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Selection of finfish species for aquaculture development in Martinique (F.W.I.)

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Abstract — *Since 1981, in Martinique, a programme of selection of fishes suitable for aquaculture has been conducted. The criteria were adaptability to specific tropical environments and to rearing conditions. Zootechnical and socio-economical constraints have led to the choice of three species, endemic and exotic : the palometa (**Trachinotus goodei**), the red drum (**Sciaenops ocellata**) and the red florida hybrid (**Oreochromis** sp.).*

Palometa has shown good growth performances : 400 g in 7 months from 17 g mean weight fingerlings. It accepts a commercial artificial diet and is quite resistant to pathologies. Control of maturation and spawning either natural or induced by hormonal injection appeared rather difficult. For two years trials held over, 88 females were injected, giving only 43000 viable eggs. That is the reason why larval rearing could rarely been tried. Other techniques to control the reproduction should be investigated.

Red drum is an exotic species from the gulf of Mexico. Thanks to the numerous works from the USA, encouraging results have been obtained in a short time on larval rearing and grow-out. Eggs were imported from Texas and Florida. Best survival rate after two months rearing reached 17 percent (fry from 2 to 5 g). In grow-out, the expected result is 300 g within 6 months from hatching.

*Red tilapia was introduced in Martinique in 1986. The strain reared is the red florida hybrid : (**Oreochromis mossambicus** X **O. urolepis hornorum**) X (**O. aureus**). Broostock, larvae and fingerlings are reared in brackish water (19 ppt). Grow-out is conducted in tanks (recirculated freshwater and seawater) and in net cages in the sea.*

*Prospects of a prompt development of the aquaculture of palometa are poor. Reliable rearing technology has to be set up for this species. On the contrary, tilapia hybrid culture is on the development either in sea water cages or as an alternating crop for giant freshwater prawn (**Macrobrachium rosenbergii**) farms. In the same time red fish is on the experimental phase with three sites of grow-out with a local commercial diet. These two latter species appear well suited for aquaculture development.*

INTRODUCTION

Martinique, French West Indies, appears as a specially suitable place to develop aquaculture. Its situation, among the Caribbean islands, its privileged relation with France, and its geographical characteristics offer many advantages to develop such an activity. The eastern coast provides a lot of sites well protected by coral reefs. A clean and warm oceanic stream supplies throughout the year good quality water with relatively constant temperature and salinity. The limited tourist and industrial development protects this island against pollution. The population is traditionnally an important consumer of seafood. But local fisheries only supply 50 % of the demand. Thus, a large quantity of seafood is imported... Martinique profits by the help provided by the French Government and especially the presence of IFREMER research centre.

In 1981, a programme began for the selection of the most suitable finfish species for aquaculture in tropical areas. This programme started with native species selected for their availability in the wild and their high value on the local market. These species were : *Ocyurus chrysurus* (yellowtail snapper), *Lutjanus analis* (mutton snapper), *Lutjanus apodus* (school master), *Lutjanus synagris* (lane snapper), *Lutjanus griseus* (gray snapper), *Trachinotus goodei* (palometa) and *Trachinotus falcatus* (permit). Wild-caught juveniles were placed in net floating cages and fed a commercial compounded food. Survival and growth were monitored to determine their rearing abilities. Experiments on maturation and spawning were attempted to know about their reproduction.

After a first selection, the programme extended to exotic species as red drum (*Sciaenops ocellata*) and the red florida hybrid (*Oreochromis* sp.). Lot of works were achieved in spawning and rearing these species and the feasibility of culturing red drum and red tilapia has already been proved successfull in the USA. In Martinique, the first experiments were focused on intensive larval rearing. Presently, a programme is underway on broodstock management and reproduction for both species. In the same time, several pilot-scale farms have been initiated to determine economic feasability to rear red tilapia as fish food for human consumption.

SELECTION PHASE

The main criteria of selection can be summarized in three parts : grow-out, maturation and spawning, and fingerlings production.

Grow-out phase

For both native and exotic species, the grow-out trials were always conducted in net floating cages moored in open water (René et Haffner, 1982). These facilities are less expensive for construction and power and do not require coastal land for which demand and price are high. An exception is made for red tilapia raised also in fresh water as an alternating crop for the giant freshwater prawn (*Macrobrachium rosenbergii*). In that case tanks or ponds are used. The diets were commercial pellets previously formulated for the european seabass (*Dicentrarchus labrax*) (50 % protein) and for the red tilapia (35 % protein).

