RESEARCHES ON BRACKISHWATER AQUACULTURE IN COTE D'IVOIRE (*)

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by

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INTRODUCTION

First of all, I would like to take this opportunity to thank very much Dr. LIAO for his nice welcome at the Tungkang Marine Laboratory, and also to thank all the members of the laboratory who always answered our questions with so much kindness and patience, particularly Dr. WANG and Mr. CHANG who took us into the country to visit many interesting farms.

I think that the few weeks we spent here in Taïwan helped us very much in getting a new very positive insight into aquaculture.

The aim of my talk is to try to give you an idea of our working context and of our research activities in aquaculture at ORSTOM.

ORSTOM .....AND AQUACULTURE

O.R.S.T.O.M. which means, "Institute of Scientific Research for the Development in Cooperation", is a French public institute.

The particularity of this research institute is to work in foreign countries on request of their Governments. O.R.S.T.O.M. has a very wide range of scientific topics and activities (geology, biology, oceanography, social sciences, agronomy, etc...). About 700 scientists are distributed into seven departments, 50 research units and more than 30 countries, mostly in Africa and South America.

One of these departments called "Knowledge and exploitation of aquatic ecosystems" (98 scientists) deals with ecological studies, small scale and industrial fisheries, water quality, microbiology...and since 1979, with aquaculture.

Our aquaculture staff is based in Côte d'Ivoire at the Abidjan Oceanographic Research Center (C.R.O.). It was initially constituted to reinforce an Ivorian staff which already shows reliable experiences in this field. The present mixed research group is composed of 10 scientists and technicians among whom 5 from ORSTOM and 5 from Côte d'Ivoire working in cooperation. So, you can understand that research in aquaculture at ORSTOM is still very recent, of modest importance, and constitutes a new orientation which needs to be developped.

BRIEF PRESENTATION OF COTE D'IVOIRE

Côte d'Ivoire is located in West Africa, approximately between 5 and 10° North of the equator (fig. 1). The country's surface area is 322.463 km² and the total population is about 8 million people. The climate is sub-equatorial in the South of the country, with 2 rainy seasons and 2 dry seasons. The temperature is always high (yearly mean of 26°C).

Ivorians are great fish consumers. With about 25 kg per capita per year, fish constitutes the main source of animal proteins (70 % against 15 % for meat and 15 % for other sources). The annual fish consumption is about 200.000 tons of which 110.000 tons need to be imported as frozen fish and only 90.000 tons results from the national fisheries.

Two ways are under investigation to try to increase the national fish production :

- better management of fisheries
- development of aquaculture

Concerning aquaculture, there has been some development of tilapias (Oreochromis niloticus) freshwater pond culture, mostly in the Center and North of the country, with the help of CTFT (Centre Technique Forestier Tropical) and FAO. Our own activity, at ORSTOM, is focused more on the brackishwater environment. Côte d'Ivoire has a very wide coastal lagoon system (fig. 1), with a total surface area of more than 1200 km² of

WORKING CONCEPTS

One thing that we should keep in mind, is that, because of a complete absence of traditional practice, brackishwater fish culture in Côte d'Ivoire is just starting from nothing and this makes a great difference with most of the South-East Asian countries.

Then, our general concept of work is to try to develop culture techniques as simple as possible, that have some chances of being adopted by the local people. This means a technology adapted to the social and ecological environment, with low capital investment and easy to manage. For example, the net-enclosure technique which fits perfectly this definition is now widely used in the ivorian lagoons (fig. 2).

Also, we are working with indigenous species, mostly because these species are naturally adapted to the ecological environment and

The main criteria of preselection are the following :

- large maximum size
- wide geographic distribution
- large range of salinity tolerance
- sexual maturation in the lagoons
- high fecundity
- hardiness
- flesh of good quality

In this first step, economic criteria are not taken into consideration because the study applies to all West African lagoons, where people may have different habits and tastes according to their country. Besides, a given lagoon environment may be more suitable for the culture of a particular species, depending for instance on its salinity tolerance. Thus, the aim of the preselection step is only to establish a list of local species displaying, by their biological caracteristics, a high potential for aquaculture.

The final choice is dependent on the results of the following selection step and on the particular context in which aquaculture is planned.

Up to now, among the 150 species of the Côte d'Ivoire brackishwater fish communities, almost 30 have been identified as potential candidates for aquaculture.

The selection, is based mostly on experimental rearing trials of the preselected species.

