

## **Effect of Light Intensity on Initial Survival of Fat Snook (*Centropomus parallelus*, Pisces: Centropomidae) Larvae**

**Vinicius Ronzani Cerqueira\* and André Macedo Brügger**

*Laboratório de Piscicultura Marinha, Departamento de Aquicultura, CCA, Universidade Federal de Santa Catarina, 88.040-970 Florianópolis - SC, Brazil*

### **ABSTRACT**

*Different light intensities were tested during the larval rearing of fat snook (*Centropomus parallelus*) to evaluate its influence on survival and functional swim bladder rate. Newly-hatched larvae were obtained by stripping of hormonally induced broodstock, and were stocked in 32-liter tanks at densities from 30 to 50 L<sup>-1</sup>. Four experiments were carried out testing six light intensities: 50, 100, 200, 500, 1500, and 2500 lx, and total darkness as a control. Mean survival ranged from 0.06 to 16.0% and were significantly influenced by light intensity. Complete darkness resulted in 100% mortality after one week, larvae appeared to have starved since they had empty stomachs. The species has the characteristics of a visual-feeder. Survival was the highest at 200 lx, while at 500 lx was higher than at 50, 100, and 2500 lx. Frequency of functional swim bladder ranged from 36.8 to 100%, but it was not significantly correlated with light intensity. Based on this study, a medium light intensity, 200 to 1500 lx, is recommended for rearing fat snook larvae. Extreme values must be avoided, mainly in the first two weeks after hatching.*

**Key words:** Fat snook, larva, *Centropomus parallelus*, light intensity, first-feeding.

### **INTRODUCTION**

Techniques for artificial reproduction of marine finfish are well developed for many species. However, the rearing of the small and fragile larvae is still a bottleneck in the development of largescale aquaculture production (Sorgeloos & Léger, 1992). Survival rates in larviculture rarely exceed 40%. One of the most common problems in this phase is the adaptation to the first food. Some abiotic factors can have great importance at this time; light is one of them. Most fish larvae, particularly those in the pelagic habitat, are visual-feeders, using sight as the main sense to locate prey (Blaxter, 1966). Some morpho-physiological characteristics, like the presence of cones and not of rods in the retina, the

absence of retinomotor and the majority of the mechanoreceptor and chemoreceptor movements, suggest that fish larvae need a well illuminated environment in the first days of life (Blaxter & Staines, 1970; Blaxter, 1975).

Rearing larvae under the optimum range of light intensity can improve growth and survival rates (Kiyono & Hirano, 1981; Tandler & Mason, 1983; Chatain and Ounais-Guschemann, 1991), and functional (inflated) swim bladder rate, a parameter useful to evaluate larval quality (Chatain and Ounais-Guschemann, 1990; Coves *et al.*, 1991; Kitajima *et al.*, 1994). Illumination requirements depend on the species being considered, but in general, for commercial cultivation of larval marine finfish, light intensity is maintained within

---

\* Author for correspondence

250 and 2000 lx (Sweetman, 1992; Planas and Cunha, 1999).

Fishes of the genus *Centropomus* are not yet cultivated commercially, but some species have appealing qualities for aquaculture, namely the common snook, *C. undecimalis* and the fat snook, *C. parallelus*. High mortality rates at the end of the first week in the rearing of common snook larvae is a major limiting factor in the development of larviculture on a commercial basis (Tucker, 1987). Earlier work on the intensive larviculture of fat snook, *C. parallelus* (Cerqueira *et al.*, 1995), concluded that a better understanding of the influence of light intensity and the nutritional quality of food on the first feeding period, would lead to improvements in cultivation techniques. The present paper describes the effect of light intensity on survival and functional swim bladder rate of fat snook larvae.

## MATERIALS AND METHODS

**Location and Period of Study:** Experiments were conducted at the Laboratório de Piscicultura Marinha (LAPMAR) of the Universidade Federal de Santa Catarina (Florianópolis, SC), using seawater from Barra da Lagoa Bay, during the months of January and February 1993-1995.

