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# Intensive larval rearing trials of red Drum (*Sciaenops ocellata*) in Martinique (F.W.I)

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**Abstract.** — The red drum *Sciaenops ocellata* (Linnaeus, 1766) was introduced in Martinique (F.W.I) from the United States (Texas and Florida). Thirteen intensive larval rearing attempts, from 7 batches of imported eggs, have been conducted for two years. From newly hatched larvae through metamorphosis, larvae were reared in cylindroconical tanks (300 and 1000 l). Post larvae were weaned and raised up to 1-4 g fingerlings in raceways (1800 l). Mean stocking density ranged 50-75, 6-23 and 1.5-2.5 larvae per litre for phases 1, 2 and 3, 4 respectively of the rearing. For larval rearing attempts 3, 4, 8 and 11, survival rates were 6, 16, 17 and 5 percent respectively. 30000 two month old fingerlings were produced. Growth of the larvae was widely related to the mean stocking density. Larvae were fed rotifers, followed by brine shrimp nauplii, weaned onto squid and shrimp meat before they were finally fed on commercial pellet (55-60 % protein). During the grow-out phase, the food conversion rate ranged from 1.1 : 1 to 1.8 : 1 and final stocking density fluctuated between 0.7 and 5.5 kg/m<sup>3</sup>

## INTRODUCTION

The red drum, *Sciaenops ocellatus* (Linnaeus, 1766), was selected in 1987 as a potential candidate for culture in Martinique (French West Indies). This exotic species from the Gulf of Mexico was previously introduced in Martinique in June 1985.

In the United States, because of the commercial significance of this species, several studies have been conducted from many years. The main objective is to preserve natural resources for recreational and professional fishing activity. Artificial propagation (maturation and spawning) under controlled conditions (temperature and photoperiod) have been studied (Arnold, 1978; Roberts et al., 1978; Arnold et al., 1979). Larvae are reared on extensive culture systems in ponds (Colura et al., 1976; McCarty et al., 1986). Growth of red drum fingerlings in impoundments was reported by Theiling and Loyacano (1976).

In the Caribbean area, small islands such as Martinique do not provide enough land for extensive culture. That is the reason a reliable technique for intensive rearing has to be set up. As broodstock is not yet available in Martinique, eggs and larvae were imported from the USA (Texas and Florida) to initiate the programme.

From 13 larval rearing trials carried out since 1987 in Martinique, four rearings (attempts 3, 4, 8 and 11) were conducted with efforts focused on improving larval survival. This paper presents the results and observations made during the course of the study and contributes to preliminary information for the establishment of a reliable technique for fingerling production under intensive rearing system.

## MATERIAL

Eggs were imported from USA. Seven batches were shipped from April 1987 to October 1988 : 4 from the University of Texas (C.R. AR-NOLD., April, May and June 1987, May 1988) and 3 from the Department of Natural Resources in Florida (D. Roberts., October 1987, June, October 1988).

Cylindroconical fiberglass tanks, 300 litres and 1000 litres and raceways 1800 litres were used. During the rearing, water was supplied through sand filters.

Larvae were fed rotifers, followed by artemia, weaned onto squid and shrimp meat before they finally fed on commercial pellets (55-60 % protein).

Artemia collectors, size graders, slow defrosting distributors, demand feeders (run 3 and 4), automatic feeders (vibrating distributors -run 8- or feeding trays -run 11-) were also used during the rearings.

From 13 larval rearing trials, run 1 was preliminary. Attempts 2, 7, 9, 10, 13 were strictly devoted to experimental purposes. Trials 5 and 6 had failed prior to metamorphosis. Runs 3, 4, 8, and 11 led to a consequent production of fingerlings for experimental grow-out purposes. The following results principally concern these latest runs.

## METHODS

Rearing period was separated in four phases, previously determined by both biological and technical constraints (transfer of population, change in food items...) and also by specific operations necessary for larval rearing control (sampling, enumeration, screening...) (Fig. 1). Fish were screened at the end of the second phase (30 to 34 days old) onto 3 mm size grader for the trial 3 and onto 1.5-2.0 mm size grader for the trials 8 and 11. The length of the different phases (1, 2, 3, 4) are about 2, 2, 1 and 3 weeks respectively. The growth of larvae was recorded by measuring the individual length of batches of 15-60 larvae at 3-7 day intervals. The survival rates were based upon the enumerations between each phase of the rearing, and the dead larvae removed from the tanks during cleaning operations.

