Acadja-enclos Used in Côte d'Ivoire as an Extensive Aquaculture System

S. HEM[a]
Institut français de recherche scientifique pour le développement en coopération (ORSTOM)
Centre de recherches océanologiques (CRO)
BP V18 Abidjan, Côte d'Ivoire

J.L.B. AVIT
Ministère de l'Enseignement supérieur et de la Recherche scientifique en Côte d'Ivoire (MESRS)
Centre de recherches océanologiques (CRO)
BP V18 Abidjan, Côte d'Ivoire

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Abstract

Acadja is a fishing method widely practiced in the coastal lagoons of Benin. The principle of this traditional fishery is to set dense masses of branches in shallow water, which attract wild fish in large numbers. The yearly production is very high: 7 to 20 $t \cdot ha^{-1}$. Exploited within a short time (two to three months), the acadja system could be considered simply as a fish trap or aggregating device. If harvested after a longer period (six to 12 months), it may be considered as a culture system (retention, breeding, propagation, natural feeding and growth). This contribution explores the latter. Two production systems were used: an acadja-enclos (enclosure with acadja) and an enclosure without acadja used as a control. After 12 months, a biomass equivalent to 8 $t \cdot ha^{-1}$ was harvested from the acadja, eight times higher than the control system. Among the 18 species of fish harvested, *Sarotherodon melanotheron* represented 79% of the biomass. Analysis of the fish population showed that the young fry had entered through the net at the beginning of the experiment and grown in the acadja-enclos. There were no differences in condition factor between the *S. melanotheron* from the acadja-enclos and from open water. Further experiments have shown that acadja-enclos, which can be considered as "bamboo reefs," are very suitable for fish production in rural Côte d'Ivoire. The acadja-enclos system appears to increase productivity greatly in lagoon fish culture. The same principle could be applied in extensive aquaculture or in various aquatic management programs. Further research is needed to understand the basis of this high productivity.

Introduction

Coastal lagoons are a vast area, rich and favorable for a potential aquaculture development in West Africa (Pauly 1976), but lagoon aquaculture in brackishwater has started only recently. Plans and projects have been proposed (Dada 1976), but few actions have taken place. In Côte d'Ivoire, experimental lagoon aquaculture began in 1978, with a catfish species (*Chrysichthys nigrodigitatus*) (Hem 1987), but the costs of feeding these fish is a real budget constraint (about 50% of the production cost) and hardly affordable in the rural context. For this reason, a new aquaculture research program was set up by the Centre de recherches océanologiques (CRO) d'Abidjan to develop extensive aquaculture systems for rural conditions. For this, production

[a]Current address: ORSTOM, BP 5045, 34032 Montpellier Cedex 1, France.

methods must be technically simple, with minimum external input (such as energy and food pellets, etc.) and using the available local resources and village labor.

Acadja is a traditional fishery system in Benin (West Africa). Usually implemented in shallow water of about 1 m depth, an acadja is a brush park made from wood and branches. These attract fish. This kind of fishery is found in many countries (Kapetsky 1981), but it is particularly developed and well-designed in the lagoons of Benin (Welcomme 1972). The high productivity of the acadja system has a dual basis: (1) attraction and migration of wild fish into the acadja, (2) reproduction and growth of fish inside the acadja system (Fig. 1, I). Harvests of 4 to 20 $t \cdot ha^{-1} \cdot year^{-1}$ have been recorded from acadjas and their prolific spread within the lagoons of Benin have caused serious social conflicts (Pliya 1980): conflict between the acadja owners and lagoon fishermen who complain that the acadja attracts all the fishes from the wild stock (natural resource competition); and conflict between acadja operations and navigation (lagoon space competition). Hence, acadjas are no longer allowed in some regions, e.g., lakes Aheme in Benin and Togo in Togo.

Therefore, our research was designed to avoid such conflicts and to turn the acadja into a culture system. Our new fish production system has been called an "acadja-enclos" (Fig. 1, II). For this, the traditional acadja is modified by surrounding the densely packed tree as other material with a net.