The main criteria of selection are the following :

- high commercial interest
- fast growth
- easy fry supply
- resistance to handling stress
- acceptance of artificial feed

If a given species shows good performances in the rearing conditions, then the next step is to try to control the whole biological cycle in captivity, to elaborate a proper artificial feed formula and to develop a suitable culture technique.

Until now, experimental studies have been initiated at the Abidjan C.R.O. with 4 kinds of local fish families :

Bagridae....	Chrysichthys nigrodigitatus	"catfish"
Cichlidae...	Tilapia guineensis	"tilapias"
	Sarotherodon melanotheron	
Clariidae...	Heterobranchus longifilis	"catfish"

The present status of knowledge on these different species is very unequal since they have been studied for more or less time.

Chrysichthys nigrodigitatus :

commercial scale. Extension work has already begun under control of the "lagoon aquaculture project" and about 10 private farms have started producing C. nigrodigitatus in net-enclosures. The first results obtained by these farms are very encouraging and proved to be economical.

The rearing cycle of **C. nigrodigitatus** is the following :

The brooders are kept in enclosures, at a low density (1 fish/ 5 m²). They are fed daily with an artificial pelleted feed (35 % crude protein) and two times per week with beef liver.

For spawning in captivity, an original technique called "forced mating" was established. This technique is based on observations of the natural spawning behaviour in the lagoon, where C. nigrodigitatus is known to reproduce in rock cavities. In practice, a selected pair (1 male + 1 female) of mature brooders is choosen and enclosed in a spawning box made of a piece of large diameter PVC tube (fig. 4). During their stay in the box, the brooders are not fed and let in darkness. The use of hormones is not necessary. Spawning generally occurs after 7 to 30 days, depending on the initial eggs diameter of the female. At spawning, the eggs stick to the PVC tube and they also stick together forming a single big mass. The fecundity of the species is about 20.000 eggs per kg of female bodyweight.

The incubation is done in mobile basket incubators to allow good oxygenation of the eggs. Hatching occurs after 5 days at a temperature of 27-29°C. the hatching rates are generally high, about 50 % to 80 %.

The larvae are placed in hatchery tanks for yolk resorption and larval rearing. They are fed with an artificial feed (45 % protein) supplied as a fine powder. After 3 weeks, the fry reach an average weight of about 0,1 g. They are then transferred to nursery ponds located on the edge of the lagoon. After 5 months, the juveniles, weighing about 20 g, are ready to be placed in lagoon net-enclosures for grow-out. They are stocked

at a density of 10 fish/m² and fed with pellets (35 % protein). The commercial size (300 g) is reached within about a year.

In enclosures, the annual production is of 25 to 30 tons per hectare.

The research on C. nigrodigitatus is now continued on the following topics :

* We are studying the digestibility of local agricultural by products for the formulation of a low cost and efficient artificial feed.

* As spawnings were up to now obtained only during the natural reproductive season (July to December), experiments on the role of exogenous factors in sexual maturation are under way in order to try to obtain an all year round fry supply.

Tilapias

I will not tell you anything about the interest of tilapias for aquaculture because you probably know it better than me.

In Côte d'ivoire, the first trials of tilapia brackiswater culture were done by the CTFT (1978-1979) with Oreochromis niloticus. But, despite the good growth of this fish, there were a lot of problems because of diseases and mass mortalities when it was reared in brackishwater even of moderate salinity (5 ‰). The reason for these mortalities is still not clearly understood. Then, experiments were made to evaluate the aquaculture potential of two local species of brackishwater tilapias, Tilapia guineensis and Sarotherodon melanotheron (fig. 5), which are naturally adapted to the lagoon environment.

The growth of these two species has been compared both in mixed and monosex intensive culture. The results clearly showed that the best performances are obtained with S. melanotheron male monosex culture. However, even in that case, the economic profitability of this species in intensive culture is up to now restricted by a mediocre efficiency of the artificial feed (pellets with 31 % proteins).

In fact, the present status of tilapia culture in brackishwater lagoon is actually rather negative in Côte d'ivoire. In the one hand, we have an exotic species, O. niloticus, displaying good growth rate and feed conversion ratio (F.C.R.) but high mortality in intensive culture in saline waters, and on the other hand two endemic species, S. melanotheron and T. guineensis, perfectly adapted to the lagoon environment but with slow growth rate and high F.C.R. (Tab. 1).