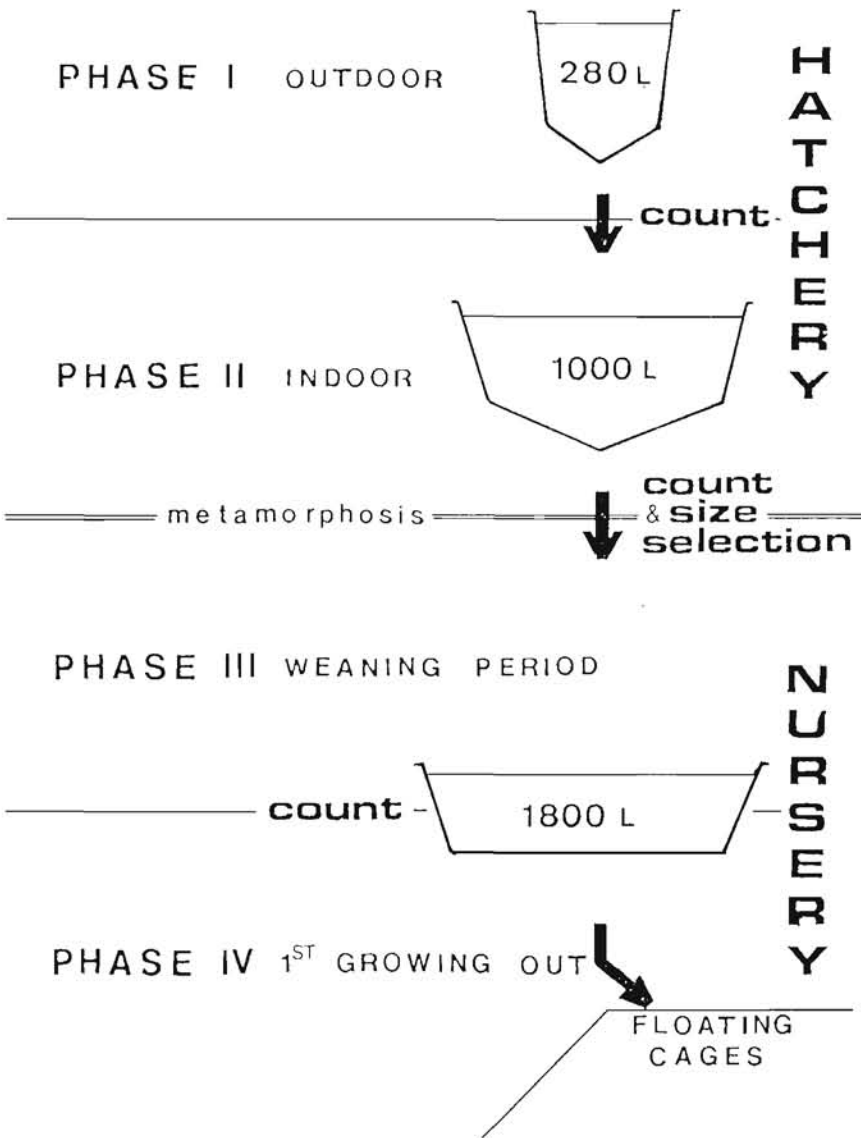


Fig. 1. — Rearing of Red Drum.

Environmental parameters were monitored regularly. Temperature ranged from 25 to 29.5°C and salinity from 32 to 35 ppt. The rate of water exchange fluctuated from 10 to 100 percent per hour. Light was natural (1000-20 000 lux and 11-13 hours daylight) during the first, third and fourth phase of the rearing and artificial during the second phase with an increase of the photoperiod to 14-16 hours daylight. Ammonia concentration, regularly monitored never exceeded 0.1-0.2 mg/l.

Larvae were fed live prey (rotifers and nauplii of brine shrimp) 3-4 times a day; one part directly in the rearing tanks, and one part in a continuous feeding system to delay the period of food supply. Weaning in raceways needed the use of slow defrosting distributors for frozen shrimp and squid and later, automatic distributors for dry pellets. During the fourth phase of rearing, vitamins are daily added to the first distribution of food.

## RESULTS

### Transportation

Six shipments were carried out since May 1987. Live larvae ranged from 11 000 to 238 000, according to the time of transportation (9 to 19 hours) and the density of larvae (1600 to 5500 eggs or larvae per litre). Survival rate fluctuated between 60 to 98 %, excepted for one batch, where an accident reduced the survival to 14-19 %. Four shipments are considered in this study (Table 1). A 12 hour trip led to 95 % survival rate with a density of 5000 eggs per litre. A 19 hour trip reduced the survival to about 60 percent with almost the same density.