Materials and Methods

The experiment was made in the Ebrié Lagoon in brackishwater (0-5 ppt salinity) at the Layo Aquaculture Research Station. Three 25x25-m enclosures surrounded by net no. 210/60 (mesh 14 mm) (knot to knot) were used to enclose the devices. They were built on sandy bottom with the same technique already used for catfish enclosures (Hem 1982). At the start, the three enclosures were cleared of all fishes, using a small mesh seine net (8 mm) (knot to knot). The first enclosure was kept empty and used as a control structure (Fig. 2). The second enclosure was filled with *Sclera* sp., a kind of floating aquatic grass which thrives along the lagoon border, spread over 100 m^2, surrounded by bamboo sticks embedded in the sand (Fig. 2, Section AB). This aquatic grass is known as one of the natural habitats of *Sarotherodon melanotheron*, the main species which colonizes acadjas. This experiment was designed to investigate other sources and kinds of substrates rather than using wood, the depletion of which in the surrounding area may have undesirable ecological impact.

The third enclosure was an acadja-enclos: a brush park, set up like the traditional acadja in Benin. One hundred packages of dry branches were spread over 100 m^2, and also surrounded by embedded bamboo sticks (Fig. 2, Section CD).

There was no stocking with fingerlings. The first recruitment began with small wild fish (1 to 2 g body weight) being attracted into the acadja-enclos through the meshes (net no. 210/60, meshes 14 mm). Once inside the acadja system, they feed and grow larger so that they are trapped within the acadja-enclos.

The three systems were left for 12 months without any intervention, except to inspect the nets every three weeks. After this, the three structures were harvested and the total length and body weight of every fish collected were recorded.

Results and Discussion

The total production of each device is presented in Table 1: 11.7 kg and 18.2 kg were respectively collected from the control enclosure and the acadja-enclos with aquatic grass. On the other hand, 80.5 kg

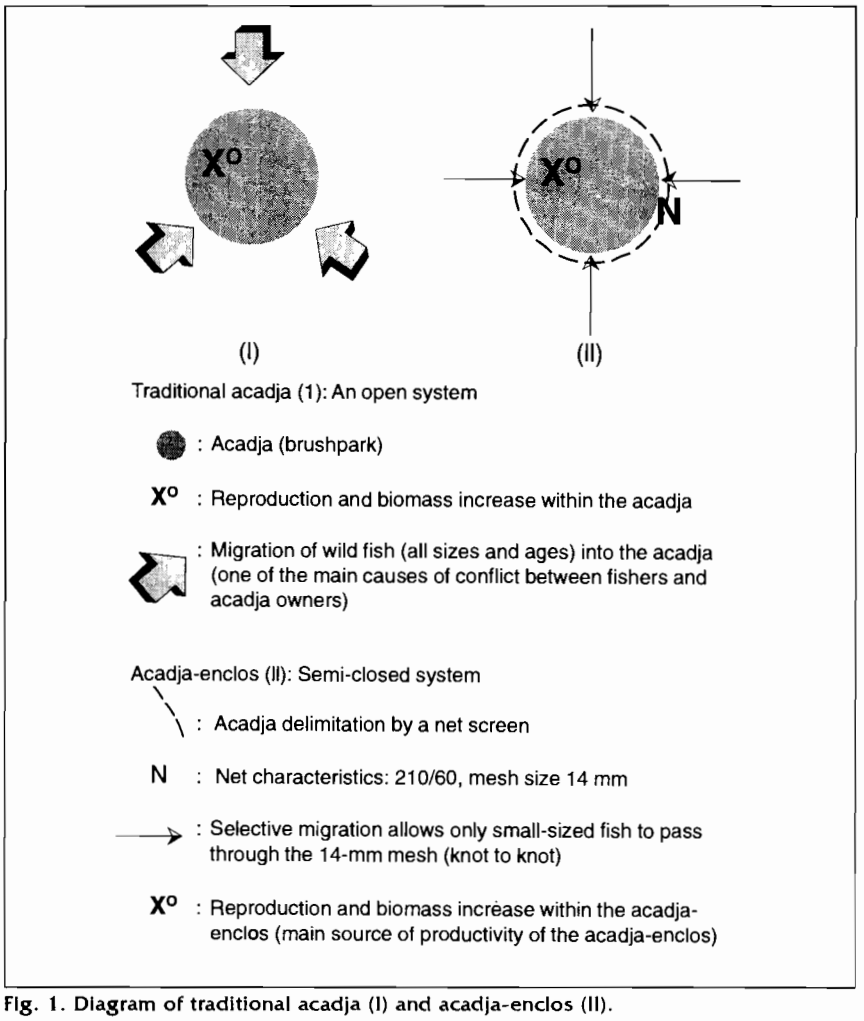

Fig. 1. Diagram of traditional acadja (I) and acadja-enclos (II).

were recorded from the acadja-enclos with a brush park. Thus, it is clear that acadja-enclos produced about seven times more than the control enclosure.