**Experimental Units and Conditions:** In the experimental room, illumination was provided by incandescent lamps (100 W) in Experiment 1 and fluorescent lamps (40 W) in the others. An electronic timer controlled photoperiod to 14 h daylight. Different light intensities were obtained through a combination of the number of lamps and their distance to the water surface, measured by a portable luxmeter. Four experiments were carried out with six light intensities: 50, 100, 200, 500, 1500, and 2500 lux (1 klux  $\approx$  3-4 W m<sup>-2</sup>), and complete darkness as a control. Twelve cylindrical fiberglass tanks of 40 L capacity were separated in groups of three and covered by a plastic black canvas. Each group had different light intensity, resulting in four treatments with three replicates. In the treatment without light (0 lx), experimental routine (feeding, sampling, observation, etc.) was accomplished very quickly with the help of a flash-light.

In Experiment 1, all tanks had external biological filters of 4 L capacity. Water was collected by gravity, sent back to the tank by an airlift. In the other experiments, starting at Day 8 after hatching, the rearing water was partially (10%) changed daily to maintain good water quality. Each tank had constant and gentle aeration and the volume of water was maintained at 32 L.

**Water Quality:** Water temperature was controlled with a thermostat and 50 W electric glass heaters and monitored daily. Salinity, dissolved oxygen, pH, nitrite and non-ionized ammonia were measured two times a week in at least one tank of each treatment. Temperature was 25-29 °C, dissolved oxygen was 3.2-5.5 mg L<sup>-1</sup>, salinity was 35 g L<sup>-1</sup>, pH was 7.9-8.1, nitrite was 0-0.58 ppm, and non-ionized ammonia was 0-0.042 ppm.

**Origin of Larvae:** Wild broodstock were induced with 500 and 1,000 IU kg<sup>-1</sup> of human chorionic gonadotropin, respectively for males and females. Larvae were obtained by stripping eggs followed by artificial fertilization and incubation of eggs (Cerqueira, 1995). The number of larvae was estimated from five 10-mL samples taken from different sections of the 35-L incubation tank. Larvae were transferred to the experimental tanks soon after hatching, using a beaker or by siphoning with a plastic pipe. Initial density was 49 larvae L<sup>-1</sup> in Experiment 1 and 30 L<sup>-1</sup> in the others.

**Feeding:** Rotifers and microalgae, *Nannochloropsis oculata* were cultivated outdoors in translucent fiberglass tanks of 1,000 and 2,500 L capacity, respectively, in semi-continuous system. Larval tanks also were inoculated with algae, at a density of 200-500 x 10<sup>3</sup> cells mL<sup>-1</sup> to maintain rotifers in good nutritional condition. Larvae were fed rotifers from Day 2 or 3 after hatching at densities of 7-10 mL<sup>-1</sup>. Adult female rotifers, *Brachionus rotundiformis* and *B. plicatilis* had a mean lorica length of 161 and 194  $\mu$ m, respectively.

**Statistical Analyses:** Survival and functional swim bladder data were analyzed by a non-parametric model, the chi-square ( $\chi^2$ ) test, in a contingency table, to determine the effect of light intensity, at a significant level of 5%. When needed, Yates correction and Fisher exact test were accomplished (Levin, 1987).

