exceed 6 per cent), *Mauritia flexuosa* (1-4 per cent) and the *Malpighia* type.

The swamp forest is characterised by a great variety of species whose cumulative percentages are relatively high.

Allochtones

Pollen of plants growing further away and whose ecology is different from the other floristic associations just studied are grouped under this category. They are interesting in that they enable us to define the geographic origin of pollen in the sediments and their mode of transport, and to evaluate the importance of this transport at a given time.

There are 4 genera in this group: *Alnus* and *Podocarpus*, abundant in the moist forests of high elevations, and *Myrica*, which is most probably from the same region and has never been reported in Guiana by other authors to date. *Hemitelia* (Cyatheaceae) spore is included in this group because this tropical American genus grows at relatively high elevations (Tyron & Tyron 1982).

Although these taxa are poorly represented (0.4-1.2 per cent), it should be noted that they are found at the same level and must have been similarly transported. The simultaneous presence of *Podocarpus* and *Hemitelia* in the sediments has been reported by Muller (1959) in recent samples from the Orinoco delta.

Other NAP

The herbaceous taxa included in this group are those which do not belong to any of the floristic associations described earlier, those which could belong to many groups at the same time, or those considered to be of anthropic origin. None of them are observed in significant numbers.

Miscellaneous

This group includes pollen which could be identified only up to the family level or a little higher and hence could not be grouped under any of the above categories.

Marine elements

There are two elements in this group: dinoflagellate cysts and tests of foraminifers. Dinoflagellate cysts are mostly represented by genera such as *Lingulodinium*, *Operculodinium*, *Spiniferites* sp. and *S. mirabilis*, generally observed in deltaic habitats. They are not abundant and their percentage calculated on the total pollen + spores count is low.

The organic tests of foraminifers are better represented. Although their distribution does not follow any definite pattern as has been observed in the recent sediments of the Continental Plateau in the Ivory Coast (Caratini *et al.* 1987), their percentage is nevertheless higher when the mangrove is well represented.

Freshwater elements

Mainly represented by the freshwater algae, *Botryococcus*, and some rare *Concentricystes* but always in low percentages (most often less than 1 per cent of the total pollen + spores count), these elements are too poorly represented to be utilised for our interpretations. They are mostly found at levels where species of swamp savannas are most common.

Pollen diagrams

Only the diagrams of important species with a significant ecology or grouped in certain floristic associations are given (Fig. 3). Detailed results are shown in Table 2.

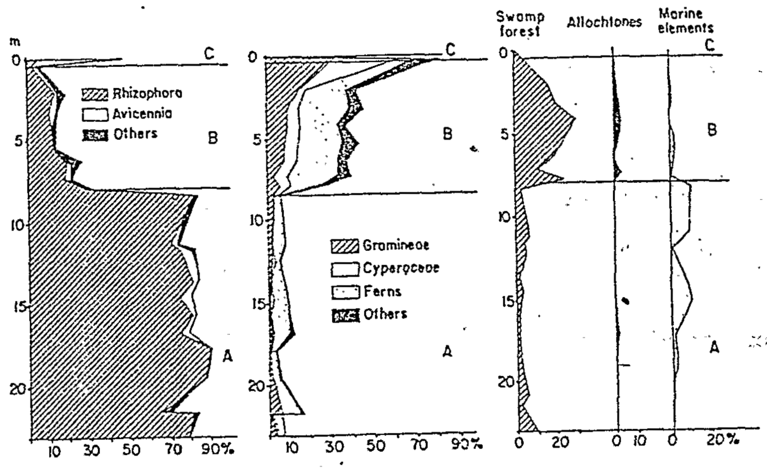

Fig. 3. Palynological diagramme of GUY 2.

Mangroves

The first group constitutes the mangrove pollen. The diagram shows 3 curves. One shows the percentage of *Rhizophora*, another of *Avicennia* and the third represents the other characteristic mangrove genera which are observed periodically.

Three zones can be clearly distinguished:

- the first, from the bottom of the core up to about 8 m, shows that the vegetation was completely dominated by a *Rhizophora* forest. Such a diagram confirms that the site is in the middle of a *Rhizophora* forest, not far from the coast and in a tidal channel environment where the percentage of *Rhizophora* pollen is always very high (Caratini *et al.* 1973);
- from 8 m to the top, *Rhizophora* suddenly decreases and are practically absent in the upper levels;
- a third zone, although less distinct, can still be distinguished corresponding to the upper levels. It reflects the present landscape with an abrupt extension of *Avicennia*, which was poorly represented till now. It must be remembered that there is an *Avicennia* forest near the borewell and also that *Avicennia* pollen which are not easily dispersed are observed in significant amounts in the interior or in the neighbourhood of their productive regions.

