Aquat. Living Resour., 1989, 2, 81-89

Suitability of brackish water tilapia species from the Ivory Coast for lagoon aquaculture. II - Growth and rearing methods

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Received October 10, 1988; accepted January 9, 1989.

Legendre M., S. Hem, A. Cisse. *Aquat. Living Resour.*, 1989, 2, 81-89.

Abstract

In intensive culture, the two species of brackish water tilapia, *T. guineensis* and *S. melanotheron*, have proved disappointing. Even under most favourable conditions, *i. e.* the monosex male culture of *S. melanotheron*, a poor growth rate (about $0.5\,g.d^{-1}$) and a mediocre feed conversion do not presage a profitable aquaculture exploitation. On the other hand, extensive culture trials using the original "acadja-enclosure" technique have given very encouraging results.Annual fish yields of more than 8 t/ha, including 70 to 80% of *S. melanotheron* of marketable size, are possible without any artificial feeding.

Keywords : *Tilapia guineensis, Sarotherodon melanotheron*, growth, aquaculture, brackish water, Ivory Coast.

Potentiel aquacole des tilapias lagunaires de Côte-d'Ivoire. II-Croissance et méthodes d'élevage.

Résumé

En élevage intensif, les deux espèces de tilapias lagunaires, *T. guineensis* et *S. melanotheron*, se sont avérées décevantes. En effet, même dans la situation la plus favorable, l'élevage monosexe mâle de *S. melanotheron*, une vitesse de croissance médiocre (de l'ordre de 0,5 $g.j^{-1}$) et une mauvaise transformation des aliments artificiels ne permettent pas dans l'état actuel d'envisager une exploitation rentable. Les essais d'élevage extensif utilisant la technique originale des « acadja-enclos » ont par contre donné des résultats très encourageants.Des rendements annuels en poissons de plus de 8 t/ha, dont 70 à 80% de *S. melanotheron* de taille marchande, sont possibles sans aucun apport en aliment artificiel.

Mots-clés : *Tilapia guineensis, Sarotherodon melanotheron*, croissance, aquaculture, eau saumâtre, Côte-d'Ivoire.

INTRODUCTION

For a decade, the Ivory Coast has been involved in developing brackish water aquaculture in order to utilize more efficiently its wide surface area of coastal lagoons. For this purpose, research has been initiated with several species considered as potential candidates for fish farming, mostly catfishes (*Chrysichthys nigrodigitatus* and *Heterobranchus longifilis*), tilapias and a pompano (*Trachinotus teraia*). Concerning tilapias, the first rearing trials in lagoons were performed during the past few years with a foreign species, *Oreochromis niloticus*. These trials, carried out by different research or extension projects, have confirmed the rapid growth of this species but high mortality rates have been regularly experienced, the origin of which has not been clearly identified (Magnet and Kouassi, 1978 and 1979; Magnet, 1980; Coche, 1982). This may indicate that the species is not suited for intensive aquaculture in Ivory Coast brackish waters and, as a matter of fact, *O. niloticus* culture is presently restricted to the totally desalinated lagoon area (Doudet, 1988). Consequently, it seemed essential to estimate the rearing potential of two indigenous species, *Tilapia guineensis* and *Sarotherodon melanotheron*, which are typical estuarine fishes, and are therefore naturally suited to the lagoon environment (Daget and Iltis, 1965; Payne, 1983; Albaret, 1987). Moreover, these species are highly esteemed and widely consumed locally.

Although the aquaculture potential of *T. guineensis* and *S. melanotheron* have been refered to previously (Pillay, 1965; Sivalingam, 1976; Pauly, 1976), experimental reports on their performances in culture are very limited (Magnet and Kouassi, 1979; Philippart *et al.*, 1979) and some could not be found (McLaren, 1949; Smith, *in* Pillay, 1965). More recently, work has been initiated at the Abidjan Oceanographic Research Centre in order to determine their respective potentials for brackish water aquaculture. Investigations ware carried out into two different rearing options, intensive and extensive.

The first comparative study on the growth of *T. guineensis* and *S. melanotheron* in intensive culture was realized for the entire cycle, the grow-out stage being performed in lagoon enclosure (Legendre, 1983). Based on this preliminary investigation, further experiments were focused mainly on the influence of stocking density, monosex rearing and feeding on growth performance. Because the use of enclosure poses various practical problems related to some aspects of the behaviour of these species, and particularly of *T. guineensis* (nest building, fry proliferation, difficulty of catching), experiments were subsequently carried out either in tanks (Cisse, 1986) or in "cage-enclosure" (Legendre, 1986). Like the enclosure (Hem, 1982), the cage-enclosure is adapted to shallow sites (1 to 1.5 m deep), frequent in the lagoon environment. This very simple structure is made up of a mesh pocket hung on bamboo poles, the bottom being pinned to the sediment by means of metal rods. The impact of these structures on sedimentary ecosystems and their general conditions of utilization have been discussed by Guiral (1986).

The extensive method of rearing is derived from the "acadja" fishing technique traditionally practiced in coastal lagoons of Benin. The principle of this fishery is to set up dense masses of branches artificially planted in the muddy bottom of shallow waters, where fish from the wild concentrate and develop. This attractive effect is thought to be related to the significant increase of surfaces on which natural fish food such as micro-fauna and periphyton develop. But it is difficult to dissociate this effect from the fact that fish may also be attracted by acadjas because they provide a shelter. The explanation of the phenomenon is not so clear and depends probably on the biology of the colonizing species. However, the figures given by Welcomme (1972) indicate that the yearly yield of acadja is of about 8 to 20 tons of fish per hectare, which shows a significant increase compared to the lagoon yield. This led to the idea of surrounding acadjas with an enclosure net for extensive aquaculture fish production. The aim of the so-called "acadja-enclos" is to enhance the development of natural food within the rearing environment, thus reducing the need to provide artificial feed which considerably reduces the fish production cost (Hem, 1988).