Table 1. Origine of the larvae and results of shipments.

Origine of the batch	Shipment length (hours)	Mean density of eggs or larvae (n/litre)	Final number of larvae	Survival %	Attempt reference
Texas	19	5 500	51 000	60	3
Texas	19	2 500	48 000	94	4
Florida	12	5 000	79 000	95	8
Florida	16	5 100	61 000	72	11

### Growth

Feeding scheme during the rearing was almost similar. Change of food item is mostly dependant of the growth and associated to a precise size of the larvae. Larvae were fed rotifers (10 to 55 ind./ml/day) from day 15-20, nauplii of *Artemia* (2 to 35 ind./ml/day) from day 12-17 to day 32-33, fresh meat (squid and shrimp) from day 28-35 to day 35-40 and then on dry pellet from day 28-35 to the end of the rearing.

Fig. 2-5 present the growth curves of the different attempts. Two months old larvae reached quite different sizes. Mean standard length ranged from 32 to 64 mm (batch 11 and 3 respectively).

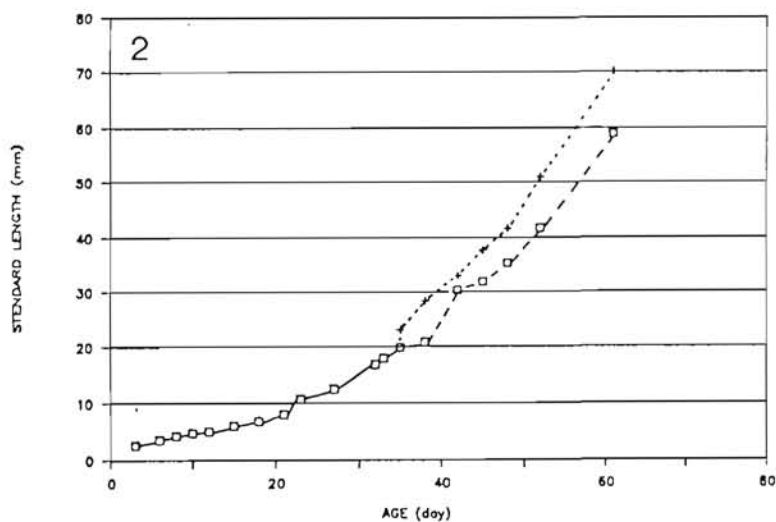
Daily growth drastically increased from phase 1 to phases 3-4. Phase 1 ranged from 0.13 to 0.27 mm; phase 2 from 0.39 to 0.77 mm and phase 3-4 from 0.63 to 1.45 mm (Table 2). During the first grow-out (phase 4), feeding rate decreased from 43 % to 5 % from the beginning to the end of the period. Food conversion rate ranged from 1.1 :1 to 1.8 :1. Final stocking density reached 5.5 kg/m<sup>3</sup> (Table 3).

**Table 2.** Daily growth rate (mm) (Groups A-H).

Phase	Run	3	4	8	11
1		0.27	0.14	0.15	0.13
2		0.77	0.50	0.39	0.45
3-4		1.41(A) 1.30(B)	1.45(C)	0.94(D) 1.04(E) 1.19(F)	0.63(G) 0.69(H)

**Table 3.** Nutrition rate and food conversion rate of the red drum during the first grow out. (phase 4).

RUN	3	4	8	11
Period (day-day)	40-67	36-75	54-75	47-60
Daily nutrition rate (%)	14.1-7.0	42.7-5.1	20.5-8.7	20.4-8.2
Initial mean weight (g)	0.41	0.10	0.38	0.23
Final mean weight (g)	5.66	5.74	2.55	0.71
Final stocking density (kg/m <sup>3</sup> )	4.80	5.48	3.79	0.69
Food conversion efficiency	1.11	1.48	1.82	1.78

**Fig. 2.** — Growth (SL) of Red drum from newly hatched larvae through fingerling (Day 61). Trial 3.  
(— — Group A. .... Group B).

