Aquaculture, 119 (1994) 175–190
Elsevier Science B.V., Amsterdam

AQUA 40089

Available algal biomass in tropical brackish water artificial habitats

A. Annabelle Konan-Brou and Daniel Guiral
Centre de Recherches Océanologiques, Abidjan, Ivory Coast

(Accepted 31 July 1993)

ABSTRACT

Experiments were conducted in February 1990 at the Layo Aquaculture Station located in Ebrié Lagoon, Ivory Coast, to find a reliable technique for the estimation of algal biomass and to understand the process that leads to a high tertiary productivity. Periphyton, growing on bamboo, was sampled at different settlement levels in an "acadja-enclos" at 200 m off the lagoon bank. "Acadja-enclos" is an extensive aquaculture system where *Sarotherodon melanotheron* (Cichlidae), a herbivorous fish, occurs mostly. Organic charge and periphytic concentrations (chl *a*, pheopigment, total pigments) were determined on each sample (from different locations). Specific microalgae composition and light intensity were also estimated. The periphytic community within the "acadja" was mainly composed of filamentous algae with *Rhizoclonium* (Kützing) (Chlorophyceae) as the major genus. Cyanobacteria and many species of the diatom *Nitzschia* comprised a high proportion of the epiphytes found. From a quantitative point of view, horizontal and vertical distributions of the biomass (mainly composed of algae) seemed to have been controlled by the availability of photosynthetic energy. However, the vertical heterogeneity was greater than the horizontal one. The maxima were situated close to the compensation depth. A high correlation was found between chlorophyll and organic matter ($r = +0.810$); this reflects the high percentage of algal biomass. The total yield of the "acadja" (1250 m^2) was evaluated at 60 kg of dry matter; this value was five times higher than the algal biomass of the Ebrié Lagoon in the Layo area. Moreover, algal concentrations due to proliferation of periphytic species were eight times higher in the "acadja" than in the lagoon waters.

INTRODUCTION

The "acadja" system (which originated in the Benin Republic in West Africa) has been used in the Ivory Coast since 1950 (Konan, 1990). This fishing method, now disseminated among Ivorian traditional fishermen, uses an under-exploited vegetal species *Bambusa vulgaris* (Hem, 1988) and contributes to increasing the productivity of the lagoons.

"Acadja" (artificial habitat) is a traditional fishing method used for about a century in the coastal lagoons of the Benin Republic (Welcomme, 1972),

Correspondence to: A.A. Konan-Brou, Centre de Recherches Océanologiques, 29, rue des Pêcheurs, BP V 18, Abidjan, Ivory Coast.

0044-8486/94/$07.00
SSDI 0044-8486(93)E0189-G

Cameroun, Ivory Coast, Ghana, Nigeria, Sierra-Leone, Togo, Bangladesh, Cambodia, China, Ecuador, Kampuchea, Madagascar, Mexico, and Sri Lanka (Kapetsky, 1981). In fact, an "acadja" is a kind of artificial reef or mangrove which is composed of dense masses of branches planted at the bottom of shallow waters and it attracts large numbers of wild fish (Gnonhoué, 1984). The major species of fish found in these structures is *Sarotherodon melanotheron*. These fishes stay in the "acadja" to avoid predators, grow well by eating the abundant natural food (benthic microalgae and invertebrates) and breed within the "acadja" (Hem et al., 1990). That is why "acadja" may also serve as an extensive aquaculture system.

The high productivity (8 to 21 t ha^{-1} year^{-1}) of fish biomass in Benin (Gras, 1958; Welcomme, 1972) in this extensive aquaculture system is of great interest to many scientists. This paper describes the "acadja" phenomenon and highlights the significant socio-economic advantages which can be derived from this experience if it is promoted and given a good backup. These studies will also help us establish a reliable technique for the estimation of algal biomass.

MATERIALS AND METHODS

Experiments were conducted during the annual dry season, in February 1990, at Layo Aquaculture Station located in the Ebrié Lagoon (Fig. 1) which receives marine water through the Vridi channel and fresh water from the nearby Agneby River as well as precipitation and surface runoff. The annual salinity cycle of the lagoon in the experimental zone fluctuates between 0‰ and 9‰ (Konan and Abé, 1990) with maximal values occurring in February–March (Guiral, 1983).