The acadja-enclos was strongly colonized by *S. melanotheron* (79% of the biomass). The acadja device appears to be well-adapted to *S. melanotheron* behavior, enhancing their colonization and population development. The other species listed in Table 1 had little or no influence on the biomass in the acadja-enclos. However, the presence of other catfish, *Heterobranchus longifilis*, a very fast growing species and predator of *S. melanotheron* and other species could lower the biomass.

The high percentage of *S. melanotheron* in the biomass requires a more detailed analysis. As young *S. melanotheron* entered the acadja-enclos through the mesh net, it was noticed that their growth corresponded probably to about the age of one year with a 210-g average body weight for females and 160 g for males.

Comparing the condition factor index, there were no differences between the *S. melanotheron* in the acadja-enclos and those growing in the open waters.

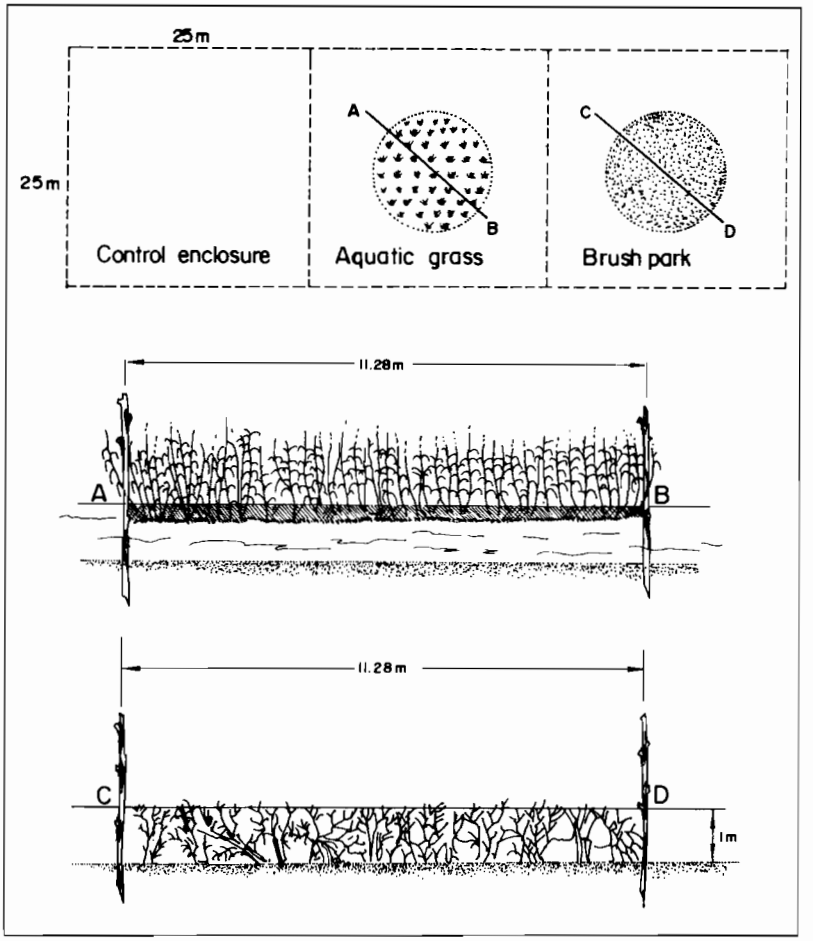

Fig. 2. Experimental design of an acadja-enclos used as a culture system. Device surrounded by net no. 210/60, mesh 14 mm. Section AB: acadja-enclos made from aquatic grasses; and Section CD: acadja-enclos made from brush park.