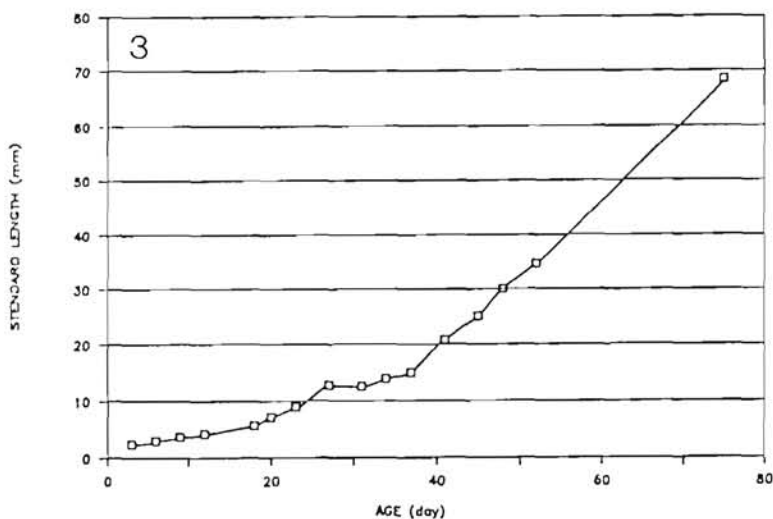


Fig. 3. — Growth (SL) of Red drum from Newly hatched larvae through fingerling (Day 75). Trial 4. (--- Group C).

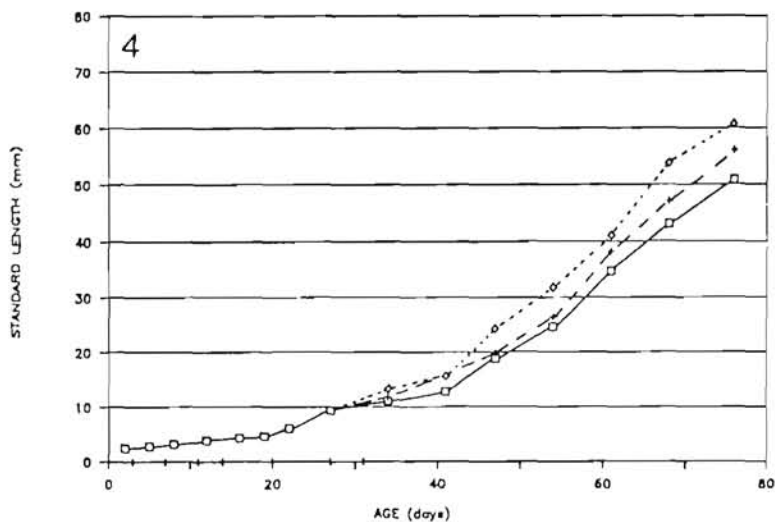


Fig. 4. — Growth (SL) of Red drum from newly hatched larvae through fingerling (Day 76). Trial 8. (--- Group D; - - Groupe E; ..... Groupe F).

### Survival

Runs 3, 4, 8, 11 produced respectively 3 300, 7 200, 17 400 and 2 700, 2 months old fry with a final survival of 6.5%, 15.0%, 22.0% and 5.3% (Fig. 6). About 30 000 fry were raised during these experimental larval

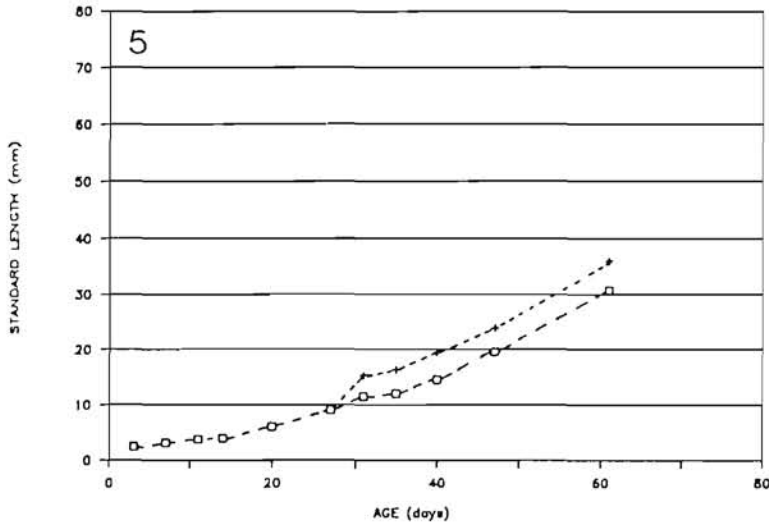


Fig. 5. — Growth (SL) of Red drum from newly hatched larvae through fingerling (Day 61). Trial 11. (— — Group G; ..... Group H).