The "acadja-enclos" was located in the Ebrié Lagoon about 200 m from the lagoon bank and had an area of 1250 m^2 (25 m×50 m) and a depth of 135 cm. The "acadja" was built with 8000 bamboo sticks (10 m^{-2}) 12 months before our experiments commenced.

In February 1989, ten *S. melanotheron* fingerlings weighing 5 g each, were put in the "acadja" (which was surrounded by a net) at a stocking density of 10 m^{-2}.

The area actually occupied by the bamboo represented almost 65% of the total area of the "acadja". Four perpendicular, 2-m-wide paths and a circle (with a diameter of 4 m) situated in the center of the "acadja" were free of bamboo (Fig. 2a). The central circle which contained branches served as a spawning area and the paths facilitated catching fish within the "acadja".

To analyse the variability of the fixed organic matter and periphytic concentrations in function of the "acadja", the bamboo sticks were sampled at 10-cm intervals from the sediment to the +50 cm level and at 5-cm intervals from the +50 cm level to the +125 cm level. The zero level was chosen at the water–sediment interface because of the variability of the water level as a function of the tidal range and tidal cycle (mean amplitude is about 15 cm).

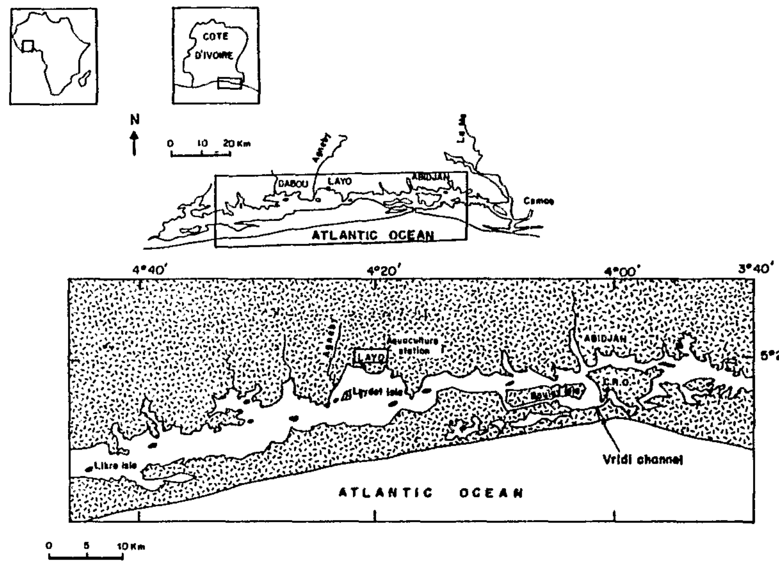

Fig. 1. Location of the Layo Aquaculture Station (Ebrié Lagoon, Ivory Coast).

Furthermore, the level was easily identifiable by the black and red rings around the bamboo. The black ring resulted from ferrous iron in anaerobic water and the red ring from the oxidation of ferrous iron to ferric iron in oxygenated water. At each level, a 1-cm-wide ring was marked and scraped with a knife to include the entire circumference of the bamboo. This scraping procedure excludes the eventual variability of algal colonization as a function of the orientation of the bamboo. The diameter of each ring was then measured to calculate the area actually sampled.

To test the existence of an eventual horizontal variability within the "acadja", a transect was made from the periphery to the center, parallel to the lagoon bank. The surfaces of pieces of bamboo measuring 60 cm each were selected and divided into 5 levels (L1 to L5) according to a procedure described by Konan (1988). A 2-cm-wide ring of algae was then sampled. Four peripheral external bamboo (PE), four internal (PI) and six central ones (C) were sampled (Fig. 2a).