This paper presents a synthesis of the main results obtained concerning growth rates of *T. guineensis* and of *S. melanotheron* in intensive culture, and *S. melanotheron* annual production in "acadja-enclos". The prospects offered by these brackish water tilapias for aquaculture are discussed considering both rearing methods.

MATERIAL AND METHODS

The experiments were carried out at the Layo aquaculture research station, located 40 km west of Abidjan in an oligo- to mesohaline area of Ebrié lagoon.

Nursery stage

For growth comparison, fry at the end of yolk sac resorption were collected from mouth-brooding males for *S. melanotheron* or from nests established in the enclosures for *T. guineensis*. They were placed into separate 0.5 m^3 circular tanks at a stocking density of 1 600 fry per m^3, and fed twice a day to satiation with a paste feed composed of powdered milk, egg yolk and vitamin premix (Hem, unpubl.). Every week, samples of 50 fish were removed, anesthetized (MS 222, Sandoz laboratory), placed on paper towels to absorb most of the adhering water, and individually weighed to the nearest 1 mg.

Fingerling stage

The growth during the fingerling stage (from 0.5 up to 40 g) was studied in 16 m^2 earthen ponds in which fry of the same species were placed at a stocking density of 6 fish per m^2. The fish were fed with a 31% crude protein powdered feed distributed twice daily and six days a week, with a daily rate fixed at 5% of the total fish biomass. Periodically, samples of about 30 fish were captured with a seine net, anesthetized, and individually weighed to the nearest 0.1 g.

Grow-out stage

Intensive rearing

Three experiments were carried out to study the effects of stocking density, monosex culture and feeding frequency on growth rates. The fish were obtained from aquaculture stations of the "Projet de Développement de l'Aquaculture lagunaire": from Jacqueville station for *S. melanotheron* and from Mopoyem station for *T. guineensis.* Fish originating from the Layo station were used only for two experimental groups of *S. melanotheron* in the stocking density trials.

The influence of four stocking rates, 20, 50, 100 and 150 fish per m^3, was tested in 4 m^3 cage-enclosures on growth and mortality rates of *T. guineensis* and *S. melanotheron.* Each treatment was duplicated and a population with an equilibrated sex-ratio was always used.

The respective growth of males and females was followed for both species between 10 and 150 g average weight. The fish were placed in duplicate 4 m^3 cage-enclosures, either in mixed (sex-ratio close to 1 : 1) or monosex rearing types, at a constant stocking density of 20 fish per m^3. For monosex rearing, fingerlings were sorted as soon as the sexual dimorphism of the genital papilla became visible. One month later, they were sorted again in order to rectify possible errors of sexing. For *S. melanotheron,* distinction between sexes was facilited by a difference in opercular colouration, pinkish in females and bright yellow in males (Shaw and Aronson, 1954). This allowed a more precocious sexing for *S. melanotheron* (from 15-20 g) than for *T. guineensis* (from 25-30 g).

In order to improve feeding conditions, the influence of the feeding frequency was tested in male monosex culture of *S. melanotheron.* The fish, of approximately 75 g initial mean body weight, were reared in 25 m^3 cage-enclosures, at an initial stocking density of 15 fish per m^3. Five feeding frequencies were compared: 1, 2, 4 and 8 meals distributed during the day between 8.30 AM and 7.00 PM, and 8 meals distributed during the night between 8.30 PM and 7.00 AM.

In the first and second experiments, the fish were fed with a 31% crude protein pelleted feed, distributed twice daily and six days a week, at a daily rate of 4.5% of total fish biomass. The composition of the feed was as follows: fish meal (20%), groundnut cake (20%), soybean cake (15%), wheat bran (25%), corn meal (20%), with an additional 2% of vitamin premix.

In the third experiment, a pelleted feed containing 30% crude protein and with 270 kcal per 100 g of feed was used (Cisse, 1989). The daily rate initially fixed at 5% of total fish biomass, was progressively reduced to 2% until the end of the experiment.

In all cases, monthly samples of 50 to 100 fish were removed from the cages, anesthetized, and individually sexed and weighed to the nearest 1 g. Every month, daily feeding rates were readjusted, based on the weight of the sampled fish. The efficiency of artificial feeding was estimated on the basis of the feed conversion ratio, calculated for the entire experimentation period by the following relation: total weight of distributed feed/total gain in fish biomass.

Extensive rearing

Two successive experiments on "acadja-enclos" were carried out between 1984 and 1986.

The aim of the first investigation was to quantify the increase in fish production related to different kinds of acadja. For this purpose, three 625 m^2 lagoon enclosures were used.

– The first one, empty of any kind of substrate, served as a control.

– In the second one, a 100 m^2 area of floating plants (*Scleria* sp.) was set up in the centre and fixed in place with bamboo poles.

– In the third one, 100 bundles of branches were placed over a 100 m^2 central area limited by bamboo poles.

None of these enclosures were stocked with fingerlings. The fish entered from the wild through the net (mesh of 14 mm), and were retained in the system after growth.

The aim of the second experiment was to evaluate the productivity of the "acadja-enclos" as an extensive culture system. Two acadjas of 200 m^2 and one of 400 m^2, constituted of bundles of branches, were implanted in the central area of three 625 m^2 lagoon enclosures. Each of them was stocked with reared *S. melanotheron* fingerlings of 40 g initial body weight, at a stocking density of 5 fish per m^2 of acadja.