To understand the drastic change at about 8 m, it is necessary to follow the evolution of other floristic associations constituting the pollen spectrum, mainly those characteristic of moist savannas or swamp forests often growing in the hinter-land behind the mangrove forests and whose presence may be linked to various factors.

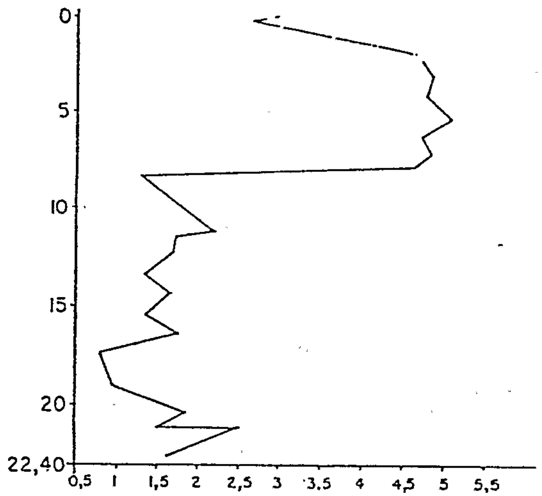

Fig. 4. Diversity indices of samples from GUY 2.

Swamp savannas

The three principal taxa constituting this group are the Gramineae, Cyperaceae and Pteridophytes. As in the mangrove, here also there is a change at a depth of about 8 m.

Zone A is clearly observed and is characterised by a low percentage of Gramineae and Cyperaceae pollen. The percentage of fern spores is slightly higher (5-10 per cent). During this period, the landscape was that of a *Rhizophora* forest, where Gramineae and Cyperaceae do not generally grow. The fern spores observed here may have been transported by rivers and deposited in the sediments. Above 8 m, there is a rapid rise in the three curves corresponding to zone B and showing the establishment of swamp savannas. Zone C is characterised by a decrease in the swamp savanna.

Other elements

Among the other elements observed, pollen characteristic of swamp forests growing near the site may be considered. In zone A, the swamp forests is poorly represented, the mangrove constituting the principal elements of this zone. In zone B, the percentage rises up to about 4 m and then tapers off almost completely at the top where it hardly exceeds 2 per cent. The almost total absence of forest species in the upper levels may be surprising because the present landscape is an open formation where pollen can easily penetrate, but in coastal French Guiana, since a few decades, man has been increasingly exploiting the woody forest species and this destructive action can be observed in the pollen spectrum.

Allochtonous pollen are also good indicators in so far as their presence here is seen only in zone B, at a period when the landscape was an open one, where they could easily penetrate. We may deduce that they were transported continentally because they are not found in zone A where marine influence was noticed.

The presence or absence of marine plankton (Dinoflagellate cysts and tests of foraminifers) indicate the importance of marine influence at the time of deposition. These elements are present in zone A, testifying the marine influence during this period. This is to be expected because the mangrove forest needs brackish environment subjected to tidal balance to grow. In zone B, the marine influence is less and completely disappears in zone C.

Diversity index

Diversity index is often utilised to demonstrate the characteristic features of a population. Among the various indices created to put in evidence the floristic diversity of a sample, we have used Shannon's index (1948) which consists in defining the relative abundance of a species in a population from the total number of individuals of each species.

The results show that the samples can be grouped according to 3 different values. The first group includes the two upper samples with a value of about 2.8, the samples of the swamp savannas have a mean value of 4.8 and those characterising the mangroves have a mean value of 1.6. These results confirm those of pollen analysis, because they enable the distinction of the same 3 zones A, B and C defined earlier.

DISCUSSION

Some relevant data should be considered to understand the drastic change in the vegetation at about 8 m, i.e. the replacement of the mangrove by swamp savanna. Carbon dating at 19, 60 and 20 m has given an age of about 8000 years BP. We now know that since 15000 BP, the sea-level was gradually rising and stabilised at about 5000 BP.

If we take the average rate of sedimentation of about 1 m per 400 years* we can estimate the age to be about 9000 BP at the bottom of the core. Till 5000 years ago, the rate of sedimentation seems to have been more or less equal to the rise in the sea-level. The shore-line has remained stationary and, as testified by the high percentage of *Rhizophora* constantly observed, the site has remained in the same environment during this period.