## RESULTS

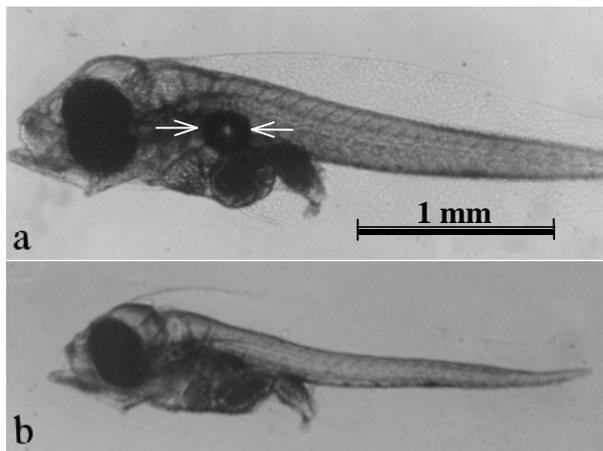
**Experiment 1:** In the tanks under dark condition, there were no survivors after one week. Larvae were always observed with empty stomachs. In the other treatments, larval survival on Day 10 was 0.06, 0.85 and 0.21% for 100, 500 and 2500 lx, respectively. It was significantly affected by light intensity. The best result was obtained at 500 lx (Table 1). Functional swim bladder (82 to 100%) was not affected by light intensity. Larvae presenting a normal inflated swim bladder had a visible gas bubble in it (Fig. 1).

**Experiment 2:** From Day 3 to Day 4, there was an accidental loss of larvae in four tanks, caused by water contamination. The remaining tanks were maintained and the experiment was carried out normally. Survival fell to near 0% in the 0 lx control treatment by Day 7. A few individuals survived until Day 8. Once again, survival was affected by light intensity (Table 2). In the 500 lx treatment, it was higher (7.81%) than in the 50 lx (0.41%) and 1500 lx (0.98%) treatments. Unlike the previous experiment, functional swim bladder rates were significantly different among treatments. In the 1500 lx treatment, it was significantly lower (36.8%) than in the others (100%).

**Table 1** - Survival and functional swim bladder rate of fat snook (*Centropomus parallelus*) larvae reared at different light intensities, at Day 10 after hatching (Experiment 1).

Light intensity (lx)	Survival (%)				Swim bladder (%)			
	R <sub>1</sub>	R <sub>2</sub>	R <sub>3</sub>	μ	R <sub>1</sub>	R <sub>2</sub>	R <sub>3</sub>	μ
0	0	0	0	0	-	-	-	-
100	0.06	0.12	0	0.06 <sup>b</sup>	100	100	-	100 <sup>a</sup>
500	0.95	0.57	1.02	0.85 <sup>a</sup>	100	78	100	93 <sup>a</sup>
2500	0.06	0.19	0.38	0.21 <sup>b</sup>	100	66	83	82 <sup>a</sup>

R<sub>i</sub>: replicates. μ: mean. <sup>a,b</sup> Means with different superscripts are significantly different (p<0,05).



**Figure 1** - 11-day-old fat snook, *Centropomus parallelus*, larvae: a- with functional (inflated) swim bladder (between arrows), b- without functional swim bladder.

**Experiment 3:** Like in the previous experiment, five tanks were accidentally lost due to water contamination. However, there was a notable increase in survival in general, with significant differences observed among treatments (Table 3). The highest was in the 200 lx (16.0%) treatment and the lowest in the 2500 lx (5.6%), with no significant differences between 500 (10.4%) and 1500 lx (12.6%). Like in Experiment 2, there was a significant effect of light intensity on functional swim bladder. In 200 lx (65.2%) and 500 lx (76.3%), the observed rates were higher than in 2500 lx (42.5%).

**Table 2** - Survival and functional swim bladder rate of fat snook *Centropomus parallelus* larvae reared at different light intensities, at Day 14 after hatching (Experiment 2).

Light intensity (lx)	Survival (%)				Swim bladder (%)			
	R <sub>1</sub>	R <sub>2</sub>	R <sub>3</sub>	μ	R <sub>1</sub>	R <sub>2</sub>	R <sub>3</sub>	μ
0	0	0	0	0	-	-	-	-
50	0.41	...	...	0.41 <sup>b</sup>	100	...	...	100 <sup>a</sup>
500	4.27	11.35	...	7.81 <sup>a</sup>	100	100	...	100 <sup>a</sup>
1500	1.56	0.41	...	0.98 <sup>b</sup>	26	47.6	...	36.8 <sup>b</sup>

R<sub>i</sub>: replicates. μ: mean. ... lost replicate. <sup>a,b</sup> Means with different superscripts are significantly different (p<0,05).