In all cases, the structures were left for 12 months without fishing and without any input of artificial feed. At harvest time, the different kinds of acadja were removed and the entire fish population was captured with a seine net. The different species present were identified and all fish counted and weighed.

RESULTS

Nursery stage

The growth of *S. melanotheron* and *T. guineensis* were followed from the end of yolk sac resorption. At this stage, *T. guineensis* fry are very small and weigh about 2 mg, whereas *S. melanotheron* fry hatched from bigger eggs (Legendre and Ecoutin, 1989) already weigh about 20 mg.

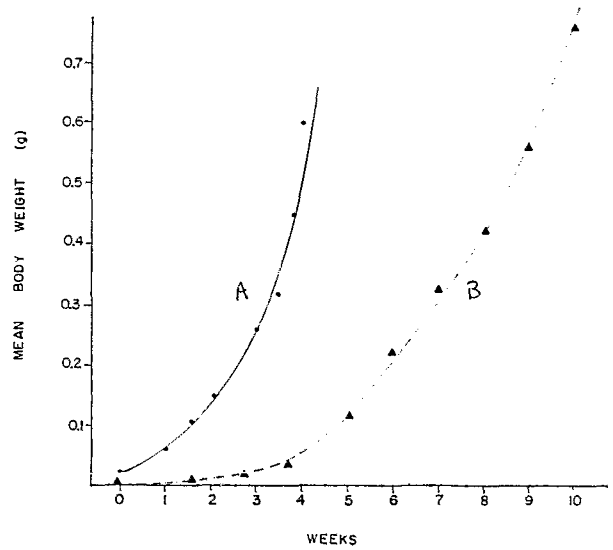

Figure 1. – Growth of *S. melanotheron* (A) and *T. guineensis* (B) fry in circular tanks.

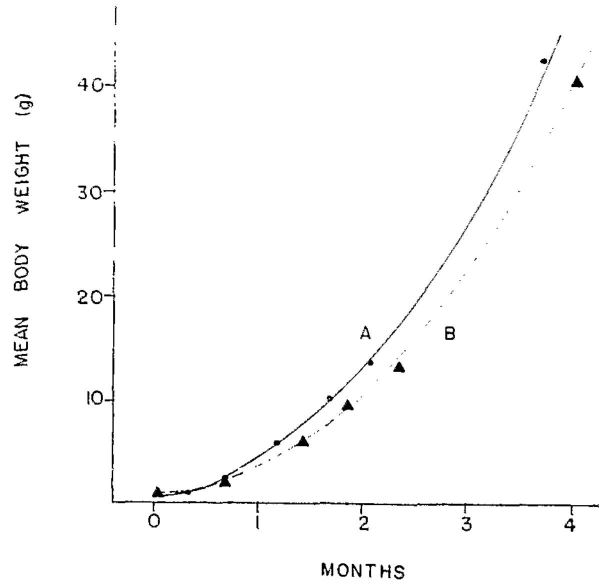

Figure 2. – Growth of *S. melanotheron* (A) and *T. guineensis* (B) fingerlings in earthen ponds.

Regarding this initial difference but also because of a better growth rate (*fig.* 1), *S. melanotheron* reach 0.5 g about one month before *T. guineensis*. For *S. melanotheron*, mortality rates in circular tanks are low and do not exceed 5% of the initial fry number. A peak of mortality has been observed for *T. guineensis* at the onset of first feeding, after which the mortality rate stabilized at a similar level to that of *S. melanotheron*.

Fingerling stage

The growth curves obtained in fingerling ponds (*fig.* 2) show that up to about 10 g the average growth rate is still lower for *T. guineensis* than for *S. melanotheron*. However, this difference tends to decrease progressively and between 10 and 40 g, the two species display a similar growth pattern.

Grow-out stage

Intensive rearing

In the range tested, between 20 and 150 fish per m^3, no influence of density on the growth of *S. melanotheron* was observed (*table* 1). On the other hand, a significant difference ($p<0.03$) in growth rates was noted between the two populations of *S. melanotheron* used during the course of these tests (growth rates of 0.35 to 0.38 $g.d^{-1}$ for fish originating from Jacqueville and 0.22 to 0.28 $g.d^{-1}$ for those originating from Layo), showing the importance of the history of fish on their growth performances. For *T. guineensis*, growth rates did not differ significantly at the different densities tested (*table* 2). In both species mortality rates varied little. Situated around 15% for the three lowest densities, they were

Table 1. – Mean growth rate, mortality rate and feed conversion ratio (FCR) for *S. melanotheron* as a function of stocking density in mixed rearing. Means of duplicates for 20 and 50 fish per m^3; single experiments for higher densities. Origin of fish: ([a]): Jacqueville, ([b]): Layo.

Initial stocking density (N/m^3)	Mean daily growth ($g.d^{-1}$)	Mortality rate (%)	FCR
20[a]	0.35	15.3	6.6
50[a]	0.36	15.2	6.4
100[a]	0.36	22.6	7.0
100[b]	0.22	15.5	9.1
150[a]	0.38	23.3	6.7
150[b]	0.28	33.1	8.7

Table 2. – Mean growth rate, mortality rate and feed conversion ratio (FCR) for *T. guineensis* as a function of stocking density in mixed rearing. Means of duplicates.