The algal matter was suspended by dispersion in an ultrasonic box containing water from the lagoon. This water was previously filtered through a glass fiber membrane (0.7 μm porosity). For all the sampled levels, a spectrophotometric analysis between 600 and 730 nm (Beckman D U-64) of the algal

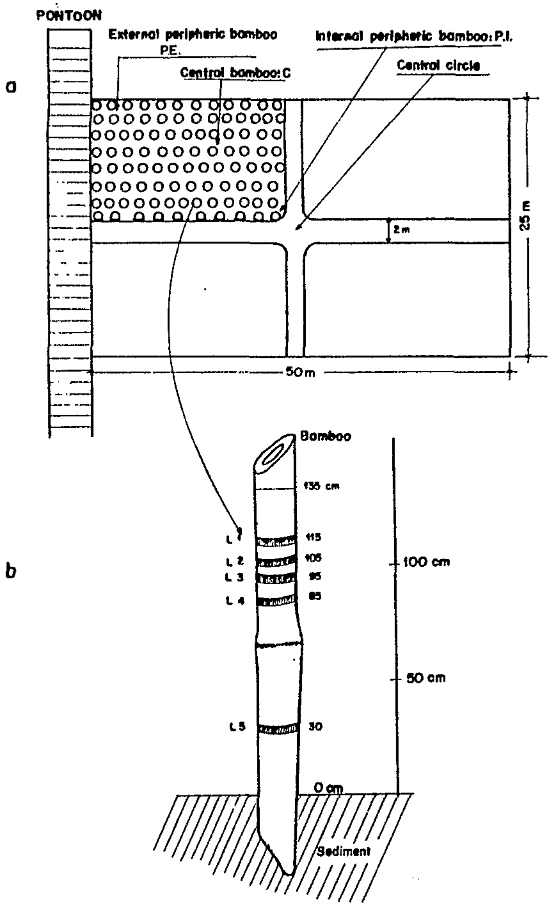

Fig. 2. (a) Structure of the "acadja-enclos". (b) Sampled levels on bamboos during horizontal heterogeneity study of organic and periphytic biomass.

matter was made after grinding the algae and extracting the pigments in 90% acetone. The concentrations of chlorophyll *a* and pheopigments were determined following the Yentsh and Menzel (1963) method, after extraction with methanol.

The organic and mineral matter were obtained by filtration on a glass fiber

membrane (Whatman GF/F (0.7 μm)) of known ash content. The concentrations of minerals and organic matter were determined respectively by difference of weight before and after incineration. A correction was applied to exclude the salt weight linked to the fact that the filter imbibes water.

A third aliquot of algal material was fixed with formol (2% final concentration) for a future determination of the specific periphyton.

To compare the total biomasses (attached and free algal and organic) from the "acadja" to those from seston of water outside the "acadja", organic and mineral sestonic matter at 50 m were determined. Three subsurface water samplings were made in the two media.

Photosynthetically active light intensity was measured with an integrator quantameter (Li-cor, Li 188 B) and a spheric cell (Li-cor, Li 193 SB) in and outside the "acadja". The extinction coefficients around the sampled bamboo were estimated from the light intensity (photosynthetically active) taken at every 10 cm depth.

RESULTS

Light penetration profile

The coefficients of light extinction were higher within the "acadja" (Table 1) than in free lagoon waters. Water transparency (resulting from the turbidity and the coloration of water) was 60% lower in the central circle than in open lagoon waters but was 60% higher in waters around bamboo. The compensation depth corresponded to only two-thirds of the water within the "acadja". In the lagoon, the superficial sediment (at a depth of 1.35 m) received more than 10% of the incident energy.

Sestonic matter

The sestonic concentrations (organic and mineral) were significantly higher ($P<0.01$) within the "acadja" than in the free lagoon waters (Table 2). The

TABLE 1

Light extinction coefficient and compensation depth of the lagoon and the "acadja" waters

Location	Light extinction coefficient (m^{-1})	Depth compensation (m)
Lagoon	1.96	2.35
External peripheral bamboos (PE)	4.87	0.94
Central bamboos (C)	5.29	0.87
Internal peripheral bamboos (PI)	5.08	0.91
Central circle	3.24	1.42

TABLE 2

Average concentrations, seston (organic and mineral) and phytoplanktonic biomass (chlorophyll *a* and pheopigment) and coefficient of variation in the superficial lagoon waters and in the "acadja"

	Mineral matter (mg l^{-1})	Organic matter (mg l^{-1})	Chl *a* ($\mu g\ l^{-1}$)	Pheo ($\mu g\ l^{-1}$)	Active (%)
Acadja water	8.8	10.6	7.5	1.4	83.9
CV	9.1	17.0	8.0	11.4	
Lagoon water	6.2	7.7	7.6	1.6	82.3
CV	14.6	9.3	4.7	11.7	

mean phytoplanktonic biomasses estimated by the total chlorophyll pigments concentrations (active and degraded chlorophyll *a* were similar for the two media. The coefficients of variations of organic concentrations and algal biomasses were very high within the "acadja" suggesting that seston composition in the superficial waters of this medium was more heterogeneous.