**Experiment 4:** Survival was below 1%, like in Experiment 1, with significant differences among treatments (Table 4). The highest rate (0.78%) was observed in the 200 lx treatment. It was higher among larvae reared at 500 (0.31%) and 1.500 lx (0.27%) than among those reared at 2.500 lx (0.03%). Functional swim bladder rates (88.8-100%) were not affected by light intensity.

**Table 3** - Survival and functional swim bladder rate of fat snook *Centropomus parallelus* larvae reared at different light intensities, at Day 14 after hatching (Experiment 3).

Light intensity (lx)	Survival (%)				Swim bladder (%)			
	R <sub>1</sub>	R <sub>2</sub>	R <sub>3</sub>	μ	R <sub>1</sub>	R <sub>2</sub>	R <sub>3</sub>	μ
200	4.1	27.8	...	16.0 <sup>a</sup>	65	65.4	...	65.2 <sup>a</sup>
500	2.8	22.9	5.4	10.4 <sup>b</sup>	92	45	92	76.3 <sup>a</sup>
1500	12.6	...	...	12.6 <sup>b</sup>	64.7	...	...	64.7 <sup>ab</sup>
2500	5.6	...	...	5.6 <sup>c</sup>	42.5	...	...	42.5 <sup>b</sup>

R<sub>i</sub>: replicates. μ: mean. ... lost replicate. <sup>a,b</sup> Means with different superscripts are significantly different (p<0,05).

**Table 4** - Survival and functional swim bladder rate of fat snook *Centropomus parallelus* larvae reared at different light intensities, at Day 14 after hatching (Experiment 4).

Light intensity (lx)	Survival (%)				Swim bladder (%)			
	R <sub>1</sub>	R <sub>2</sub>	R <sub>3</sub>	μ	R <sub>1</sub>	R <sub>2</sub>	R <sub>3</sub>	μ
200	0.93	0.62	...	0.78 <sup>a</sup>	100	100	...	100 <sup>a</sup>
500	0.31	0.41	0.20	0.31 <sup>b</sup>	77.6	100	88.8	88.8 <sup>a</sup>
1500	0.31	0.20	0.31	0.27 <sup>b</sup>	100	100	100	100 <sup>a</sup>
2500	0.10	0	0	0.03 <sup>c</sup>	100	-	-	100 <sup>a</sup>

R<sub>i</sub>: replicates. μ: mean. ... lost replicate. <sup>a,b</sup> Means with different superscripts are significantly different (p<0,05).

## DISCUSSION

At 0 lx, larvae were observed to have empty stomachs and total mortality occurred by Day 7 or 8 after hatching, indicating that fat snook larva was a visual-feeder. By Day 5 or 6, at an average temperature of 26 °C, the yolk sac was already exhausted, as observed in previous studies with this species (Cerqueira, 1995). Several other fish larvae, such as herring *Clupea harengus* (Blaxter, 1966), plaice *Pleuronectes platessa* (Blaxter, 1968), and

halibut *Hipoglossus hipoglossus* (Tilseth *et al.*, 1992), are also considered visual-feeders and are not able to capture food if light intensity is below a certain threshold. Other species, in spite of being able to capture food even in the darkness, are also considered visual-feeders because consumption decreases abruptly under dark conditions, like in cod *Gadus morhua* (Ellertsen *et al.*, 1980) and gilthead sea bream *Sparus aurata* (Tandler and Mason, 1984). According to these authors, in darkness larvae find food accidentally or by making

use of neuromasts. Some larval fish, such as black porgy *Mylio macrocephalus* (Kiyono and Hirano, 1981) and striped bass *Morone saxatilis* (Chesney, 1989), feed normally in the presence or absence of light. They are not visual-feeders and use chemo and/or mechanoreception in the location of prey.

