Nursery rearing of the Asian sea bass, *Lates calcarifer*, fry in illuminated floating net cages with different feeding regimes and stocking densities

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Abstract

Successful rearing of hatchery-reared sea bass, *Lates calcarifer*, fry in illuminated floating cages was demonstrated in a 42-day experiment. Three feeding regimes, *i.e.* natural zooplankton (NZ) + minced fish flesh (MFF), NZ alone, or MFF alone and two stocking densities (600 and 1 200 individuals m^{-2}) were tested in a 3 × 2 factorial experiment. Fish reared in unlit cages and fed MFF alone during daytime served as the control. Results showed that no interaction existed between stocking density and feeding regime and that the two stocking densities used did not influence fish growth in terms of mean final body size. In general, sea bass reared in lit cages (NZ + MFF and NZ) grew and survived better than the control fish (MFF). However, fish reared under NZ + MFF feeding regime had the highest final mean total length (TL, 42.1 mm) and body weight (BW, 1 311.8 mg) followed by fish reared under NZ feeding regime (mean TL = 26 mm, BW = 415 mg). Fish in the unlit control cages exhibited the poorest growth (final mean TL and BW: 26 mm and 277.6 mg BW). Furthermore, specific growth rates (range: 5.7-8.5% day^{-1}) of fish in lit cages were significantly better than those of fish in the unlit control cages (mean: 3% day^{-1}). Percentage survival (38%) of fish stocked at 600 m^{-2} density and fed NZ was not significantly different from fish in the NZ + MFF feeding regime. However, increasing the density to 1 200 ind. m^{-2} tended to significantly decrease percentage survival (20%) of fish with NZ feeding. Fish reared in the unlit control cages had the poorest survival of 13-14%. The high percentage composition by number (CN, 88%) of copepods in the stomachs of sea bass fry fed on NZ alone and the equally high percentage feeding incidence (94%) indicated that fish fed sufficiently on natural zooplankton. Supplemental feed using minced fish flesh contributed about 43-59% of the fish diet in addition to natural zooplankton.

Keywords: *Lates calcarifer*, sea bass fry, floating cage nursery, illuminated cages, zooplankton.

Élevage de Lates calcarifer *en cages flottantes éclairées ou non et soumis à différents régimes alimentaires et densités de stockage.*

Résumé

Le succès de l'élevage en écloserie de *Lates calcarifer* et en cages flottantes éclairées est démontré sur une expérience de 42 jours. Trois régimes alimentaires sont testés : du zooplancton naturel (NZ) et de la chair de poisson (MFF), du zooplancton uniquement ou du MFF seul ; pour deux densités de stockage de *Lates calcarifer* (600 et 1 200 individus par m^2).

Les poissons élevés en cages non éclairées et nourris seulement de MFF durant la journée ont servi de témoins. Les résultats montrent qu'il n'existe pas d'interaction entre la densité de stockage et le régime alimentaire et que les deux densités de stockage utilisées n'influencent pas la croissance du poisson en terme de poids moyen final.

En général, les poissons élevés en cages éclairées (NZ + MFF et NZ), grossissent et survivent mieux que les poissons témoins (MFF). Cependant, les poissons élevés avec un régime alimentaire NZ + MFF atteignent une taille moyenne finale plus élevée (TL, 42 mm et de poids moyen 1 312 mg) suivis par les poissons élevés avec le régime NZ (26 mm, 415 mg). Les poissons en cages témoins non éclairées ont la croissance la plus faible (26 mm et 278 mg). De plus, les taux de croissance spécifiques (5,7-8,5 %/jour) des poissons en cages éclairées étaient significativement meilleurs que ceux des témoins (3 % par jour).

Le taux de survie (38 %) des poissons stockés à une densité de 600 par m^2 et nourris de NZ n'était pas significativement différent des poissons au régime alimentaire NZ + MFF. Cependant l'augmentation de la densité (1 200 individus par m^2) tend à diminuer le taux de survie (20 %) pour les poissons nourris de NZ; les poissons témoins ont le taux de survie le plus faible 13-14 %. Le fort pourcentage de copépodes observé dans les contenus stomacaux 88 % chez 94 % des poissons (de régime alimentaire NZ) indique que les poissons sont suffisamment nourris.

Mots-clés : *Lates calcarifer*, juvéniles, cages flottantes, zooplancton.