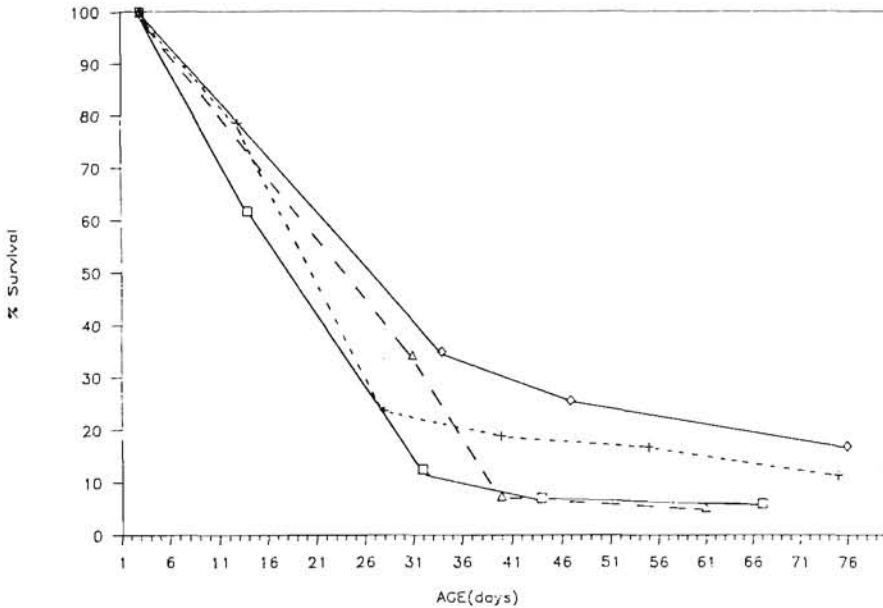
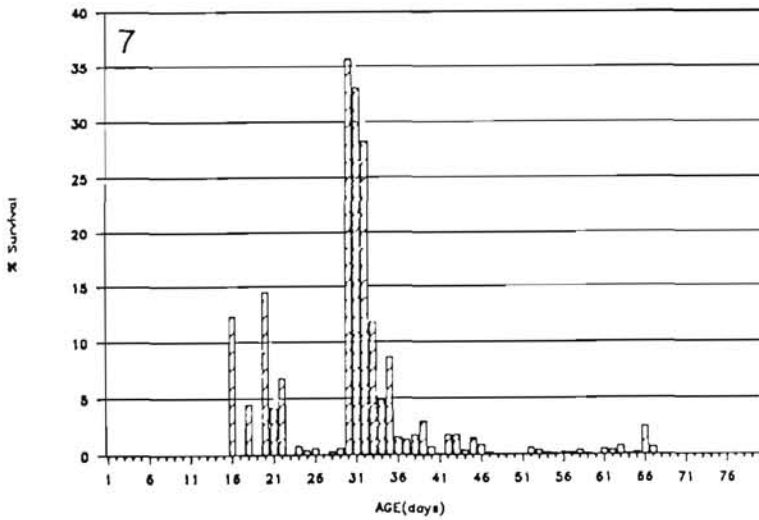
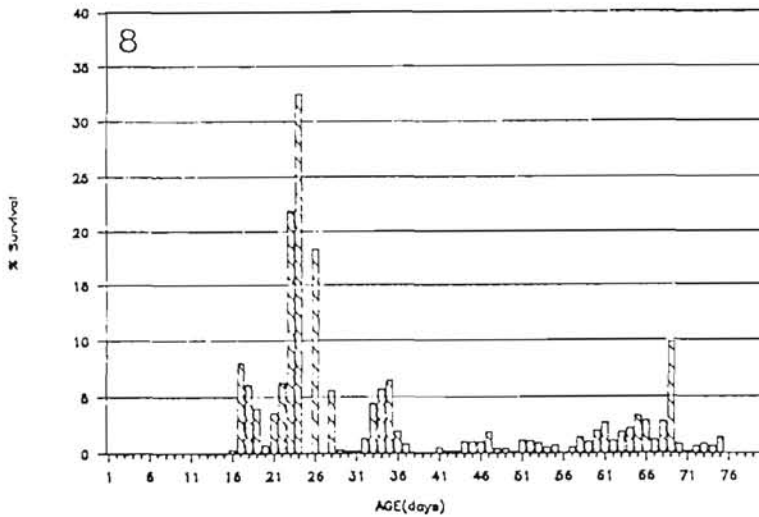