Initial stocking density (N/m^3)	Mean daily growth ($g.d^{-1}$)	Mortality rate (%)	FCR
20	0.30	13.7	6.3
50	0.34	13.4	6.1
100	0.30	13.5	6.1
150	0.29	24.7	7.5

however significantly higher (greater than 20%) in cultures at the highest densities (*tables* 1 and 2). Therefore, stocking densities higher than 100 fish per m^3 are not recommended for rearing.

A sex-linked difference in growth rates was observed in both lagoon tilapia species. For *T. guineensis* (*fig.* 3, *table* 3), the growth of males is always superior to that of females (0.41 $g.d^{-1}$ against 0.27 to

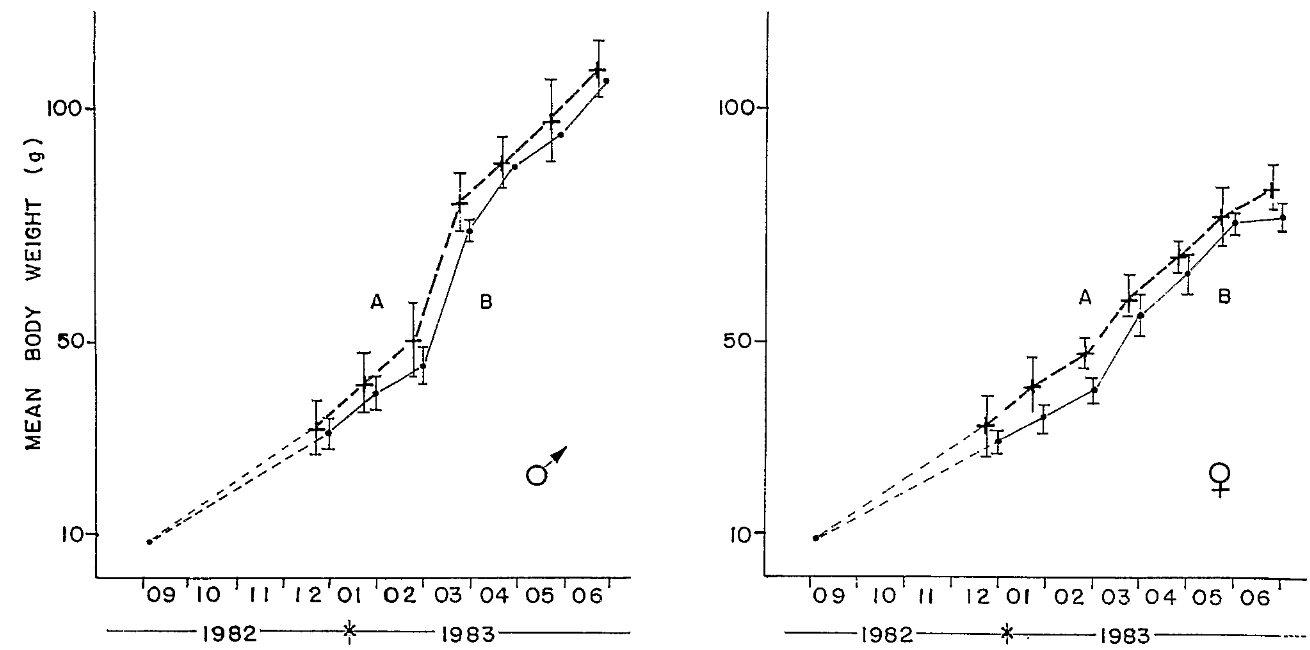

Figure 3. — Growth of male and female *T. guineensis* in mixed (A) and monosex (B) rearing in cage-enclosure. Fine dashed lines refer to fish growth before sexing. Vertical bars indicate differences between replicates.

$0.30\,g.d^{-1}$), regardless of the culture system (mixed or monosex). Conversely, for *S. melanotheron*, (*fig.* 4, *table* 3), a significant increase in the growth of males is observed when one goes from mixed ($0.32\,g.d^{-1}$) to monosex culture ($0.49\,g.d^{-1}$), whereas the growth of females remains steady ($0.42\,g.d^{-1}$).

A remarkable acceleration in growth rates was seen in both species during February-March (*fig.* 3 and 4), and was also observed simultaneously in all the fish groups belonging to the stocking density trials (Legendre, 1986). This acceleration, independent of stocking rates, was more pronounced in *S. melanotheron* (growth rates comprise between 0.48 and $1.20\,g.d^{-1}$ depending upon the experimental group, against 0.42 to $0.86\,g.d^{-1}$ only for *T. guineensis*). This phenomenon is related to the occurrence of an algal bloom (green water) which itself corresponds to the higher turbidities observed during the experiment. At this time, chlorophyll concentrations (75 mg per m^3) were more than double those observed in April when water transparency increases again. This strongly suggests that despite the intensive character of the culture, lagoon tilapia growth rates are in fact dependent on natural food availability in their environment.

Feed conversion ratios (FCR) obtained during these experiments show a poor utilization of artificial feed regardless of the species, density or type of culture used (*tables* 1 to 3). In the best cases, FCR were higher than 5, whereas classic FCR of 1.5 to 3 are obtained in intensive tilapia culture (Coche, 1982).

In order to optimize growth rates and FCR, the influence of feeding frequency was tested in male monosex culture of *S. melanotheron.* The results show that a feeding frequency of four meals per day gives the best growth performance (*fig.* 5). Night feeding or the increase in the feed distribution frequency up to eight intakes per day does not lead to any further improvements. Under the best situation, the fish have been brought from 75 to 235 g in about 8 months. However rapid growth rates were observed only during the first 2 months of the trial and overall the FCR (4.67) remains too high to allow an economic return.