Specific composition of the periphyton

The distribution of the different species of the periphytic community as a function of depth shows a predominance of filamentous algae mainly composed of Chlorophyceae, Rhodophyceae, Pheophyceae, Bacillariophyceae and some species of Cyanobacteria (Table 3). About 20 photosynthetic species were found and the more important were *Rhizoclonium* sp. (Kützing), *Coleocheate* sp. (De Brébisson), *Lyngbya rivulariarum* (Gom.), *Scytonema myochrous* (Dillw.), *Audouinella* sp. (Bory de Saint Vincent), *Pleurocladia lacustris* (A. Braun), *Cymatopleura solea* (W. Smith) and three species belonging to the genus *Nitzschia*.

Rhizoclonium was the dominant genus of the periphytic community settled on the short bamboo of the "acadja-enclos". This genus was very abundant at all levels except from +75 cm to +80 cm and from +85 cm to +90 cm where Cyanobacteria were more important. Moreover, we have noticed that a high colonization by pennate diatoms of the genus *Nitzschia* occurred from +90 cm to the water–sediment interface. These diatoms constitute an abundant epiphytic flora associated with all filamentous algae. *Pleurocladia lacustris* (Pheophyceae) preferentially settled at intermediate depths between +95 cm and +60 cm levels.

Whatever the location of the bamboo within the "acadja", the specific composition of the periphytic population was almost identical to that previously described (Table 3).

From a qualitative point of view, algal cells from the +105 cm level (situated under the tide range zone) presented a picture of cells with partial dehydration and altered cell morphology. Close to the water–sediment interface, spongiar colonies, represented by *Spongilla lacustris*, were present (Boury-Esnault, 1980). The absorption spectra of acetonic extracts shows that chlorophyll *a* was the major pigment of the periphytic matter from the "acadja" (Fig. 3a). However, at the water–sediment interface, there was a second pigment with a maximun absorption at 613 nm (Fig. 3b).

Quantitative data of algal and organic biomasses

Vertical distribution. Concentrations of chlorophyll *a* were relatively low around the subsurface levels (+125 cm to +100 cm), but increased with depth up to +35 cm. Chlorophyll *a* values were 8 to 15 times lower than those found at the intermediate levels (+95 cm to +35 cm). Whatever the level, the pheopigments represented almost 20% of the total extracted pigments. The vertical profiles of organic matter and total pigments were similar but the former had an amplitude two times lower (Fig. 4). At each level, integrated value was estimated to obtain total organic and periphytic biomasses found on the sampled bamboo. These integrated values are respectively 7.8 g and 17.6 mg for this sampled bamboo.

Fig. 5a,b presents the probability distributions of organic matter and total pigments, respectively. The maximum concentration of organic matter was centered around +95 cm, while the maximum concentration of total pigments was centered around +65 cm. The two vertical profiles had different shapes. The organic matter distribution can be represented by the Gamma law while the total pigment is represented by the Gaussian distribution. This result suggests that organic matter was more sensitive to light intensity. Levels from +110 cm to +30 cm had a relatively constant percentage (4 to 6%) of periphytic and total biomass. The comparison between the two profiles of vertical distribution of organic and periphytic biomasses revealed a more important contribution to the total organic biomass than the algal biomass from the subsurface levels (from +125 cm to +100 cm). Conversely, the intermediate levels (from +50 cm to +30 cm) represented a more important percentage of total pigments.

Horizontal distribution. The mean concentrations of organic biomass and total pigments by level and by bamboo location were calculated. Whatever the level, bamboo situated in the external periphery of the "acadja" had higher mean concentrations but these were characterized by a high variability. On the other hand, bamboo sticks in the central position had, generally, lower and more homogeneous values. The intermediate levels (L3 and L4) had higher concentrations, particularly for total pigments.