Fig. 6. — Mean percent survival of the Red drum to day (61-76) in attempts 3, 4, 8 and 11. (— — 3; ..... 4; ..... 8; — — 11).

rearings. During the first month of rearing, survival never exceeded 35% (attempt 8) (Table 4). The best result was obtained during the second month of the fourth rearing (66%). Dramatical periods appeared around days 30-32 for run 3 (« unexplained mortality ») and around days 22-26 for

**Table 4.** Larval survival rate of Red Drum from newly hatched larvae through fingerling.

Phase	Run	3	4	8	11
1		62	79		
1-2		12	24	35	34
3		56	74	74	22
4		84	89	66	70
1-2-3-4		6	16	17	5

**Fig. 7.** — Daily rate survival of Red drum (attempt 3).**Fig. 8.** — Daily rate survival of Red drum (attempt 4).



run 4 (microsporidia (?) infestation). An other long period of « unexplained mortality » extended from day 30 to day 41 (run 11). A technical accident was recorded on day 69 (run 4). *Amyloodinium ocellata* (Brown, 1931) infested run 3 by day 16-22 and probably gas bubble disease affected run 8 during the first grow-out stage (Fig. 7-10).

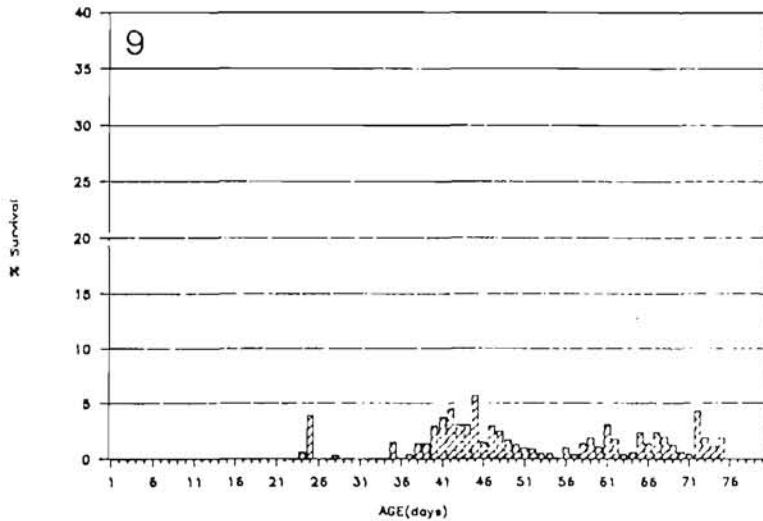


Fig. 9. — Daily rate survival of Red drum (attempt 8).

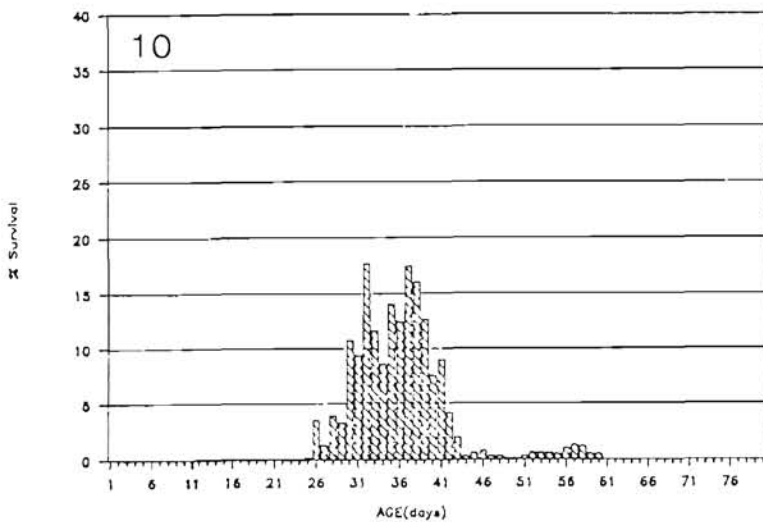


Fig. 10. — Daily rate survival of Red drum (attempt 11).

## DISCUSSION

Temperature between 25-29.5°C ranged correctly in the optimum defined by Lee et al. (1984); Holt et al. (1987). Salinities of 35-38 ppt were above the natural conditions at 20-35 ppt (Simmons and Breuer, 1962 in Holt et al., 1981) and above the optimal of 25-30 ppt for the larval rearing purposes (Holt et al., 1987).