Extensive rearing

In the first experiment the results of the harvest after 12 months without artificial feeding show that acadja made of bundles of branches lead to a production (80.5 kg) eight times greater than in the control enclosure without any substrates (11.7 kg) (*table* 4). Conversely, the implantation of floating plants in the enclosures shows no clear improvement of the results as compared to the control (18.2 against 11.7 kg of total fish production). Among the 80.5 kg of fish harvested (an equivalent mean of 8 metric tons per ha per year) in the brush park ("acadja-enclos"), 79% of the biomass was represented by marketable *S.*

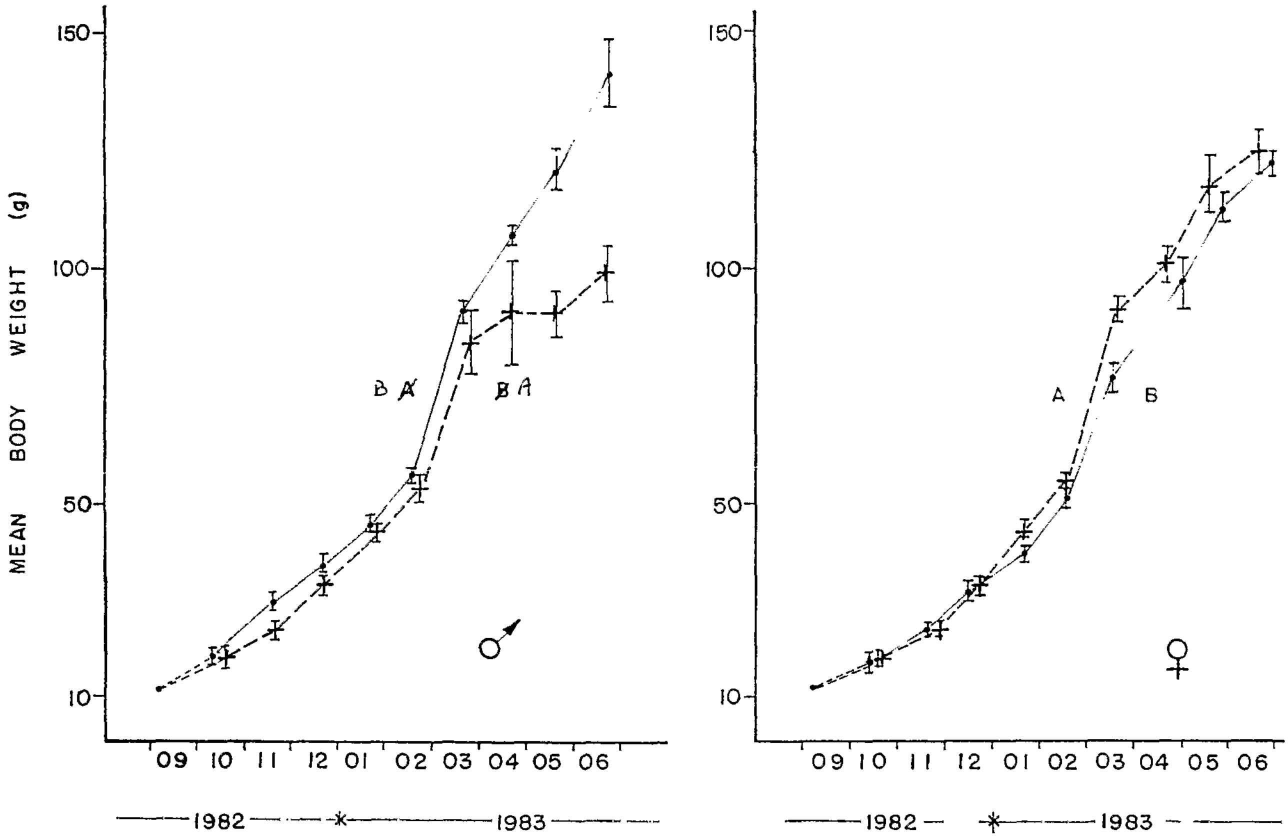

Figure 4. – Growth of male and female *S. melanotheron* in mixed (A) and monosex (B) rearing in cage-enclosure. Fine dashed lines refer to fish growth before sexing. Vertical bars indicate differences between replicates.

Table 3. – Growth rates of males and females, and feed conversion ratio (FCR) for *S. melanotheron* and *T. guineensis* in mixed and monosex rearing. Means of duplicates; initial stocking density 20 fish per m^3.

Species	Rearing type	Mean daily growth ($g.d^{-1}$)		FCR
		Males	Females	
S. melanotheron	Mixed	0.32	0.43	6.6
	Monosex female	/	0.42	5.8
	Monosex male	0.49	/	5.9
T. guineensis	Mixed	0.41	0.30	6.4
	Monosex female	/	0.27	7.5
	Monosex male	0.41	/	6.5

melanotheron of 200 g average body weight. According to this preliminary result, the "acadja-enclos" may be considered as a promising system for extensive culture of this species.

In the second experiment, where "acadja-enclos" exclusively made of bundles of branches were stocked with reared *S. melanotheron* fingerlings, some variability in the fish production (from 33 to 98 kg per 100 m^2) was observed among the different replicates (*table* 4). The reason for this variability is not clear, but the lower biomass harvested in treatments D and F (*table* 4) could be related to some extent to predation by *Heterobranchus longifilis* (4 to 7 kg individual weight) which accidentally penetrated the structures. In spite of this, the mean production obtained from the four "acadja-enclos" trials was very satisfactory (66.4 kg per 100 m^2 of acadja), considering that the fish never received any artificial feed.