The absence of light seems to make the snook larvae very calm. Wallace *et al.* (1988) and Chesney (1989) also observed that darkness maintained larval Atlantic salmon *Salmo salar* and striped bass *Morone saxatilis* in a very calm condition during the first days of life, resulting in high survival. Coves *et al.* (1991) kept sea bass *Dicentrarchus labrax* larvae in the dark for a period of 10 days, before feeding *Artemia* nauplii. Barahona-Fernandes (1979) pointed out that high light intensities could be lethal for the young and transparent sea bass larvae. Kelley and Lee (1991) observed high mortality rearing milkfish *Chanos chanos* larvae at light intensities above 10,000 lx.

High mortality was generally observed during the first week in all experiments of the present study. However, there was a significant variation in survival, most notably between Experiment 3 and 4 despite that the methodology for these two was identical. Mortality may be attributable to many factors, particularly egg quality, possibly a result of poor broodstock health and/or the spawning induction method. Differences in survival and growth related to the quality of larvae have been reported previously for other fish species (Lavens and Sorgeloos, 1991; Tamaru *et al.*, 1994).

In Experiment 3, with 200 and 500 lx, the highest survival rates for 14-day-old fat snook larvae were obtained. Unfortunately, in the same Experiment and in Experiment 2, some toxic substance liberated by electric heaters caused total mortality in five tanks.

Functional swim bladder rates were high in general, and were not consistently related to the light intensity range tested. In Experiment 2 and 3 there was a dependent relationship, and the lowest rates were observed in the 1500 and 2500 lx treatments. Chatain and Ounais-Guschemann (1991) found no significant differences in functional swim bladder rates rearing larvae of gilthead sea bream *Sparus aurata* at different light intensities and photoperiods. Cerqueira and Chatain (1991), rearing larvae of European sea bass *Dicentrarchus labrax*, observed higher rates using 9 h of photoperiod (compared to 24 h) and 500 lx.

Survival was dependent on light intensity in all experiments of the present study. In the 200 and

500 lx treatments, survival rates were significantly higher than in the other treatments. Cerqueira *et al.* (1995), also rearing fat snook larvae, observed higher survival at 500 than 100 lx. Edwards and Henderson (1987) obtained high survival rates rearing common snook larvae at 3300 to 5200 lx.

According to Blaxter (1968) 500 lx would be adequate to provide a good first-feeding condition for larval fish in laboratory. This is particularly true in the case of visual-feeders that have pure-cone retina, like haddock *Melanogrammus aeglefinus*, sole *Solea solea* and *Microstomus kitt*, sardine *Sardina pilchardus*, and Asian sea bass *Lates calcarifer* (Blaxter and Staines, 1970).

Barahona-Fernandes (1979) reported that European sea bass *Dicentrarchus labrax* larvae reared in the range 150 to 1000 lx survived better than in the range 1400 to 3500 lx. Tandler and Mason (1983), rearing gilthead seabream *Sparus aurata* larvae, observed a higher survival in 1370 lx than in 205 lx. Chatain and Ounais-Guschemann (1991) found for this same species that 600 and 1300 lx resulted in better survival compared to 150 and 300 lx. The range 500 to 1400 lx seems to be also adequate for rearing mullet *Mugil cephalus* larvae (Liao and Chao, 1991). However, larvae of some other species, like cod *Gadus morhua* and halibut *Hipoglossus hipoglossus*, showed better feed consumption at low light intensities, 1.4 and 0.5 lx, respectively (Ellertsen *et al.*, 1980; Gulbrandsen, 1991). Some others are more adapted to high light intensities, like black porgy *Mylio macrocephalus* and striped bass *Morone saxatilis*, that fed more and survived better at 3000 and 2000 lx, respectively (Kiyono and Hirano, 1981; Chesney, 1989). On the same note, Person-Le Ruyet *et al.* (1991) recommended 6,000 to 12,000 lx for rearing turbot *Scophthalmus maximus* larvae.