The growth performance of red fish larvae : 38 mm SL in four weeks at 28.5°C is similar to the result of trial 3. The succession of rotifers and brine shrimp nauplii is a classical feeding scheme for rearing fish larvae. During the first phase, a good quality food is provided by rotifers fed *Chlorella* or baker's yeast enriched with fish liver oil (Kitajima et al., 1980 in Foscari, 1988). Important risk was taken by feeding the second phase larvae onto the single brine shrimp nauplii. Early weaning is successfully practised on sea bream *Pagrus major* from 13 mm total length (Peter, 1980 in Mok 1985; Foscari, 1988). Preliminary investigations were realised on red fish, without success. The red sea bream (*Pagrus major*), under intensive and large scale rearing is fed manually with fish meal and early stage (30-40 days old) with artificial diet 250 % of their body weight 10 times a day (during one week). Then 150 % until the end of the second month of cage culture. Hidalgo et al. (1988), learnt from different authors that such different species as guppy, carp, mullet, carassin, blackbass, trout, sea bass, sea bream, may be conditioned to use the demand-feeder with efficiency in few hours... For the red fish this solution should reduce drastically the feeding rate and still improve the food conversion rate. The latter ranging from 1.1 : 1 to 1.8 : 1 (phase 4) is rather satisfying despite the excess of food distributed.

For many sea water species, artemia is suspected to induce mortality in rearing larvae (Bryan and Madraisau, 1977). Many causes are identified by Sorgeloos et al. (1980). Over the past few years, studies pointed out the importance of fatty acids to provide required quality of artemia as food for fish larvae.

Artemia deficiency in highly unsaturated fatty acid (HUFA), 20 : 5 and 22 : 6n-3 is suspected to induce high mortality on rearing fish larvae (Watanabe et al., 1978, 1979; Watanabe, 1979; Fujita et al., 1980).

For the species : *Seriola quinqueradiata* produced in Japan, the use of nauplii of artemia is avoided when possible (Cueff, pers. comm., 1973). Mok (1985) drastically increased larval survival rate of the white sea bream, *Mylio berda* when copepod nauplii were substituted to brine shrimp nauplii. High content in linolenic acid (18 : 3 n-3) in some strains such San Francisco Bay strain is pointed out in different works (Watanabe et al., 1978; Gatesoupe et al., 1983). Some of these authors suggest that the excess in linolenic acid would induce high mortality in fish larvae. In the present attempts (trials 3, 4, 8 and 11) the different strains of brine shrimp eggs have not been analysed. However, the quality of the nauplii fed as sole source for about 15 days is widely suspected. As observed on larval rearing attempts 5 and 6, other authors such as Lee and Hirano (1979) on *Sillago sihama*; Fujita (1973) on *Chrysophrys major*; Kitajima (1978, in Foscari, 1988) on *Seriola quinqueradiata*, have reported similar scenarios

of mass mortality of larvae 4, 7 and 10 days after the first feeding on nauplii. If no guarantee exists on the artemia strains whatever its origin (geographical area, period of harvest...) (Sorgeloos, 1980), the feeding regime must be modified. Other food items such as copepods (Soletchnik et al., in press), or enriched metanauplii of artemia (Bryan and Madraisau, 1977) should be substituted to nauplii.

If nutritional deficiency affected some of the rearing, pathological events and environmental quality also contributed to reduce the larval survival. The first phase of the rearing, is quite a safe phase. Larvae are fed rotifers and larval survival can reach high rates (up to 80 %). The second phase is much more critical for the larvae. Cannibalism, food adequacy, pathologies (*Amyloodinium* sp.), Microsporidia (?) affected drastically the survival. The dinoflagellate *Amyloodinium ocellatum* is a well known parasite of the red drum (Paperna, 1983; Johnson, 1987). This ectoparasite is also an endemic species in Martinique and has been observed in the rearings of sea bass *Dicentrarchus labrax* in floating cages (D. Gallet, Pers. Comm., 1984). If these parasites induced high mortality on the first attempt, a prophylactic control was established with daily observation of larvae to prevent the pathogen development.

One other cause of mortality called « unexplained mortality » affected two of the rearing attempts (trials 3 and 11) few days after a freshwater treatment against the parasite *Amyloodinium ocellatum*. Investigations (environmental control, histological studies...) were unsuccessful to explain the phenomenon. One hypothesis is that the fresh water treatment at early stage would induce failure in the development of the larvae.