DISCUSSION

Growth comparison between sexes

In *S. melanotheron*, the fact that the ratio between the male and female growth rates reverse when one goes from mixed to monosex culture, shows clearly that the lower growth of males under mixed culture is a consequence of mouth-brooding. It is indeed

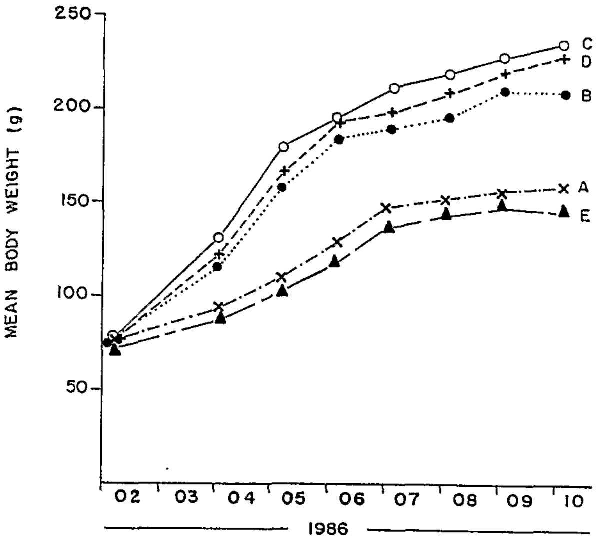

Figure 5. — Growth of male *S. melanotheron* in monosex rearing as a function of feeding frequency. A: 1 meal per day; B: 2 meals per day; C: 4 meals per day; D: 8 meals per day; E: 8 meals per night.

to eggs, and in monosex culture ($0.49\,g.d^{-1}$) where there is no incubation.

As for *T. guineensis* the sex-linked difference in growth rates is always in favour of males, irrespective of the rearing type. Finally, in both species the potential growth of males is higher than that of females, which seems to be the general case in tilapias.

Growth comparison between species

Although in mixed rearing the average growth for the best performing sexes of both species (the male for *T. guineensis* and the female for *S. melanotheron*) has always been very similar at the conclusion of the different trials (Cisse, 1986; Legendre, 1983 and 1986), the best growth performances have in fact been obtained with *S. melanotheron* males when reared in a monosex culture. Moreover, the growth rate of *S. melanotheron* is much higher than *T. guineensis* during the nursery and fingerling stages which contributes to reduce the total duration of the rearing cycle. *S. melanotheron* is therefore particularly recommended for lagoon aquaculture, since this species also has a higher market value than *T. guineensis* in Ivory Coast

Table 4. — Total biomass (kg) and relative proportion of the main species harvested after 12 months in acadja-experiments. For comparison with experiment N° 1 and mean calculation, biomass data in exp. N° 2 refer to production per 100 m² of acadja.

	Experiment N° 1						Experiment N° 2						Mean for trials	
Species	A		B		C		D		E		F		C, D, E and F	
	(kg)	(%)	(kg)	(%)	(kg)	(%)	(kg)	(%)	(kg)	(%)	(kg)	(%)	(kg)	(%)
Sarotherodon melanotheron	1.5	12.8	10.4	57.1	63.6	79.0	27	50.0	79	80.6	21	63.6	47.7	71.8
Tilapia guineensis	0.3	2.6	3	16.5	0.3	0.4	8	14.8	7	7.1	4	12.1	4.8	7.3
Heterobranchus longifilis	7.1	60.7	2.1	11.5	8.3	10.3	9	16.7	2	2.1	3	9.1	5.6	8.4
Others	2.8	23.9	2.7	14.9	8.3	10.3	10	18.5	10	10.2	5	15.2	8.3	12.5
Total harvested biomass	11.7	–	18.2	–	80.5	–	54	–	98	–	33	–	66.4	–

Exp. N° 1: without stocking fingerlings. A: control, without any substrate; B: with 100 m² of floating plants; C: with 100 m² of bundles of branches.

Exp. N° 2: with stocked fingerlings (5/m² of acadja). D, E: with 200 m² of bundles of branches; F: with 400 m² of bundles of branches.

known that under mixed culture *S. melanotheron* reproduces actively, and that the males do not feed during brooding (Legendre and Ecoutin, 1989). Therefore, for the same level of sexual activity, one can state that the difference in growth rates between males and females of *S. melanotheron* is a function of the fish's possibility to take eggs into the mouth for incubation. In mixed cage-enclosure culture, the presence of the net placed between the fish and the bottom sediment disturbs the uptaking of eggs without completely eliminating it. In this situation, male growth rates ($0.32\,g.d^{-1}$) are intermediate between those observed in enclosures ($0.18\,g.d^{-1}$; Legendre, 1983) and in concrete tanks (0.21 to $0.30\,g.d^{-1}$; Cisse, 1986) where there is direct access (Weigel, 1983). Consequently, research directed towards the latter species has been abandoned.

However, because of a better growth rate, *T. guineensis* was preferred to *S. melanotheron* for pond culture in Nigeria (P. Vincke, pers. comm., 1988). This could reflect a better adaptation of *T. guineensis* to the fish pond environment, but could also be related to differences between various West African populations of these fishes. In this context, it is interesting to observe that in Nigerian brackish waters, the maximal size of *T. guineensis* (named *T. melanopleura* by the author) is reported to be much greater than that of *S. melanotheron* (Sivalingam, 1976), while an inverse situation is observed in Ebrié lagoon (Albaret et Ecoutin, unpubl. data).