The species were preselected for their adaptability to cage rearing and to formulated pelleted food (table 1). This table summarizes the effort on these species and overall characteristics with emphasis on growth performances.

As a result of these trials, *Lutjanus synagris* and *L. apodus* averaging less than 250 g in two years were eliminated. *Ocyurus chrysurus* growth is somewhat higher but not very fast. However it has been kept for further experiments due to the abundance of juveniles in the wild and its high market price.

Lutjanus analis, *L. griseus* and *Trachinotus falcatus* present a fast growth but are rather rare in the wild. So their selection will be determined by the next criteria.

Tab. 1. — Synthetic results on grow-out phase of preselected species

SPECIES	Origin	Growth experiments period	Number of fish (g/ month)	Growth from fingerlings	Pathology
Trachinotus goodei	Wild	10/81-11/84 05/85-8/86 06/86-12/86	60 50 120	300/6	Parasitism
Trachinotus falcatus	Wild	10/81-11/84	40		
Ocyurus chrysurus	Wild	10/81-01/85 10/85-9/86 06/86-12/86	20000 500 500	300/18	Nutritional disease
Lutjanus *analis* *griseus* *apodus* *synagris*	Wild	10/81-4/84	1000	350/12 370/24 250/24 140/21	Nutritional disease
Sciaenops ocellata	Hatchery	07/87-1/88 08/88-1/89	4000 6000	500/6	No
Oreochromis	Hatchery	Since 1987		350/6	Parasitism in full sea water

Maturation and spawning

The selection under these criteria was determined by the availability of broodstock. If collection efforts for broodstock were not successful, age of first maturity was determinant. Experiments were conducted on maturation to know about the spawning season, the response to environmental stimuli and/or to hormonal induction. Table 2 summarizes the

Tab. 2. — Main sexual characteristics and reproduction methods

SPECIES	Origine broodstock	Age first maturity	Spawning season	Broodstock studied	Spawning	Main problems
Trachinotus falcatus	Wild-caught juveniles	4 years (ADAM data)	—	0	No	—
Trachinotus goodei	raised in cages	1-1,5 year (IFREMER data)	Throughout the year (IFREMER data)	100	Hormonal injection	Viability of eggs
Ocyurus chrysurus	Wild-caught Juveniles and adults	2 years (IFREMER data)	March October (IFREMER data)	200	Natural & hormone	Low fecundity
Lutjanus analis	None	5-6 years (Claro, 1981)	March-August (Claro, 1981)	0	No	—
Lutjanus griseus	None	1 year (Claro, 1983)	July-october (Campos, 1975)	0	No	—
Sciaenops ocellata	Juveniles from hatchery Texas raised in cages	2-5 years (Chamberlain, 1986) artificial	Fall Natural or 1989	o 20 o excepted	No	
Oreochromis sp.	Juveniles from hatchery (Jamaïca) raised in tanks in Martinique	4 months (ADAM data)	Throughout the year	100 o 500 o	Natural (brackish water)	Low fecundity

different characteristics of sexual life and the trials carried out on the selected species. On three of these, no attempts were conducted because of the lack of broodstock. One because of the little number of fish studied (*L. griseus*), the other because of the late age of first sexual maturity (*L. analis, T. falcatus*). So, these species have not been selected for the moment.

Trachinotus goodei presents early age of first maturity and responds to hormonal induction. But very few eggs of good quality have been obtained. Trials are underway to improve egg viability. *O. chrysurus* was spawned using either injection of HCG or without induction (natural spawn).

Spawns of red drum are expected in 1989 by manipulating temperature and photoperiod cycles. Broodstock has been raised in ADAM and IFREMER facilities. Substancial progress has been quickly achieved in spawning tilapia.

Larval rearing-Production of fingerlings

Larval rearing trials have been conducted on four species; *T. coodei, O. chrysurus* and *Oreochromis* sp. from local spawns, *S. ocellata* from imported eggs (Texas and Florida). Larval culture was carried out in intensive way in hatchery. A flow-through system supplied clear sea water. The alimentation scheme included live food (rotifers and artemia) and commercial weaning pellets. The criteria of feasibility were success of first feeding, survival at metamorphosis, fast weaning and overall survival. The level of research and the problems encountered were different for each species (table 3.).