Excessive handling (samplings, screenings, transfers) during these experimental rearings also affected the survival rate. Squamation is an important factor which determines hardness of the larvae. Squamation is also related to change of behaviour on *Epinephelus akaara* (Fukuhara and Fushimi, 1988). Juveniles fully squamated are more tolerant to a wider range of environmental factors than larvae lacking scale protection. (Norman, 1975; Lagler et al., 1982). Scale formation is completed at 10-14 mm total length for the sea bream *Pagrus major* (Fukuhara, 1976 in Foscarini, 1988), at 25 mm standard length for the red drum (Holt, 1987). From preliminary data about 90 % of the red drum larvae have first spot scale on caudal part of the body when standard length ranged from 10 to 11.5 mm.

Cannibalism is usually observed on larvae from day 17-20 to day 35-40. In rearing, it increased drastically at day 25-30 during the metamorphosis, when differences in size are important. Holt et al. (1987) suggest to rear the red fish at 1-2 larvae per litre during the second phase of the rearing. Rearing density of red sea bream must be reduced to 10-15 larvae/litre to avoid cannibalism (Giovanardi, in Foscarini, 1988). In phase 2, mean stocking density ranged from 6 to 23 larvae/litre. It never exceeded 3.2 larvae/litre during the second period of rearing (phases 3-4) (Table 5). Cannibalism of red fish does not seem a « biological necessity ». It is induced by environment and rearing management. Weaned fish in small rearing tanks without current and dynamic flowthrough still had a cannibalistic behaviour. Other fishes from the same population, reared the

classical way in raceway, did not present any more this character. In an other experiment, in particular conditions of rearing with abundance of artemia supply (2000 to 3500 nauplii/larvae/day) cannibalism did not occur despite of large differences in body size of the larvae (4.5 mm to 12.0 mm SL). Larvae were reared in 40 l tanks with a density of 23 larvae/litre.

Table 5. Mean stocking density of larvae (N/litre).

TRIAL	PHASE					
	1		2		3-4	
	Initial	Final	Initial	Final	Initial	Final
3	60.9	37.6	10.5	2.1	1.8	0.9
4	57.1	44.9	12.6	5.3	2.0	1.3
8	87.8	61.4	30.7	15.6	3.0	1.9
11	67.7				3.2	1.0

The swimbladder hyperinflation was observed at different stages of the larval rearing. According to different pathologists it is more or less a stress syndrome as spinal abnormalities, calculi in the urinary bladders (Johnson and Katavik, 1984) or hypertrophic gall bladder (D. Gallet, pers. comm., 1988). Johnson and Katavic (1984) called it the Swimbladder Stress Syndrome (SBSS). During the rearing of red drum, it appeared twice, at 2 to 4 day old larvae and later during the second phase of the larval rearing. Previous experiments demonstrated neither the quality of light neither the intensity were responsible of the SBSS. Secondary experiment showed brutal change in light intensity (night-day) should induce high mortality. During the unsuccessful rearings with deficient strains of nauplii of brine shrimp, the SBSS first announced the disaster. High rate of abnormal fingerlings (pughead, spinal distortion...) in some rearings pointed out deficiency on environmental control. Such abnormalities frequently affected the gilthead Sea bream, *Sparus aurata* (Franscescon et al., 1988).

## CONCLUSION

This study demonstrates that the red drum can be reared from eggs to fingerling size in fiberglass tanks and pure sea water, with the common living preys rotifers and brine shrimp nauplii under tropical conditions in Martinique (F.W.I). Up to present, encouraging results have been obtained in rearing larvae under intensive conditions (20 to 200 larvae/litre along the larval rearing phase with a larval survival up to 35 % and 65 % for the first and second month of rearing respectively). However, an important effort has to be achieved to refine the zootechnical standard of such an intensive larval rearing. The high mortality is attributed to numerous

factors. An essential one is the availability and nutritional adequacy of live foods provided to the larvae at their different stages of growth, and principally the nutritional deficiencies of some strains of artemia nauplii, when used as single feed for larvae. A substitution or an enrichment of the nauplii would alleviate this problem. Treatments have already been set up for most of the pathological events encountered and a prophylactic control would increase the safety of the rearing. As a second step of research, there is interest to reduce the period when fishes are fed on living preys, working on early weaning with diets on microparticles...

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