A two-way ANOVA of the data set confirmed the existence of highly significant differences between levels for organic matter, chlorophyll *a* and total

TABLE 3

Vertical distribution of the periphytic species colonizing the bamboos at the Aquaculture Station of Layo

cm	125	120	115	110	105	100	95	90	85	80
Bacillariophyceae										
Centric diatoms										
Coscinodiscus sp.								(+)	(+)	(+)
Pennate diatoms										
Cocconeis sp.					(+)					
Cymatopleura solea			(+)	+	++	(+)			+	
Cymbella sp.									(+)	
Fragilaria virescens					(+)	(+)	(+)		+	
Gyrosigma acuminatum									(+)	
Navicula cuspidata										+
Navicula sp. 1				+	(+)			(+)	+	
Nitzschia romana							(+)		+	
Nitzschia sigma		(+)			+				(+)	(+)
Nitzschia sp. 1			(+)	+	(+)	(+)		+	+	+
Nitzschia sp. 2				(+)				(+)		+
Nitzschia sp. 3			(+)	+	+	+	(+)	(+)	+	+
Nitzschia tryblionella										
Pinnularia sp.		+				(+)				
Pleurosigma sp.							(+)			
Chlorophyceae										
Coleochaete sp.				(+)				+		
Rhizoclonium sp.		+++	+++	+++	+++	+++	+++	+++	+++	+
Ulothrix sp.						(+)				
Cyanobacteria										
Lyngbya epiphyta		(+)	(+)	(+)				+		+
Lyngbya rivulariarum		++	+	++	(+)	+	(+)	++	+	+++
Scytonema myochrous		+	++	+	(+)	++	++	+	+	+
Pheophyceae										
Pleurocladia lacustris							(+)	+	++	++
Rhodophyceae										
Audouinella sp.		+	+	++		+	+		++	+++

TABLE 3 (continued)

cm	75	70	65	60	50	40	30	20	10	0
Bacillariophyceae										
Centric diatoms										
Coscinodiscus sp.		(+)	+		+	(+)				+
Pennate diatoms										
Cocconeis sp.		(+)								
Cymatopleura solea	(+)		(+)		(+)					
Cymbella sp.	(+)		+	+						
Fragilaria virescens	+			+	+	+	+			+
Gyrosigma acuminatum	(+)		(+)		(+)			(+)		(+)
Navicula cuspidata	(+)									
Navicula sp. 1	+	(+)	(+)	+	(+)	(+)			(+)	
Nitzschia romana	++	(+)	+	+	+	+	(+)			
Nitzschia sigma	(+)						(+)			(+)
Nitzschia sp. 1	+	+	+	+	+	+	+	+	+	+
Nitzschia sp. 2	+	+	+	+	+	+	+		+	(+)
Nitzschia sp. 3	+	+	+	+	+	+	+	+	+	+
Nitzschia tryblionella				(+)					(+)	
Pinnularia sp.	(+)			+						
Pleurosigma sp.			(+)							
Chlorophyceae										
Coleochaete sp.									+++	+++
Rhizoclonium sp.	+++	(+)	+++	+++	+++	+++	+++	+++	++	++
Ulothrix sp.										
Cyanobacteria										
Lyngbya epiphyta					(+)		(+)			
Lyngbya rivulariarum	+	(+)	+	+	+	+	++	+	(+)	+
Scytonema myochrous	+	+++	+	+	++	++	+	++	+	+
Pheophyceae										
Pleurocladia lacustris	(+)	++	++	++	+	+	+	+		
Rhodophyceae										
Audouinella sp.	+	++	++	++		+		+	++	+

Specific biovolume is expressed as percentage of total biomass (+++ = >75%; ++ = >50%; + = >25%; (+) = <25%).
Source of identifications: Bourrelly (1966, 1968, 1970).