Tab. 3. — Synthetic results on larval rearing with selected species

SPECIES	Number of trials	Origin of eggs	Number of trials giving fingerlings	Critical stage	Problem
Trachinotus goodei	3	Local spawn	0	First feeding	Quality of eggs
Ocyurus chrysurus	27	Local spawn	1	First feeding	Feeding quality
Sciaenops ocellata	11	USA (texas) Florida	7	Metamorphosis	Cannibalism & pathologies
Tilapia	Routine	Local spawn	All	No	—

The feasibility of rearing red drum and red tilapia larvae has already been proven successful, even if further progress and improvement have to be developed. On the contrary, it seems rather difficult to get yellowtail snapper fingerlings with such a method. That is the reason why, in relation with its slow growth, this species has been eliminated. It is too early to say something about *T. goodei* according to the few larval rearings attempted on this species.

SELECTED SPECIES

Presently, as a result of the selection, works in Martinique are focused on three species : the palometa (*Trachinotus goodei*), the red drum (*Scianops ocellata*) and the red florida hybrid (*Oreochromis sp.*).

THE PALOMETA : *Trachinotus goodei*

Results

The palometa fed commercial pellets (50 % proteins) in cages reached 300 g in 6 months from 15 g juveniles. Another trial demonstrated that trash fish as food provides a similar growth (260 g in 5 months). Overall mortality from juveniles to marketable sized fish (300-400 g) fed pellets never exceeded 17 % and 10 % fed trash fish. The conversion rate, when fed trash fish, is about 2.3 :1.

Tab. 4. — Control of reproduction trials on *Trachinotus goodei*

EXPERIMENTS	Broodstock Feeding	Hormone injected	Dose per Kg	Number of trials	Number of spawns	Viability rates (%)	Improvment
1	Fresh food	–	–	7 months	1	70	Natural management
2	Trash fish	HCG	2×50 to 600 UI	10	6	0	–
3	Trash fish + fresh food + pellet	HCG	2×500 UI	10	3	0	Food
	IDEM	LHRH(a)	10 mg	10	3	0	Hormone
4	Pellets	HCG	2×500 UI	10	4	0	–
	Fresh food	HCG	2×500 UI	10	3	0	Food
5	Fresh food	HCG	2×500 UI	38	14	16-62 % (8 spawns)	No stress

The monitoring of fishes by regular biopsies suggests that the palometa can be found at final ripening stage throughout the year with two peaks of higher sexual activity (August and February). Age of first maturity occured at 1 to 1.5 years when fishes reach a weight of 300 g for males and 350 g for females.

One spawning only occured in a seven months experiment under natural environmental conditions in tank. Egg viability was 70 %. But this species was spawned many times using injection of hormones. For two years, 88 females were induced by hormonal injection (table 4), 33 spawnings occured and only 7 with viable eggs. Viability rates range from 16 to 62 %.

Discussion

The growth of palometa fed commercial pellets (Bachellier and Thouard, 1983) and trash fish (Soletchnik, 1988) is somewhat higher than the growth obtained in Venezuela by Gaspar (1977), and Gomez and Cervigon (1984) with fresh fish as food. If the feed conversion rate looks satisfying (2.3 :1), it has not been possible to determine the conversion rate with pellets because of the important loss of food in the cages. Sinking pellets seem inadequate for these fishes of pelagic behaviour. Part of pellets fall through the bottom net before being eaten. A very slow automatic feeder or the use of buoyant pellets should alleviate this difficulty. A technological effort has to be achieved in that way. During the grow-out phase, the palometa have suffered pathological events, due to parasitical infestation by the monogenean fluke *Neobenedenia melleni*. Efficient treatments exist to get rid of this parasite (fresh water dip or Trichlorfon) (Loyau, 1985). Five years of experiments in rearing *T. goodei* have shown that this parasitism was not restrictive (Gallet et *al.*, 1986).