## CONCLUSION

Fat snook larvae maintained in the dark were unable to feed, like a visual-feeder and survived just one week after hatching at a mean temperature of 26 °C. It was not possible to establish a clear relationship between light intensity and functional swim bladder rate in all experiments. However, when a significant relation was detected, 1500 and 2500 lx resulted in the lowest rates.

Survival was always affected by light intensity. It seemed that the range 200 to 1500 lx was more favorable than the extreme values tested (100 and

2500 lx), that should be avoided. Nevertheless, further studies are needed to determine optimal illumination and to improve survival of first-feeding larvae of fat snook.

## ACKNOWLEDGEMENTS

This study was supported by the Fundação Banco do Brasil (FBB), the Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq), and the International Foundation for Science (IFS). The authors are grateful to the Conselho para Aperfeiçoamento, Pesquisa e Ensino Superior (CAPES), for providing a scholarship to one of the authors (A.M.B), to the staff of Laboratório de Piscicultura Marinha, specially Jaqueline de Araújo and Javier Macchiavello, to Dr. Antônio Schlindwein and Dr. Rubens Nodari (UFSC) for statistical advice, to Dr. Naoyo Yamanaka (Ipesca-SP) and Dr. Atsushi Hagiwara (University of Nagasaki) for supplying rotifer inocula, to Dr. Luis Alvarez-Lajonchere and Shelby Banner for reviewing the manuscript.

## RESUMO

Diferentes intensidades de luz foram testadas na larvicultura do robalo peva, *Centropomus parallelus*, avaliando sua influência na sobrevivência e insuflação da bexiga gasosa. Larvas obtidas de desova induzida foram mantidas até 14 dias, em tanques de 32 L, com densidade inicial de 30-50 L<sup>-1</sup>. Foram utilizados o escuro total e 6 intensidades de luz: 50, 100, 200, 500, 1.500 e 2.500 lx. A sobrevivência média variou entre 0,06 e 16,0%, dependendo significativamente (P<0,05) da intensidade de luz. No escuro, as larvas morreram após uma semana, sem conteúdo no tubo digestivo, comprovando serem predadores visuais. Em 200 lx, a sobrevivência foi maior que em 500, 1.500 e 2.500 lx. Em 500 lx também foi superior a 50, 100 e 2.500 lx. A insuflação da bexiga gasosa ficou entre 36,8 e 100%, independentemente da intensidade de luz. Recomenda-se intensidade luminosa média, de 200 a 1.500 lx, evitando valores extremos, sobretudo nas duas primeiras semanas de vida.