INTRODUCTION

Available information is limited only to the rearing of whitefish, *Coregonus lavaretus* or *C. peled* in submerged (3-5 m below water surface) illuminated cages in deep freshwater lakes (Mamcarz and Szczerbowski, 1984; Rosch and Eckmann, 1986; Mamcarz and Nowak, 1987; Champigneulle and Rojas-Beltran, 1990; Mamcarz and Kozlowski, 1992). The whitefish were reared at water temperature of 8-16°C, from an initial length of 20-27 mm to about 42-54 mm in 38 days with mean specific growth rate of 8% day^{-1} and survival rates of 86-98% (Rösch and Eckmann, 1986). Fish prefed on dry diets had no difficulty in switching to live zooplankton as food in illuminated cages (Champigneulle and Rojas-Beltran, 1990). Furthermore, supplemental feeding during daytime using dry formulated diets during rearing of *C. peled* increased fish resistance to parasites and improved growth and survival by 50% compared with fish that fed on zooplankton only (Mamcarz and Kozlowski, 1992).

In the Philippines, nursery of the Asian sea bass, *Lates calcarifer* (Bloch) is done immediately after 21 days of rearing the larvae successively on *Brachionus plicatilis* and *Artemia salina* in the hatchery and when they have metamorphosed to early juvenile stage (average total length = 8-10 mm) (Parazo *et al.*, 1991; Barlow *et al.*, 1993). However, on an extended hatchery rearing period, sea bass larvae are fed the freshwater cladoceran, *Moina macrocopa* starting from day-15 (3.6 mm total length; 2.0 mg body weight) to partially or completely replace the brine shrimp, *Artemia salina* as food (Fermin, 1991; Ganzon-Naret and Fermin, 1994; Fermin and Bolivar, 1994). Traditionally, sea bass nursery is carried out in fertilized brackish-water ponds and in floating net cages placed inside a pond or in an open coastal area and fed chopped or ground trash fish twice daily (Kungvankij *et al.*, 1986). Elsewhere, sea bass nursery is carried out extensively in fertilized ponds with supplemental feeding of live *Artemia* or done intensively in nursery tanks and fed live *Artemia* or wild zooplankton then gradually weaned to live or frozen *Ascetes* and minced trash fish (Rimmer and Rutledge, 1991). The use of artificially illuminated floating net cages in the present study was investigated in order to develop alternative rearing techniques for sea bass fingerling production. Illuminated cage nursery rationalizes the use of light-attracted wild zooplankton at night that can serve as food for young sea bass. Sea bass larvae and juveniles are generally zooplanktivorous (Davis, 1985; Barlow *et al.*, 1993); thus, this study was conducted to demonstrate the use of light-attracted wild zooplankton as food for the nursery rearing of sea bass fry in illuminated floating cages.

MATERIALS AND METHODS

Fish and rearing system

Sea bass eggs obtained by natural spawning of cage-reared broodstock were incubated and hatched in aerated sea water in circular fibreglass tanks indoors. Newly-hatched sea bass larvae were then transferred to fibreglass rearing tanks and fed *Brachionus plicatilis* and then *Artemia salina* following the rearing protocol developed at SEAFDEC/AQD (Duray and Juario, 1988; Parazo *et al.*, 1991). After 35 days, sea bass (mean TL = 19.1 mm) were packed in oxygen-inflated double-layered plastic bags and transported to the project site at the SEAFDEC Igang Marine Substation in Nueva Valencia, Guimaras Province. Six fish groups with three replicates each were represented in a 3 × 2-factorial experimental design to test three feeding regimes and two stocking densities (600 and 1 200 m^{-2}) as shown in *table* 1.

Table 1. – Experimental treatments (NZ + MFF = natural zooplankton + minced fish flesh; NZ = natural zooplankton alone; MFF + minced fish felsh alone).

Treatment	Density (m^{-2})	Feed	Light
1	600	NZ + MFF	Yes
2	1 200	NZ + MFF	Yes
3	600	NZ	Yes
4	1 200	NZ	Yes
5	600	MFF	No
6	1 200	MFF	No

For the fish groups provided with illumination (treatments 1-4), twelve units of 1 × 1 × 1.5 m nylon net cages (mesh size = 2.1 × 3.6 mm) suspended in two 5 × 4 m floating bamboo decks were used. One 20-watt fluorescent lamp was placed at 1 m above each set of four cages to provide an average light intensity of 520 lux (Minolta digital light meter) near the water surface. For the unlit control groups, six cages were situated about 100 m away from the lit groups. In all treatments, cages were submerged to 1 m depth leaving a 0.5 m clearance above the water surface.