It seems really difficult to spawn palometa naturally without hormonal treatment (1 spawn in 7 months). This has also been observed by MOE et *al.*, (1968) working on pompano (*Trachinotus carolinus*). Although progress were achieved in spawning this fish by hormonal treatment, spawning frequency remains moderate and most spawns are unviable. Ovules are frequently retained reaching an overripening stage. Additionally, ovarian regression was observed as for *T. carolinus* (Hoff et *al.*, 1978). Whatever the improvement in food and whatever the hormone used (Soletchnik, 1988) egg viability remains nil. According to Hoff et *al.*, (1978) excessive handling stress can bring about regression or bad quality spawnings. In experiment 5 (table 4) the main objective was to reduce handling stress and the results were little better. Another trial is underway with older animals. They might produce more and better spawns as noticed by Moe *et al.*, (1968) on *T. carolinus*. Recent works suggest that spawning might be related to moon cycles.

Unfortunately, because of bad quality eggs, very few larval rearing attempts have been made on this species.

THE RED DRUM : *Sciaenops ocellata*

Results

Imported from Texas (University of Texas, Marine Lab. C.R. ARNOLD) by ADAM in 1985, the first batch of juveniles (4 g body weight) was raised in net floating cages and fed a commercial pelleted food (European Seabass : 50 % protein). This first trial was to demonstrate the ability of red drum to be reared in caribbean environment. In four months they averaged a weight of 200 g and the survival was close to 50 %. A second trial, with fingerlings from the IFREMER hatchery, was conducted in 1987. Three gram fingerlings reached an average weight of 280g in 6 months fed a 54 % protein diet and a weight of 205 g fed a 37 % protein pelleted food. The conversion rates were about 2.2 :1 and 3.7 :1 for the two foods respectively. Survival averaged in both case 60 %. The best growth was oberved, on an experimental farm, where three grams fingerlings averaged 240 g in a 4 months grow-out phase; the conversion rate was 1.6 :1 with a 54 % protein commercial food.

From the first batch, 40 fishes were isolated as broodstock. Their average weight at the end of 1988 was 5-6 kg. Spermiant males were noticed since the beginning of 1987. IFREMER has just completed a controlled environment building for maturation studies and the aim for 1989 will be to demonstrate the feasibility of inducing red drum to spawn by manipulating temperature and photoperiod cycles in Martinique.

Since 1987, studies are underway to refine intensive larval rearing techniques. While waiting for local spawns, eggs have been imported from Texas (C.R. Arnold) and Florida (Florida Department of Natural Resources, D.E. Roberts). In two months larval rearing best overall survival is closed to 20 %. More than 30 000, 2 months old fingerlings have been produced by this method.

Discussion

In Martinique, the red fish does not suffer winter conditions and the growth never slows down. So it grows a little faster than observed in Texas (Arnold *et al.*, 1987), in Louisiana (Wilson, 1987) or in South Carolina (Hopkins, 1987; Stokes *et al.*, 1987). The conversion rate are satisfying with a high protein rate food (54 %) and even inferior to those expected by Hopkins (1987) (1.6 :1 VS 1.8 :1 expected). With a 37 % protein food and 42 % animal protein, feed conversion rate reached 3.8 : 1 and are very close to the results on trout food (38 % protein), 4.2 : 1 (Stokes et *al.*, 1987). This diet might be far from optimal in promoting good growth of red drum in tropical water. After six months, experimental fishes fed on the low protein food have presented general anemia symptoms (Gallet, pers. comm.). The change of food to a 54 % protein ration (84 % animal protein) immediately stopped immediately these symptoms. Davis (1987) proposed (30-35 %) proteins in the feed with at least half animal protein. It does not seem to be enough under tropical conditions. Red drum seems particularly suitable to cage culture and the improvement that could be done, might be the formulation of a really specific pelleted food. No other pathology has been noted during the grow-out phase.

The necessity to produce fingerlings is evident for development. At present broodstock is ready to start a maturation cycle established from US works (Colura, 1974; Arnold, 1978; Roberts *et al.*, 1978; Arnold *et al.*, 1987; Roberts, 1987). The objective is to adapt in Martinique a reliable technology to spawn red drum.

For larval rearing it was not reasonable to develop the extensive technique (Colura *et al.*, 1976, McCarthy *et al.*, 1986) in such a small island. That is why many attempts have been carried out to determine intensive larval rearing techniques (Soletchnik *et al.*, in press). For two years, rearing management, feeding schemes and control of pathogens have been greatly improved. The most difficult phase stands between 15 to 30 days when cannibalism and most pathologies occur.