Since 5000 years, the sea-level is stable and the sedimentation permits a progradation and seaward shifting of the shore-line. The mangrove accompanies this seaward shift. The area it occupied previously is no more subjected to marine influence and the *Rhizophora* growing further downstream are replaced by swamp savanna species, that are less ecologically sensitive and growing in poorly drained coastal plains.

Comparison to other regions

Results of studies by other authors on cores taken from the eastern coast of South America are in accordance with ours. Fig. 5 gives the results of two of these studies undertaken in Surinam and British Guiana. Their pollen spectra are similar to that we obtained in French Guiana.

* Van der Hammen (1968) has indicated an average rate of sedimentation of 33 cm for 130 years in the first 20 m of the core from coastal British Guiana, which is in perfect accordance with our estimate.

In British Guiana, Van der Hammen (1961, 1963) studied a borewell about 30 m deep, dating 8,590±65 at 20.40 m. In this diagram, we can observe that the evolution of the vegetation is comparable to that of GUY 2. The mangrove forest dominates up to about 9 m and is then gradually replaced by savanna. Although his interpretation regarding the extent of the savanna which he attributes to the regression of the sea, differs slightly from our interpretation, the similarity of our results is however striking.

In Surinam, Wijmstra (1971), studied a borewell about 150 m deep. No dating has been made, but the first 25 m of the section shows that the mangrove seems to have evolved in the same way as in Ogle Bridge and French Guiana.

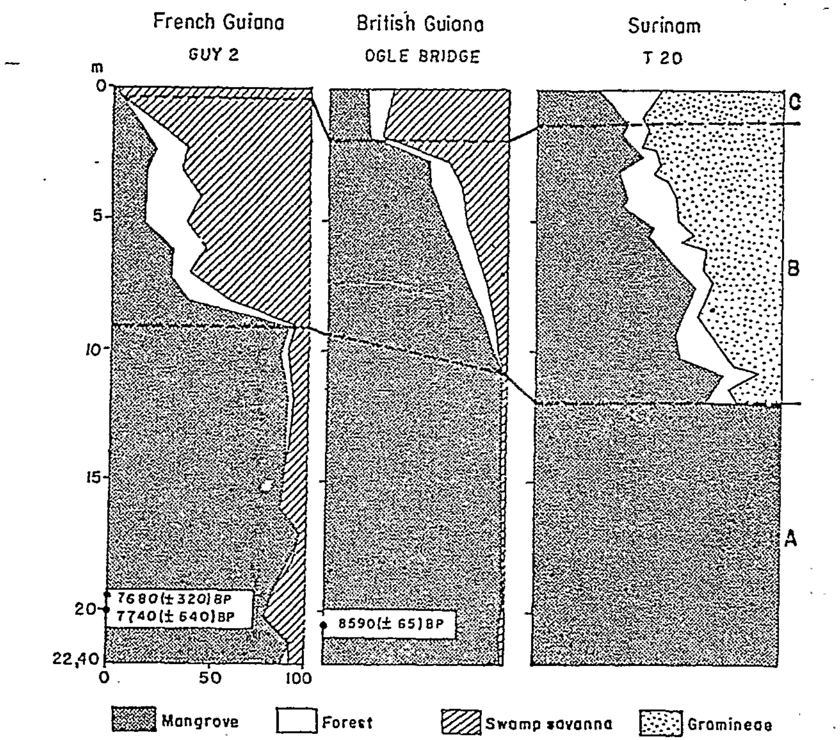

Fig. 5. Palynological correlations between GUY 2, Ogle Bridge (from Van der Hammen, 1961, 1963) and T20 (from Wijmstra, 1971).

CONCLUSIONS

The results of the borewell GUY 2 are interesting in that they concern an Holocene deposit where a dating could be obtained. So we have a valuable reference material for an accurate palaeogeographic reconstitution.

Because of its location in the equatorial zone, the Guianese platform was not subjected to any drastic climatic changes during the Holocene. Only eustatic variations, then progradation and lastly human influence were used for our interpretations.

The different stages we have observed in the succession of plant landscape have enabled us to demonstrate the perenniality of the mangrove forest during the Holocene and then its replacement since 5000 BP by increasingly open swamp savanna.

If the diminution in the mangrove forest seems to be mainly due to a natural morphological evolution of the coast, it is undoubtedly accentuated in the recent past by intense human activity. The *Rhizophora* mangrove which once formed an important floristic formation, now occupies a very small area as compared to the *Avicennia* mangroves.

Data from optical examination of organic matter, poor representation of allochtonous and marine elements support the theory that the organic matter is mainly from the land and has a local origin.

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