	Growth rate ($g.d^{-1}$)	mortality %	F.C.R.
O. niloticus	1.2 - 2.5	> 80 (after 4 months)	1.26
S. melanotheron	0.3 - 1.2	15 (after 10 months)	> 5
T. guineensis	0.2 - 0.8	13 " "	> 5

Table I - Gross performances of O. niloticus, S. melanotheron and T. guineensis in cage culture in slightly saline waters (5 ‰).
(fish density : 20/m³ ; growth followed between 10 and 150 g).

Facing this situation, we now give up with T. guineensis, the growth of which is the slowest, and works on S. melanotheron are proceeding in two days :

- trying to elaborate an efficient artificial feed to improve the growth and feed conversion ratio in intensive culture ;

- trying to develop an extensive method of rearing, allowing a reduction or even a suppression of the use of artificial feed.

In this respect, we are studying the possibility of association between the enclosure technique and the "acadjas" technique which is used in Benin. Acadjas are wood branch parks placed in lagoon shallow waters. They serve as a shelter for fish and as a substratum for the development of algae and micro-organisms which are valuable food sources for some fish species as S. melanotheron. In Benin, S. melanotheron is the major species caught in the acadjas.

We made, last year, a first trial of this association of techniques and a production of 7 t/ha/year of S. melanotheron has been obtained without any input of fertilizer or of artificial feed. This result

Several qualities confer to H. longifilis (fig. 6) a very promising future as a culture fish :

- Its geographical distribution is very wide and covers most parts of Africa.

In fact Heterobranchus is more a freshwater than a brackiswater fish, but its adaptation to the lagoon environment is very good. Until now, it has been successfully reared in saline waters up to 8 ‰, but its salinity tolerance is probably higher and still has to be investigated.

- It is an omnivorous feeder.

- It is a highly resistant species, particularly to handling stress and to low oxygen concentration (air breathing).

- Sexual maturation is possible in brackishwater (8 ‰ salinity at least).

- Mature brooders are available all year long in captivity and it is possible to obtain several spawns per female each year.

- The fecundity is high, reaching 50.000 to 90.000 eggs per female kg.

- Over all, its growth is one of the fastest ever observed among African fish species already tested in aquaculture.

For example :

A mean growth rate of 10 $g.d^{-1}$ was observed with H. longifilis (weighting 500 g to 3000 g) reared at low density in polyculture with tilapias and, in pond monoculture with 2 fish/m^2 and a 32 % protein pelleted feed, a mean weight increase from 0,1 g to 1100 g was registered after 10 months with an excellent feed conversion ratio (F.C.R. = 1.4).

Despite these particularly positive qualities, the culture of Heterobranchus in Africa did'nt take off in the past because of the lack of fry supply. During 1984, a reliable method of controlled reproduction was established for this species on our station. Oocyte maturation and ovulation can be induced after injection of human chorionic gonadotropin (HCG). Up to now, 100 % response have been obtained after a single intra-muscular HCG injection, at a dose between 1.0 and 2.5 I.U./g. body weight, with females with a mean oocyte diameter of at least 1.1 mm.

Eggs can be stripped within 14 h after HCG injection (at 27-29°C) and in most case a high percentage (about 70-90 %) of normal larvae are obtained after artificial fertilization and incubation in stagnant water and in darkness. Although, the complete biological cycle has been obtained in captivity, the survival rates after 3 weeks are still generally low. The development of a simple and reliable technique of larval rearing is at present our main aim of research with H. longifilis, before the culture of this species can be considered on a commercial scale.

Trachinotus teraia

Research on Trachinotus teraia (fig. 7) was initiated last year and the aquaculture potential of the species is still under investigation. This fish is very appreciated by ivorian consumers and his market price is nearly as high as for Chrysichthys sp. (about 120 NT $ per kg). This is one of the reason to consider it for aquaculture.

T. teraia is a very euryhaline fish, widespread in the lagoons. Biological studies done in 1985 have shown that T. teraia undergo sexual maturation in the lagoon even at low salinities and that mature spawners

So far, the juveniles are still captured from the wild but, as the stock of young fish available doesn't seem to be very important, the development of an artificial propagation technique would be necessary in future. In this respect the continuous reproduction of this species in the lagoon provides interesting prospects.