THE RED TILAPIA : *Oreochromis* sp.

Results

When ADAM introduced the red Tilapia in 1986 many experiments were carried out on different strains. Finally, the Florida strain was retained as the most suitable one for further fresh or sea water aquaculture projects.

Fish were grown in different facilities in fresh or seawater. Net cages and tanks have been compared (table 5).

All fish were fed a 35 % protein pellet at 3 % of the body weight. Results were very similar (table 5), but the best results were obtained in sea water cages. Unfortunately, parasitism (Monogeneous parasite *Noebenedenia melleni*) was responsible for high mortalities. MASOTEN is particularly efficient in oral treatment to treat this pathology.

Tab. 5. — Growth results from 1g fingerlings for red tilapia reared in different systems

	Fresh water		Sea water	
	1 15 m^3 tank	2 35 m^3 tank	3 35 m^3 tank	4 30 m^3 net cage
Flow rate — new water — recirculated water	 200 % / hour 0	 1 % / hour 15 % / hour	 2 % / hour 15 % / hour	 1000 % / hour 0
Aeration	No	Venturi syst. (Air O_2)	Venturi syst. (Air O_2)	No
Final stocking density (kg/m^3)	90	15 (50 expected)	15	18
Survival rate (%)	95	97	96	71
Food conversion rate	1.2	1.7	1.6	2
Pathologies	No	No	No	Parasitism
Mean weight (g) at day 40 100 170	 28 103 305	 22 112 318	 18 126 335	 25 118 348

Broodstock is reared in brachishwater (19 ppt). Sex-ratio is 4 females per 1 male. Fish density is 10 per m^2. Spawners are caught every week and sexed. Fertilized eggs are removed from females that incubate them of in the mouth. Each female can produce 200 to 500 eggs every 3 weeks. A 5 weeks rest period is practised every ten weeks, then broodstock is stored in small cages. Eggs are incubated in Zoug bottles. Hatching rate is close to 100 %.

Newly hatched larvae are reared in small net bags in broodstock tanks. Larvae immediately accept artificial diet. Stocking density can reach 600 larvae per litre during the first 2 weeks, 50/l at day 30 (1 g fry) and 1-2/l at day 60 (15 g to 20 g fingerlings). Survival rate averages more than 80 % in routine.

Discussion

Several species of tilapia are euryhaline but their adaptation ability to sea water is different. LIAO *et al.* (1983) in experimental rearings in Taiwan showed that red tilapia (Taiwanese strain) could be raised in fresh, brackish or sea water. Watanabe *et al.*, (1987) obtained similar results with the red Florida hybrid in Bahamas. In mixed sex attempts, growth in sea water was better than in fresh water. This was also noticed in Martinique.

Food Conversion Rates are different though freshwater gives the best results probably because of existing natural food in fresh water tanks.

Precited authors and Coche (1982) noticed that tilapia reared in saltwater are more susceptible to parasitical attacks and diseases. Such pathologies occured in Martinique and confirmed this higher susceptibility to infestations.

As for reproduction and early stages, in agreement with Watanabe *et al.* (1987) a higher fecundity in brachishwater (19 ppt) than in fresh or sea water and a better growth of larvae and fingerlings in brachishwater has been observed. Larval survival rate can reach 98 %.

CONCLUSION

Although the rearing technologies have to be further developed and refined, these species have already shown good potential for aquaculture in Martinique. They all have good growth rates fed with commercial pellets, in cages. But it is necessary to succeed in completing the egg-to-egg cycle to develop finfish aquaculture.

These species stand at present time at different levels of research and development. For the palometa, reproduction, and larval rearing are still being studied.

The production of red drum fingerlings under intensive conditions is close to being mastered. Red drum is already raised in cages in 3 different experimental sites of experiments. But works will now be focused on spawning broodstock by manipulating environmental conditions. The egg-to-egg cycle of the red hybrid has been completed in Martinique. Development has started and several projects were initiated in 1988, both in fresh or seawater. At this time, the expected production is 50 tonnes in 1989, and 150 t in 1990.

The red hybrid and the red drum are very attractive for development purposes and should soon become an important economical activity.

Palometa has a lower priority as an aquaculture candidate as it is rather difficult to rear. But a lot of local tropical species have not been yet studied and might be interesting for aquaculture...

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