Acadja-enclos with brush park. After this first experimentation, the replications of the acadja-enclos were performed with larger surfaces (200, 400 and 2,500 m^2). The harvests from two 200-m^2 acadja-enclos were 109.1 kg and 195.9 kg (equivalent, respectively, in yield per hectare: 5.4 t and 9.8 $t \cdot ha^{-1} \cdot year^{-1}$). Only 131.9 kg (equivalent in yield per hectare: 3.3 $t \cdot ha^{-1} \cdot year^{-1}$) was recorded from the 400-m^2 acadja-enclos. Harvests of 241.1, 358.8, 337.1, and 877.5 kg were recorded from four larger acadja-enclos (2,500 m^2). By extrapolating the data to yield per hectare, an average of 1.8 $t \cdot ha^{-1} \cdot year^{-1}$ was recorded (Hem and Avit 1991). There was no proportional relationship between the size of acadja-enclos and their respective yields: curiously, yields became lower with the larger sizes of acadja-enclos. These results show that large acadja-enclos units (over 500 m^2 per unit) give apparently lower yielding profit than small ones. But the main problem related to acadja-enclos using brush park is more of its environmental rather than economic impact.

The building of larger acadja-enclos, however, can lead to ecological and social problems. The quantity of wood and branches, required for a 2,500-m^2 acadja-enclos is 18 to 20 t and the impact of wood

Table 1. Biomass (g) of different species harvested from three acadja-enclos; for details, see text.

Species	Control	With aquatic grass	With a brush park
Elops lacerta	75	16	51
Ethmalosa fimbriata	22		
Hepsetus odoe		34	
Chrysichthys nigrodigitatus			91
Chrysichthys maurus	2,212	831	2,936
Synodontis spp.	176		888
Heterobranchus longifilis	7,104	2,108	8,311
Gerres spp.			32
Hemichromis fasciatus	240	710	1,514
Tylochromis jentinki jentinki	26		24
Tilapia guineensis	313	3,058	762
Sarotherodon melanotheron	1,491	10,437	63,697
Tilapia mariae			355
Ctenopoma kingsleyae		54	464
Eleotris senegalensis		377	1,316
Citharichthys stampflii		134	
Synaptura lusitanica			
Cynoglossus senegalensis	18	347	
Penaeus notialis	72	72	7
Macrobrachium spp.		69	74
Callinectes spp.		48	
	11,749	18,295	80,522

cutting on the surrounding forest is highly visible. Moreover, the yearly destruction of brush parks (60 to 70% in this case), and accumulation of organic matter in the lagoons, would have undesirable long-term consequences for the environment. Therefore, the idea of making acadja-enclos out of brush parks has been abandoned, in favor of using only bamboo.

Acadja-enclos with bamboo. The search for new substrates for acadja-enclos led us to try bamboo (Fig. 2). Trials were first made in small acadja-enclos, followed by replications of larger dimensions (800, 1,250 and 2,500 m^2). The density of bamboo sticks was 10 per m^2. The results were very promising. An average of 8.3 $t \cdot ha^{-1} \cdot year^{-1}$ of biomass has been recorded (see Table 2) showing also the advantage of bamboo substrates which can last a longer time (five to six years). No accumulation of organic matter has been found with acadja-enclos made with bamboo. Moreover, vertical bamboo sticks are an ideal substrate for the proliferation of natural fish feeds: periphyton and aufwuchs (Plates 1 and 2).

In order to evaluate the total productivity of such acadja-enclos, we harvested by removing all the bamboos. This was necessary for the experiment, but not realistic under commercial conditions. Such complete harvesting includes the small fishes which are not marketable and would mean starting the next cycle with uncertain recruitment (Fig. 3). An alternative harvesting strategy is shown in Fig. 4.

Further research programs will focus on appropriate harvesting techniques without removing the bamboos. The design of a bamboo acadja-enclos for selective harvesting is shown in Fig. 5.

Undoubtedly, acadja-enclos can contribute to enhancing the productivity of West African lagoons. Technically simple, using materials and labor from local sources, acadja-enclos can be considered as using appropriate technologies for rural aquaculture in Africa. The present lack of bamboo in some

Table 2. Results of four trials with acadja-enclos using bamboo.

Item	1988	1989	1990	1991
Surface of acadja-enclos using bamboo (m^2)	800	2,500	800	800
Biomass harvested after 12 months ($kg \cdot year^{-1}$)	878.4	1,530	771	518
Productivity extrapolated ($t \cdot ha^{-1} \cdot year^{-1}$)	11.0	6.1	9.6	6.5

Plate 1. Close view of the bamboo sticks.

Plate 2. Tooth marks from fish grazing on the bamboo.

regions should not be considered as a serious constraint. The creation of bamboo plantations could solve this rapidly. Bamboo, considered in Asia as a serious "wonder grass," also protects soil against erosion and can be used for many other purposes.