## REFERENCES

- Barahona-Fernandes, M. L. (1979), Some effects of light intensity and photoperiod on the sea bass larvae *Dicentrarchus labrax* (L.) reared at the Centre Oceanologique de Bretagne. *Aquaculture*, **17**, 311-321.
- Blaxter, J. H. S. (1966), The effects of light intensity on the feeding ecology of herring. In: *Light as an Ecological Factor*, eds. R. Bainbridge, G.C. Evans, and O. Rackham. Blackwell Science. Publication, Oxford, 393-409.
- Blaxter, J. H. S. (1968), light intensity, vision, and feeding in young plaice. *J. Exp. Mar. Biol. Ecol.*, **2**, 293-307.
- Blaxter, J. H. S. (1975), The eyes of larval fish. In: *Vision in Fishes, New Approaches in Research*, ed. M. A. Ali. Plenum Press, New York, 427-443.
- Blaxter, J. H. S. and Staines, M. (1970), Pure-Cone Retinae and Retinomotor Responses in Larval Teleosts. *J. Mar. Biol. Ass. U.K.*, **50**, 449-460.
- Cerqueira, V. R. (1995), Testes de indução de desova do robalo, *Centropomus parallelus*, do litoral da ilha de Santa Catarina com Gonadotrofina Coriônica Humana (HCG). Proceedings of 7<sup>th</sup> Congresso Brasileiro de Engenharia de Pesca, AEP- PE, SUDENE, Recife, 95-102.
- Cerqueira, V. R. and Chatain, B. (1991), Photoperiodic effects on the growth and feeding rhythm of European sea bass, *Dicentrarchus labrax*, larvae in intensive rearing. In: Larvi '91 - Fish and Crustacean Larviculture Symposium, eds. P. Lavens, P. Sorgeloos, E. Jaspers, F. Ollevier. *European Aquaculture Society, Special Publication*, **15**, 304-306.
- Cerqueira, V. R.; Macchiavello, J. A. G. and Brügger, A. M. (1995), Produção de alevinos de robalo, *Centropomus parallelus* Poey, 1860, através de larvicultura intensiva em laboratório. *Proceedings of 7<sup>th</sup> Simpósio Brasileiro de Aqüicultura*, Peruíbe. ACIESP, São Paulo, 191-197.
- Chatain, B. and Ounais-Guschemann, N. (1990), Improved Rate of Initial Swim Bladder Inflation in Intensive Reared *Sparus auratus*. *Aquaculture*, **84**, 345-353.
- Chatain, B. and Ounais-Guschemann, N. (1991), The Relationships Between Light and Larvae of *Sparus aurata*. In: Larvi '91 - Fish and Crustacean Larviculture Symposium, eds. P. Lavens, P. Sorgeloos, E. Jaspers, F. Ollevier. *European Aquaculture Society, Special Publication*, **15**, 310-313.
- Chesney Jr. and E. J. (1989), Estimating the Food Requirements of Striped Bass Larvae *Morone saxatilis*: Effects of Light, Turbidity and Turbulence. *Mar. Ecol. Prog. Ser.*, **53**, 191-200.
- Coves, D.; Dewavrin, G.; Breuil, G. and Devauchelle, N. (1991), Culture of Sea Bass (*Dicentrarchus labrax* L.). In: *Handbook of Mariculture: Finfish Aquaculture*, ed. J. P. McVey. CRC Press Inc., Boca Raton, 3-20.