Aquaculture potential

From our results it appears that a high density (100 fish per m^3) male monosex culture of *S. melanotheron* in cage-enclosures should give the best production results. However, the economic profitability of such a rearing is compromised by poor artificial feeding efficiency. This is characterised by high feed conversion ratios (from 4 to 6) on one hand, and by an apparent dependence on natural food availability on the other.

The poor success of artificial feed observed for brackish water tilapias can be due to different factors: inadequate composition of the feed, poor quality of raw materials, inappropriate presentation and distribution. But during an experiment which has been simultaneously carried out with *O. niloticus* under strictly similar culture and nutrition conditions, a feed conversion ratio of 1.26 has been obtained over a 4 month period (between 17 and 155 g average weight) (Legendre, unpubl.). The feeding conditions which are apparently inaproppriate for brackish water tilapias seem to be entirely satisfactory in this case; this suggests the existence of a feeding behaviour which is more efficient under culture conditions for *O. niloticus* or that there are different nutritional requirements between these species. This question should be studied more thoroughly, and especially by means of a comparative study of the digestibility coefficients of local raw materials used for feed preparation.

Since an improvement in growth has been observed during the algae bloom period, it is clear that even within the scope of intensive cage culture, natural food can improve production results significantly. Although various authors have stressed the importance and role of natural food (*see* Coche, 1982, for review), it seems to be neglected too often in intensive fish farming carried out in open environments. It is therefore recommended to follow up more systematically the abundance of plankton in the environment (especially by chlorophyll measurements) in tandem with fish surveys. In various cases, the variations in the abundance of natural food could account for the periodical fluctuations which are sometimes observed in fish growth; these variations could also account for the production discrepancies which have been obtained with the same species in different rearing sites. This seems particularly to be the case for floating cage rearing of *O. niloticus* on the two opposite sides of the desalinated Aghien lagoon (Coquelet, pers. comm., 1987).

Presently, the global evaluation of the intensive culture of tilapias in the lagoons of the Ivory Coast remains quite negative since, on one hand some species are naturally adapted to the environment but have poor performances, and on the other hand an introduced species (*O. niloticus*) presents a rapid growth but does not adapt well to the brackish water environments of Ivory Coast, even in the oligohaline zones. The real cause of mass mortalities observed for *O. niloticus* in cage cultures carried out in Ebrié lagoon remains to be clarified. However, encouraging results have recently been obtained with *O. aureus*, the growth and survival of which seem to be satisfactory in brackish water up to $15 g.l^{-1}$ salinity (Doudet, 1988). This new species could perhaps solve the problem of the intensive culture of tilapias in the lagoons of Ivory Coast.

Extensive culture in "acadja-enclos" allow a yearly mean fish production of 66 kg per 100 m^2 of acadja, without providing any artificial feed. This production, including a significant majority of marketable tilapias, is comparable to that of traditional acadjas. It is known that in the latter, *S. melanotheron* represents the main species listed in the catches (Welcomme, 1972). Although *S. melanotheron* is essentially a deposit-feeder in certain environments (Fagade, 1971; Pauly, 1976), in the lagoons of Sierra Leone its natural diet is thought to be almost exclusively composed of algae which develop on mangrove roots, on rocks or on other hard surfaces (Payne, 1983). This biological feature is obviously one of the main factors which explain the predominance of *S. melanotheron* in "open" acadjas as well as the success of its production in "acadja-enclos" where the observation of branches shows an intense superficial browsing.

The branches progressively decompose and must be changed every year; in the short term this could be a limiting factor. The replacement of traditional bundles of branches by bamboo sticks which are planted vertically into the sediment should thus represent an attractive alternative; bamboos are easy to find and last longer. The advantages of such acadja structures are presently being studied.

CONCLUSION

From an aquacultural point of view, both brackish water tilapia species have been desappointing in intensive culture. Even in the most favourable situation, *i.e.* the monosex male culture of *S. melanotheron*, growth rates and feed conversion ratios which have been obtained do not presently allow a sufficient profit margin at the end of the cycle to ensure the economic profitability of a fish farm; this has been confirmed by large scale trials carried out within the scope of the "Projet de Développement de l'Aquaculture Lagunaire" (Doudet and Legendre, 1986; Doudet, 1988). So far it has not been possible to maintain acceptable growth rates (superior to $1 g.d^{-1}$) over 1 to 2 months; these periods correspond generally to a greater richness as regards natural food in the environment. On the average, growth rates which have been obtained (around $0.5 g.d^{-1}$) thus remain quite poor, especially when compared with those observed for other tilapia species already used in aquaculture.

In this context, the extensive culture of *S. melanotheron* in "acadja-enclos" appears to be a more promising option. On the basis of the first results obtained, provisional evaluations suggest the possibility for waterside villagers to have profitable fish farms without the need for any artificial feed supply. This solution is presently being investigated on a larger scale and in various situations. These studies are particularly directed towards a better understanding the functioning of this particular artificial ecosystem in order to optimize aquaculture exploitation methods (nature of the substrates, stocking rate, harvesting frequency).

REFERENCES

Albaret J. J., 1987. Les peuplements de poissons de la Casamance (Sénégal) en période de sécheresse. *Rev. Hydrobiol. Trop.*, **20**, 291-310.

Cisse A., 1986. Résultats préliminaires de l'alimentation artificielle de *Tilapia guineensis* (Bleeker) et de *Sarotherodon melanotheron* (Ruppel) en élevage. *In:* Aquaculture research in the African regions, FIS Seminar, PUDOC, Wageningen, 103-111.