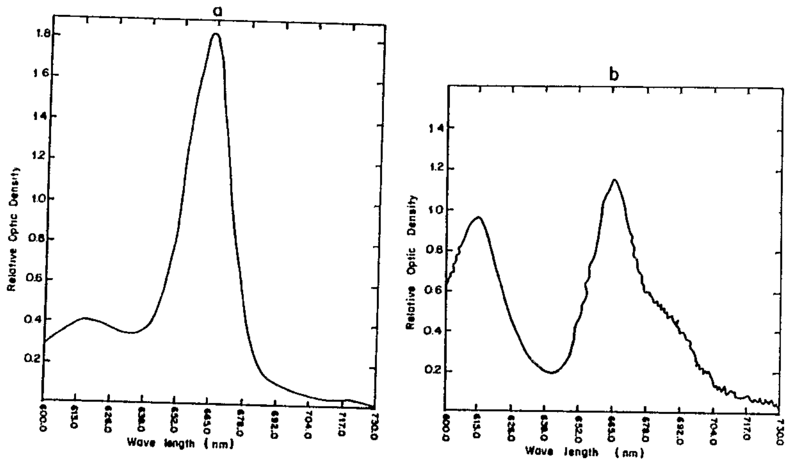

Fig. 3. Spectrum of acetonic extracts from periphytic material sampled at +70 cm (a) and at the water–sediment interface (b).

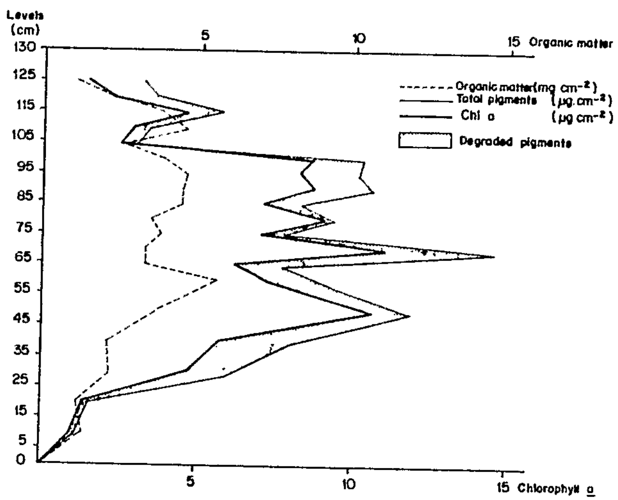

Fig. 4. Vertical distributions of organic mater, total pigment and chlorophyll *a* on a bamboo located in the center of the "acadja-enclos".

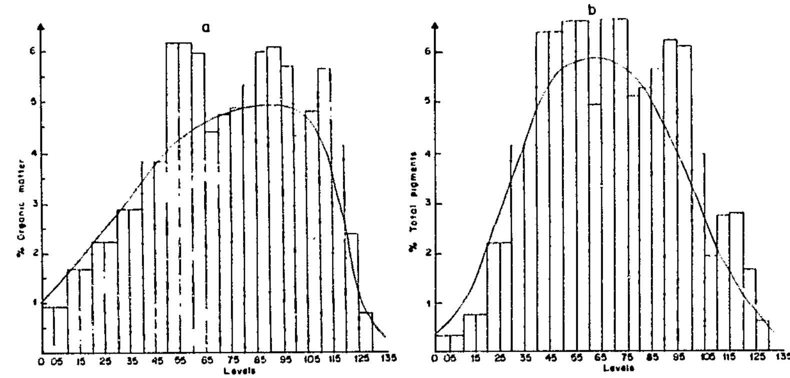

Fig. 5. Distribution of total organic matter (a) and total pigments (b) along a bamboo stick located in the center of the "acadja-enclos".

pigments (Table 4a). Independently of level, periphytic biomasses, and to a lesser degree the organic biomasses, were different among the locations of the bamboo within the "acadja". For the three analysed parameters, there was no interaction between level and location.

A Student *t*-test was made to determine the characteristic values of different levels and location (Table 4b). The distribution of the organic matter was identical at all locations, except for levels L1 and L2 of bamboos located at the external periphery of the "acadja". Similarly, these two levels (L1 and L2) and the level L5 presented higher values of total pigments than those located at the center and at the external periphery of the "acadja". The intermediate levels L3 and L4 had significantly different values (Table 4b) depending on their locations.