- Edwards, R. E. and Henderson, B. D. (1987), An Experimental Hatchery Project: Studies of Propagation, Culture and Biology of Snook (*Centropomus undecimalis*). *Proceedings of 38<sup>th</sup> Annual Gulf and Caribbean Fisheries Institute*. Miami, 211-221.
- Ellertsen, B.; Solemdal, P.; Stromme, T.; Tilseth, S.; Westgard, T.; Moksness, E. and Oiestad, V. (1980), Some Biological Aspects of Cod Larvae (*Gadus morhua* L.). *Fisk. Dir. Skr. Ser. HavUnders.*, **17**, 29-47.
- Gulbrandsen, J. (1991), Effect of Light Intensity on Feeding Success of Atlantic Halibut Larvae. In: Larvi '91 - Fish and Crustacean Larviculture Symposium, eds. P. Lavens, P. Sorgeloos, E. Jaspers, F. Ollevier. *European Aquaculture Society, Special Publication*, **15**, 336-338.
- Kelley, C. and Lee, C. S. (1991), Milkfish Culture in the U.S. In: *Handbook of Mariculture: Finfish Aquaculture*, ed. J.P. McVey. CRC Press Inc., Boca Raton, 211-226.
- Kitajima, C.; Watanabe, T.; Tsukashima, Y. and Fujita, S. (1994), Lordotic Deformation and Abnormal Development of Swim Bladders in Some Hatchery-Bred Marine Physoclistous Fish in Japan. *J. World Aquac. Soc.*, **25**, 64-77.
- Kiyono, M. and Hirano, R. (1981), Effects of Light on the Feeding and Growth of Black Porgy, *Mylio macrocephalus* (Basilewsky), Postlarvae and Juveniles. In: *The Early Life History of Fish: Recent Studies*, eds. R. Lasker, K. Sherman, 334-336.
- Lavens, P. and Sorgeloos, P. (1991), Variation in Egg and Larval Quality in Various Fish and Crustacean Species. In: Larvi '91 - Fish and Crustacean Larviculture Symposium, eds. P. Lavens, P. Sorgeloos, E. Jaspers, F. Ollevier. *European Aquaculture Society, Special Publication*, **15**, 221-222.
- Levin, J. (1987), *Estatística Aplicada a Ciências Humanas*. Trad. Sérgio Francisco Costa. 2<sup>nd</sup> ed., Harbra, São Paulo, 392p.
- Liao, C. and Chao, N. H. (1991), Grey Mullet Culture in Taiwan. In: *Handbook of Mariculture: Finfish Aquaculture*, ed. J.P. McVey. CRC Press Inc., Boca Raton, 117-132.
- Person-Le Ruyet, J.; Baudin-Laurencin, F.; Devauchelle, N.; Métailler, R.; Nicolas, J. L.; Robin, J. and Guillaume, J. (1991), Culture of Turbot *Scophthalmus maximus*. In: *Handbook of Mariculture: Finfish Aquaculture*, ed. J.P. McVey. CRC Press Inc., Boca Raton, 21-42.
- Planas, M. and Cunha, I. (1999), Larviculture of marine fish: problems and perspectives. *Aquaculture*, **177**, 171-190.
- Sorgeloos, P.; Léger, P. (1992), Improved Larviculture Outputs of Marine Fish, Shrimp and Prawn. *J. World Aquac. Soc.*, **23**, 251-264.
- Sweetman, J. W. (1992), Larviculture of Mediterranean Marine Fish Species: Current Status and Future Trends. *J. World Aquac. Soc.*, **23**, 330-337.
- Tamaru, C. S.; Murashige, R.; Lee, C. S. (1994), The Paradox of Using Background Phytoplankton During the Larval Culture of Striped Mullet, *Mugil cephalus* L. *Aquaculture*, **119**, 167-174.
- Tandler, A. and Mason, C. (1983), Light and Food Density Effects on Growth and Survival of Larval Gilthead Seabream (*Sparus aurata*, Linnaeus; Sparidae). *Proceedings of Warmwater Fish Culture Workshop*. Louisiana State University, Baton Rouge, 103-116.
- Tandler, A. and Mason, C. (1984), The Use of <sup>14</sup>C Labelled Rotifers *Brachionus plicatis* in the Larvae of Gilthead Seabream *Sparus aurata*: Measurements of the Effect of Rotifer Concentration, the Lighting Regime, and Seabream Larval Age on Their Rate of Rotifer Ingestion. In: *Research on Aquaculture*, eds. H. Rosenthal, S. Sarig. European Mariculture Society, Special Publication, **8**, 241-259.
- Tilseth, S.; Blom, G. and Naas, K. (1992), Recent Progress in Research and Development of Marine Cold Water Species for Aquaculture Production in Norway. *J. World Aquac. Soc.*, **23**, 277-285.
- Tucker Jr., J. W. (1987), Snook and Tarpon Snook Culture and Preliminary Evaluation for Commercial Farming. *The Prog. Fish-Cult.*, **49**, 49-57.
- Wallace, J. C.; Kolbeinshavn, A. and Aasjord, D. (1988), Observation on the Effect of Light Intensity on the Growth of Arctic Charr Fingerlings *Salvelinus alpinus* and Salmon Fry *Salmo salar*. *Aquaculture*, **72**, 81-84.

Received: September 22, 1999;

Revised: October 29, 1999;

Accepted: April 26, 2001.