Cisse A., 1989. Étude du rapport protéine-énergie dans l'alimentation de *Sarotherodon melanotheron* (Ruppel, 1952). Influence sur la consommation alimentaire, la croissance et la composition de carcasse. *Doc. Sc. Cent. Rech. Océanogr.*, Abidjan (sous presse).

Coche A. G., 1982. Cage culture of tilapias. *In:* R. S. V. Pullin, R. H. Lowe-McConnell Eds, The biology and culture of tilapias. *ICLARM Conf. Proc.*, **7**, 205-246.

Daget J., A. Iltis, 1965. Poissons de Côte-d'Ivoire (eaux douces et eaux saumâtres). *Mémoires IFAN*, **74**, 385 p.

Doudet T., 1988. Comparaison de la tolérance au milieu lagunaire saumâtre de différentes espèces et hybrides d'*Oreochromis* pour leur utilisation en aquaculture (lagune Ebrié, Côte-d'Ivoire). *In*: Proc. Atelier International sur la Recherche Aquacole en Afrique, Bouaké, Côte-d'Ivoire, 14-17 nov. 1988, CRDI (in press).

Doudet T., M. Legendre, 1986. L'aquaculture. *In*: Aménagement de la pêche et de l'aquaculture en Côte-d'Ivoire. Cent. Rech. Océanogr., Abidjan, 109-125.

Fagade S. O., 1971. The food and feeding habits of *Tilapia* species in the Lagos Lagoon. *J. Fish. Biol.*, **3**, 151-156.

Guiral D., 1986. Modifications et transformations des écosystèmes sédimentaires par les élevages piscicoles en lagune Ebrié. *Aquaculture*, **52**, 287-302.

Hem S., 1982. L'aquaculture en enclos: adaptation au milieu lagunaire ivoirien. *Aquaculture*, **27**, 261-272.

–, 1988. First results on "acadja-enclos" used as an extensive culture system. *In*: Proc. Atelier International sur la Recherche Aquacole en Afrique, Bouaké, Côte-d'Ivoire, 14-17 nov. 1988, CRDI (in press).

Legendre M., 1983. Observations préliminaires sur la croissance et le comportement en élevage de *Sarotherodon melanotheron* (Ruppel, 1852) et de *Tilapia guineensis* (Bleeker, 1862) en lagune Ebrié (Côte-d'Ivoire). *Doc. Sc. Cent. Rech. Océanogr.*, Abidjan, **14**, 1-36.

–, 1986. Influence de la densité, de l'élevage monosexe et de l'alimentation sur la croissance de *Tilapia guineensis* et de *Sarotherodon melanotheron* élevés en cage-enclos en lagune Ebrié (Côte-d'Ivoire). *Rev. Hydrobiol. Trop.*, **19**, 19-29.

Legendre M., J. M. Ecoutin, 1989. Suitability of brackish water tilapia species from Ivory Coast for lagoon aquaculture. I - Reproduction. *Aquat. Living Resour.*, **2**, 71-79.

Magnet C., 1980. Développement de l'aquaculture lagunaire. Centre Technqiue Forestier Tropical, Paris, 45 p.

Magnet C., Y. S. Kouassi, 1978. Essai d'élevage de poissons en cage flottante dans les lagunes Ebrié et Aghien. Centre Technique Forestier Tropical, Paris, 49 p.

Magnet C., Y. S. Kouassi, 1979. Essai d'élevage de poissons dans les lagunes Ebrié et Aghien. Reproduction en bacs cimentés, élevage en cages flottantes. Centre Technqiue Forestier Tropical, Paris, 70 p.

McLaren P. I. R., 1949. Brackish water fish cultivation experiments at Lagos, Nigeria. *Proc. Int. W. Afr. Conf.*, **3**, 281-290.

Pauly D., 1976. The biology, fishery and potential for aquaculture of *Tilapia melanotheron* in a small West African lagoon. *Aquaculture*, **7**, 33-49.

Payne A. I., 1983. Estuarine and salt tolerant tilapias. *In*: Proc. Int. Symp. on tilapia in aquaculture, Nazareth, Israel, May 8-13, 1983, 534-540.

Philippart J. C., Ch. Melard, J. C. Ruwet, 1979. La pisciculture dans les effluents thermiques industriels. Bilan et perspectives d'une année de recherche à la centrale nucléaire de Tihange sur la Meuse. *In*: L. Calembert Ed. Problématique et gestion des eaux intérieures, Derouaux, Liège, 779-791.

Pillay T. V. R., 1965. Report to the Government of Nigeria on investigations of the possibility of brackish water fish culture in the Niger delta. *Rep. FAO/EPTA*, 1973, 1-52.

Shaw E. S., L. R. Aronson, 1954. Oral incubation in *Tilapia macrocephala*. 1 – E. S. Shaw, Embryological studies. 2 – E. S. Shaw, L. R. Aronson, Experimental studies. *Am. Mus. Nat. Hist.*, **103**, 380-415.

Sivalingam S., 1976. The biology of cultivable brackish water and marine finfish in Africa. *In*: Proc. FAO/CIFA Symp. on Aquaculture in Africa, Accra, Ghana, *CIFA Tech. Pap.*, **4**, 283-291.

Smith W. N., 1965. The cultivation of *Tilapia heudelotii* in tidal ponds. 5 p., Mimeographed. *In*: Pillay, 1965.

Weigel J. Y., 1983. La commercialisation du poisson en pays lagunaire. Rapport interne, Centre de Petit Bassam, Abidjan, 67 p.

Welcomme R. L., 1972. An evaluation of the acadjas method of fishing as practiced in the coastal lagoons of Dahomey (West Africa). *J. Fish. Biol.*, **4**, 39-55.