CONCLUSION

The work done since almost 7 years by our Center has confirmed the interest of studies for the selection of local species for aquaculture in developing countries. This is particularly well demonstrated by the example of Chrysichthys nigrodigitatus for which the acquired knowledge and the techniques developped have already allowed the starting of a commercial scale culture. Investigations are continued for other selected species, such as H. longifilis and T. teraia, with the aim of achieving similar development.

RELATED LITTERATURE

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FIGURES LEGEND

Figure 1 Présentation of Côte d'Ivoire and its lagoonal system.

Figure 2 View of lagoon enclosures.

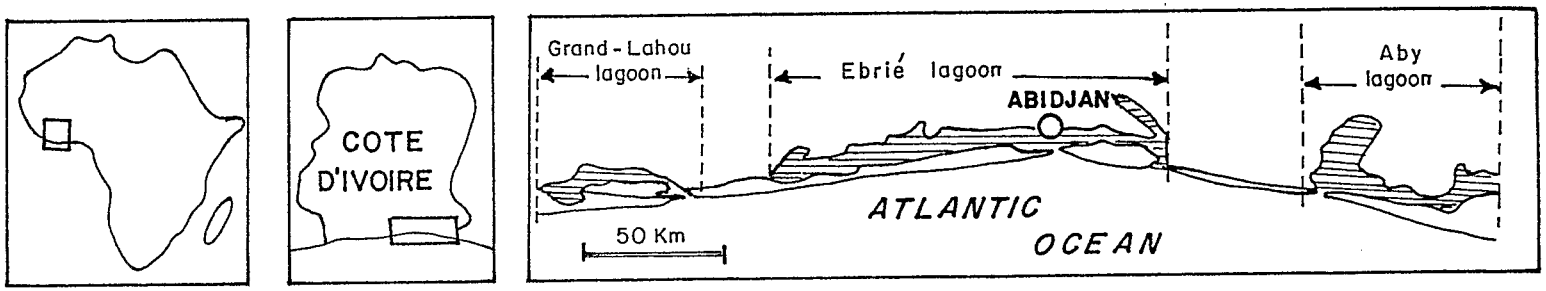
Figure 3 View of *Chrysichthys nigrodigitatus*.

Figure 4 Different kinds of pvc spawning containers for *C. nigrodigitatus* (after HEM, 1985).

Figure 5 View of *Sarotherodon melanotheron*.

Figure 6 View of *Heterobranchus longifilis*.

Figure 7 View of *Trachinotus teraia*.



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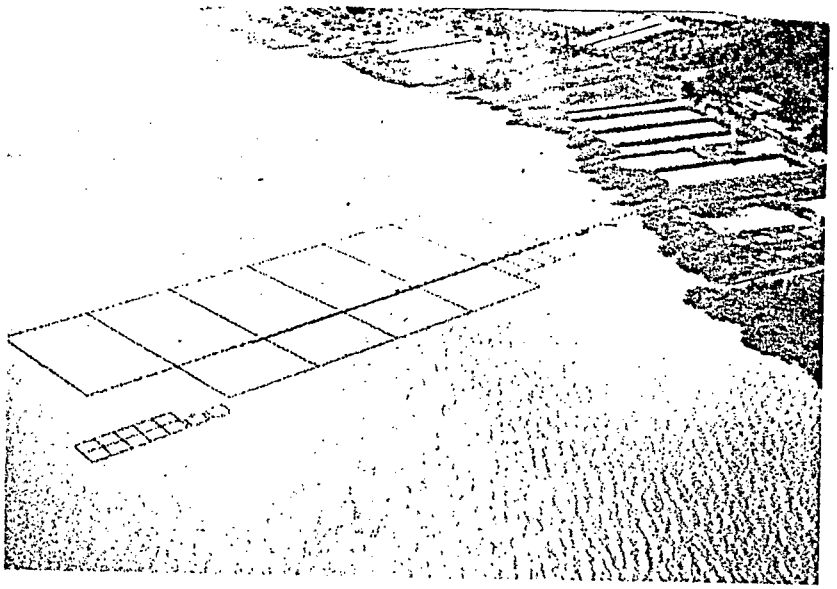

Figure 2 View of lagoon enclosures.