Considering bamboos in the central position which represented 85% of all the bamboos, the five sampled levels represented a total of 9.37% of the organic biomass and 8.10% of total pigments. Assuming that the vertical distribution is identical for all bamboos, integrated calculation for the three locations (PE, PI and PC) chosen were made. These estimations were realized by taking into account the specific characteristics of each level and location. For the bamboos located near the external periphery of the "acadja", the total organic and periphytic biomasses were respectively 1.2 and 2 times higher than those from central and from internal peripheral bamboos which gave similar values. This was equivalent to 87% of organic dry matter comprising 11.5 mg of chlorophyll pigments. From these estimates, and knowing the respective numbers of bamboo in the study area, it was possible to evaluate the total biomass in the studied "acadja". For an area of 1250 m^2, the available biomass within the "acadja" was estimated at 47 kg of dry organic matter.

TABLE 4a

Analysis of variance of the organic matter and the periphytic biomass as a function of bamboo location and depth level

		Degrees of freedom	F
Organic matter	Location	2	7.36**
	Level	4	13.04***
	Location level interaction	8	1.30
	Total (corr)	61	
Total pigments	Location	2	16.50***
	Level	4	27.00***
	Location level interaction	8	1.56
	Total	69	
Chlorophyll *a*	Location	2	19.40***
	Level	4	26.70***
	Location level interaction	8	1.36
	Total	69	

TABLE 4b

Comparison of the inter-location averages at the 5 levels (Student *t*-test)

	L1		L2		L3		L4		L5	
	C	PI	C	PI	C	PI	C	PI	C	PI
Ext.	3.83* / 3.83*	1.02 / 0.84	3.50* / 8.69***	3.78 / 1.30	2.75 / 15.40***	1.31 / 6.32***	2.94 / 11.50***	2.22 / 7.20***	1.31 / 3.50**	0.43 / 1.75
Cent.	–	1.23 / 1.74	–	0.02 / 1.94	–	2.49 / 9.94***	–	0.50 / 4.14**	–	0.23 / 0.25

Underlined values: organic matter (mg cm^{-2}); other values: total pigments ($\mu g\ cm^{-2}$).

Considering all the data (vertical and horizontal distribution) an attempt was made to obtain a reliable estimation of the total organic biomass using periphytic pigments data as a tool. The best estimation ($r=+0.638$; $n=40$) was obtained with chlorophyll *a* concentrations. This highly significant correlation reflects the essentially algal origin of the biomass which grows on bamboo. However, the use of this relation is less useful for the estimation of the total organic biomass. A logarithmic model allowed a best description of the relation between chlorophyll and organic matter ($r=+0.810$). This relation was: $\log Y=0.413\ (\log 1.578\ X)$ where Y corresponds to the organic matter expressed in mg cm^{-2} and X corresponds to active chlorophyll *a* expressed in $\mu g\ cm^{-2}$.

DISCUSSION

Dominated by the Chlorophyceae with the genus *Rhizoclonium*, the periphytic population of the "acadjas" from Layo appeared relatively different from the periphyton of rivers of the Ivory Coast described by Iltis (1982). This periphytic population was also different from the phytoplankton observed in the dry season in the zone near the Agneby river (Iltis, 1984) where Cyanobacteria were predominent. In the dry season, the periphyton from the Ivory Coast's rivers (the Bandama and the Maraoué) was mainly composed of sessile filamentous algae which trapped the usually pelagic species. In February, epiphytic species were dominated by the Cyanobacteria (*Oscillatoria* and *Lyngbya*) and the Rhodophyceae (only represented by the *Chantransia* step). But diatoms and Chlorophyceae were less represented and we have noticed a total lack of Euglenophyceae and Pyrrophyceae (while the latter was very abundant in the rheoplankton of these rivers). In March, the phytoplanktonic population of the zone of the Ebrié Lagoon influenced by the Agnéby River was dominated by the Cyanobacteria (*Microcystis, Oscillatoria* and *Lyngbya*) and the Pyrrophyceae essentially represented by the Cryptophyceae with the most abundant genus being *Cryptomonas*.