Feeding regimes

In treatment groups 1, 2, 5 and 6 sea bass were fed minced fish flesh by hand *ad libitum*, given daily between 08:30-16:30 h. This feeding practice in sea bass nursery was similar to that of Kungvankij *et al.* (1986). The diet was prepared by passing the fish flesh through an ordinary meat grinder and then storing in a refrigerator (4°C) until use. Thawing was done during feeding time. Treatment groups 3 and 4 were not given supplemental feed during the day but fish fed exclusively on natural zooplankton attracted by light at night.

Zooplankton and fish samplings

During fish stocking and every week thereafter, zooplankton sampling was done between 19:00-21:00 h in six randomly chosen cages which represented each treatment group. Using a 2-l capacity vertical water sampler (Rigosha, Japan) three samplings were done at different water depths inside the cage to obtain a composite zooplankton sample. Water samples were filtered through a 150-μm improvised plankton net. Filtered zooplankton were then washed down into a preserving vial containing 10% buffered formalin solution. Five to 10 fish samples were then taken at random from each cage using a long-handled scoop net. Fish were immediately preserved in a 50-ml glass vial containing 10% formalin solution until size measurements the following day. In an attempt to reduce cannibalism-induced mortalities "shooters", or cannibals which had a minimum size difference of approximately 33% from the rest of the stock (Parazo *et al.*, 1991) were removed weekly during sampling without replacement.

Cages were replaced with new ones immediately after sampling. Used cages were brushed thoroughly to remove algae and silt that clogged the mesh and were then dried in the sun.

During the course of the experiment, water temperature varied from 28-30°C while water salinity ranged from 32-35°/$_{oo}$. The experiment was terminated after 42 days when fish attained a mean total length of 40 mm or greater which is the minimum size for stocking in grow-out culture (Kungvankij *et al.*, 1986).

Processing of fish and zooplankton samples

Sampled fish were measured in the laboratory. Total length was measured to the nearest 0.1 mm using a vernier caliper. Individual body weight was determined to the nearest 0.1 mg using an analytical balance (Mettler AE 160, USA) after blotting the fish dry on absorbent paper. The same fish samples were dissected for stomach-content analysis. Ingested zooplankton prey were identified according to taxonomic categories. Particles of ingested minced fish flesh were arbitrarily quantified by designating + if 1-20% and ++ if 21-50% of the total volume of food was found in the stomachs of sea bass.

Filtered zooplankton from the water samples were counted and identified according to taxonomic categories under a light microscope.

Data analysis

Specific growth rate (SGR) was computed as SGR = $\ln W_f - \ln W_i / T \times 100$, where: W_f = final weight (mg) at time T in days; W_i = initial weight (mg). Percentage survival was determined by dividing the remaining number of fish in each cage by the total number of fish stocked initially excluding the samples taken weekly multiplied by 100. The compositions of the diets of all fish examined under each feeding regime at different sampling periods were pooled and the percentage of each food category as a proportion of the total number of items consumed was calculated as % CN (Schmitt, 1986). Percentage feeding incidence was computed as the number of sampled fish with food in their guts divided by the total number of fish examined. All data were analyzed by a split-split plot analysis (analysis over time) using the SAS general linear models (SAS, 1991). Significant differences among means were determined by Duncan's Multiple Range test (DMRT) at the 5% probability level. Percentage data were normalized by arcsine transformation prior to statistical test.

RESULTS

Growth and survival

The mean total lengths (TL) and body weights (BW) of sea bass sampled weekly are presented in *figure* 1. No significant differences existed between the two stocking densities used (600 and 1 200 m^{-2}, $p > 0.05$), thus data were pooled for each feeding regime. Until day 14 fish reared in lit cages and fed NZ + MFF (mean TL = 24.8 mm, mean BW = 225.2 mg) or NZ alone (mean TL = 24.5 mm, mean BW = 203.6 mg) grew significantly faster than fish reared in the unlit control cages and fed MFF alone (mean TL = 19.8 mm, BW = 118.3 mg). However, starting from day 21 and up to the end of the rearing period fish in the NZ + MFF group (mean body size: 29.5 mm TL and 421.2 mg BW) grew to a final mean body size of 42.1 mm TL and 1 311.8 mg BW which was significantly higher than those of the fish in the NZ feeding regime (32.6 mm TL, 414.6 mg BW) or MFF (26.1 mm TL, 277.6 mg BW).