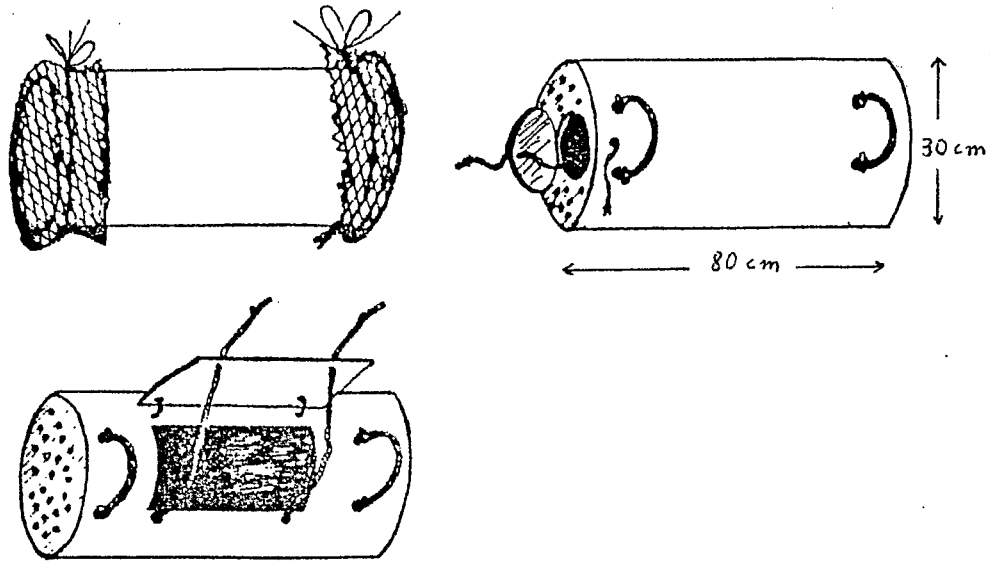

Figure 4 Different kinds of pvc spawning containers for C. nigrodigitatus (after HEM, 1985).

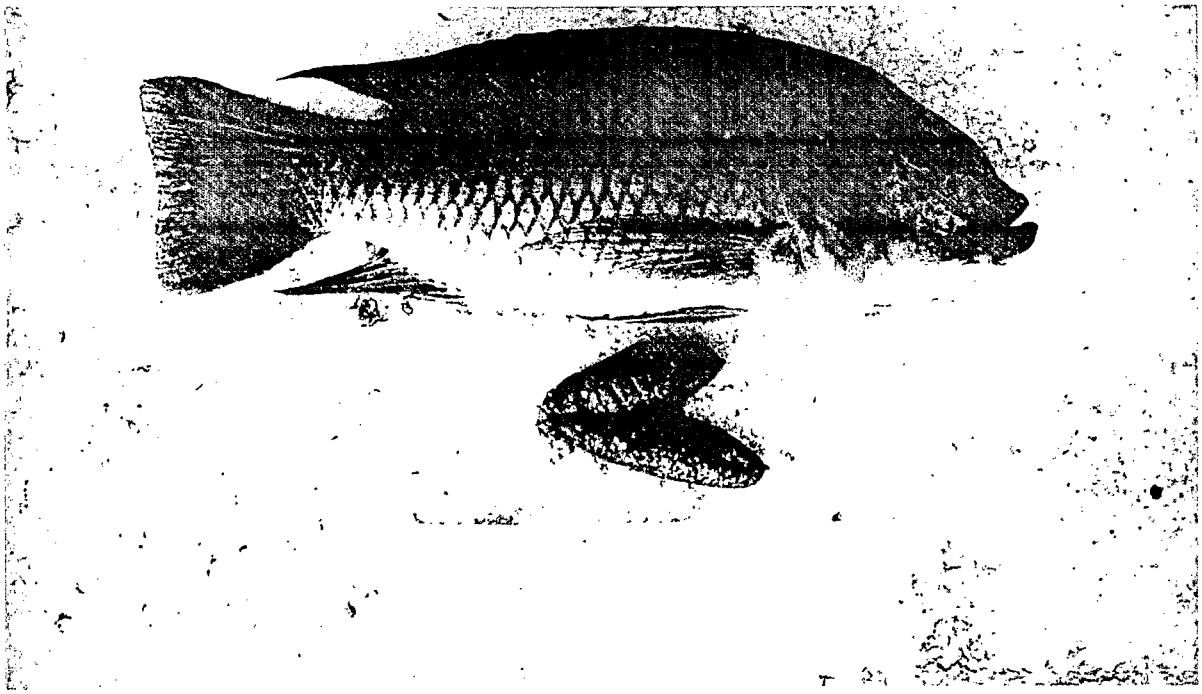

Figure 5 View of Sarotherodon melanotheron.