These few preliminary trials have shown promising results. However, before application within the rural context, preliminary economic and social considerations must be examined. This is the only way to ensure a long-term successful development.

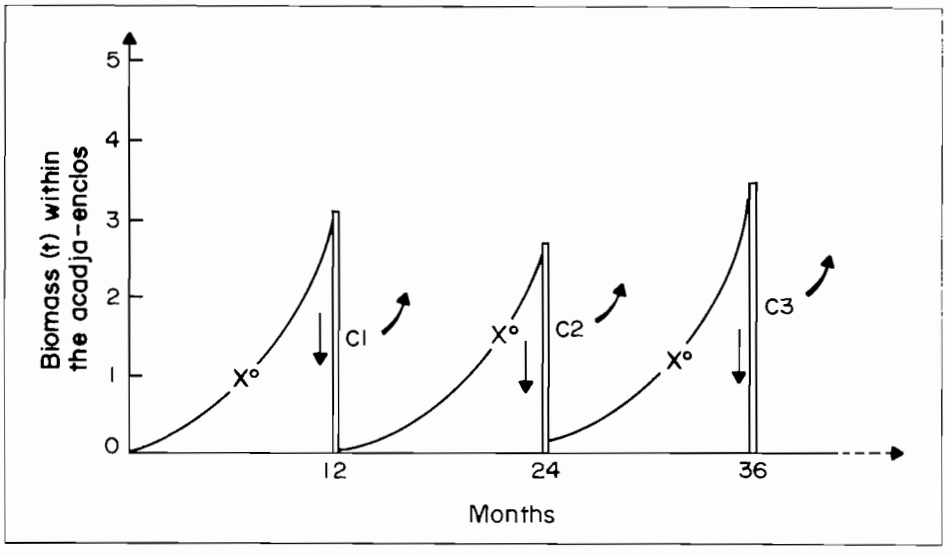

Fig. 3. Fish biomass within an acadja-enclos made with bamboo, based on annual total harvesting.

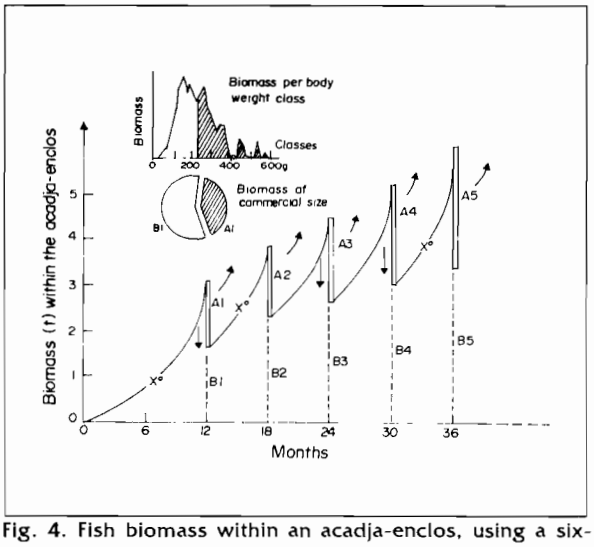

Fig. 4. Fish biomass within an acadja-enclos, using a six-monthly selective harvesting strategy where small-sized and young fishes are saved, and only fish of commercial size are exported from the system.

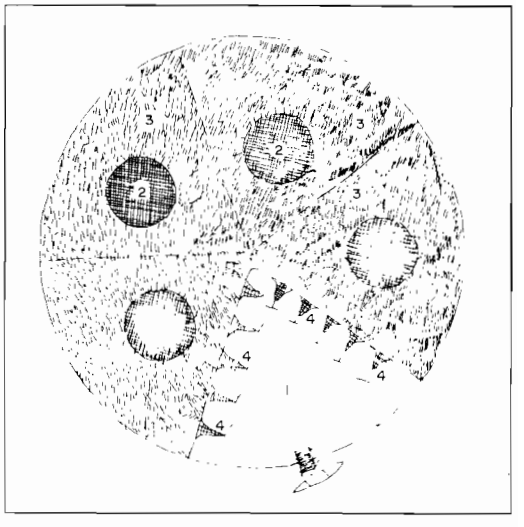

Fig. 5. Design for an acadja-enclos to allow selective harvesting, without removing the bamboo.

1. Fish attraction area (by feeding) used also as harvesting zone
2. Breeding areas arranged with dry branches
3. Bamboos
4. Size-selective access to open area

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