A comparison of the specific composition of periphytic and microphytobenthic communities was only possible for the Bacillariophyceae because only benthic diatoms were studied in the sediments of the Ebrié Lagoon (Plante-Cuny, 1977). This comparative study revealed a large number of common genera within the two communities. At the water–sediment interface, diatoms often constituted chains and presented some fixation systems (mucous peduncle or adhesive cushion) which allow them to adhere to the mineral particles of the sediment. This microbenthic flora was composed of a high proportion of pennate species (*Fragilaria, Diatoma, Nitzschia* and *Cocconeis*) with which were associated some loose large cells (*Gyrosigma* and *Navicula*). This similarity between the algal community from the "acadjas" and that from the sediments is due to the ability of diatoms to fix either onto filamentous algae ("acadja") or onto the mineral particles (sediments). This type of development imposes some morphologic adaptations and constitutes an important factor in species selection. Moreover, the importance of the colonization by epiphytic diatoms reveals a high availability of silicia. This can be verified in sediments by the abundance of fluvial quartz more or less eroded (Guiral, 1983) and with bamboos by the great number of siliceous spicules.

In Brazil, Eskinazi-Leça et al. (1980) studied some structures similar to "acadja". They found that algae which grew on bamboo were essentially composed of Bacillariophyceae (*Amphora, Navicula, Nitzschia* and *Pleurosigma*) and secondarily composed of Cyanophyceae (*Anabaena, Chroococcus* and *Oscillatoria*). The algal material from "acadjas" in Layo differed from Brazilian communities in the large number of Chlorophyceae species. In spite of these differences, the two periphytic communities were abundantly exploited by aquaculture fishes as shown by the large number of algal cells in the stomachs of Mugilidae (Brazilian structures) and in the *Sarotherodon melanotheron* stomach contents (Konan, 1988).

There was a significant reduction of the photosynthetic layer in the "acadja" when compared to the open lagoon waters. This phenomenon seems not to be associated with the rise in the particulate matter. This reduction of the photosynthetically active layer might be a result of the shading effect of the bamboos. Therefore, a reduction in bamboo density should not only increase the photosynthetically active radiation in the "acadja", but also lead to a reduction in the installation cost.

Maximal periphytic biomasses were noted for levels close to the compensation depth. However, we must realize that in this "acadja" under exploitation, the algal biomass is subject to two antagonistic processes: autotrophic production and grazing by fish. The high algal concentrations observed reflect the zones of ecological preference of these species. Nevertheless, their abundance at these deeper levels reflects their capacity to use the low light intensities. This adaptation was indirectly confirmed by the high reduction of the total biomass and even more so of the periphytic biomass (Fig. 2) in the subsurface levels (from the +105 cm level). Effectively, for these levels, the effects of tidal range resulting in the deterioration of cells (drying, alteration) must be associated with a photo-inhibition phenomenon. Given that dominant species are identical whatever the depth is (and then, whatever the total quantities of incident energy), this capacity to use the low energies occurred with an inhibition of photosynthesis for levels submitted to high light levels. Indeed, unlike phytoplanktonic algae, the periphytic population can not change its floatability; that would give it access to the optimal energy levels in the euphotic layer.

The available total organic biomass (sum of 13 kg loose biomasses and 47 kg fixed biomasses) in the sampled "acadja" was five times higher than that of the lagoon. This enrichment was demonstrated for total pigments also, with concentrations eight times higher than those from free waters. Within the "acadja", the periphytic biomass corresponded to 86% of the total algal biomass. In spite of the grazing action exerted by *S. melanotheron* on the periphyton, these results confirm the high concentration of exploitable biomass in the "acadja" compared to open lagoon waters. This may be a result of: (1) an enhanced primary productivity due to an efficient utilization of incident radiant energy, and (2) a continual rejuvenation of the algal communities by the grazing effect (Castenholz, 1961; Horppila and Kairesalo, 1990). Taking account of this rate of biomass regeneration in the "acadja" and assuming that each 5-g fingerling *S. melanotheron* eats 10–20% of its weight per day,

each fingerling would have a reserve of periphyton equivalent to 6 to 12 days supply. This level of food supply could easily be replaced by the rapid growth of the algae.

ACKNOWLEDGEMENTS

We would like to thank the International Foundation of Sciences (IFS) for research funds.

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