Generally, fish reared in lit cages and fed NZ + MFF or NZ alone had significantly higher SGR (range: 6-8% day^{-1}) and percent survival (range: 20-50%) compared

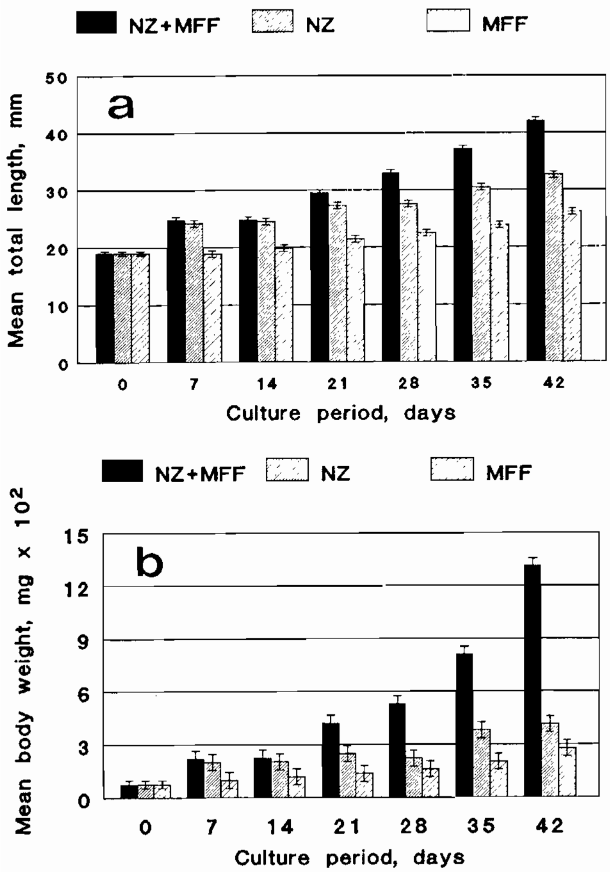

Figure 1. – Mean total length (mm) (a); and mean body weight (mg × 10^2) (b); of sea bass, *Lates calcarifer*, fry reared in illuminated floating net cages with different feeding regimes and stocking densities. Legend: NZ + MFF = natural zooplankton + minced fish flesh; NZ = natural zooplankton alone; MFF = minced fish flesh alone. Vertical lines above each bar represent standard error of the mean (SEM).

to fish in the unlit control cages (*table* 2). Percentage survival (38%) of fish stocked at 600 m^{-2} and fed NZ alone was comparable with those of fish reared under the NZ + MFF feeding regime at either density (43-50%) but was significantly higher than those of fish fish stocked at 1 200 m^{-2} (20%) and reared under the same feeding regime ($p < 0.05$).

The mean cumulative percentage of "shooters" (range: 1-2.5%) did not differ significantly among cages ($p > 0.05$, *table* 2).

Zooplankton abundance and fish feeding

The mean zooplankton abundance sampled weekly for each feeding regime is presented in *table* 3. There were four major zooplankton groups identified that included the Copepods (Calanoid, Cyclopoid and Harpacticoid and their nauplii), Pteropods, Brachyurans and Tintinnids. Higher ranges of zooplankton abundance were obtained from the lit cages than in the unlit control cages. Copepods were the most numerous taxonomic group that comprised more than 60% of the total zooplankton abundance in the lit cages and about 50% in the unlit control cages. Moreover, taxonomic groups were observed to be similar for all cages.

Table 4 shows the percentage composition by number (%CN) of sea bass fry diet. The overall mean composition of the fish diet showed that copepods (88%) were the major food items ingested by sea bass reared under NZ feeding regime. Minced fish flesh given as main food source for the MFF group or as supplemental feed to fish in the NZ + MFF group has contributed about 43 and 59% respectively to the fish diet. Mean feeding incidence was higher in the lit cages (92-94%) than in the unlighted control (82%).

DISCUSSION

The present study has demonstrated the feasibility of rearing hatchery-grown sea bass fry in illuminated floating nursery cages in a protected coastal area. From an initial size of 19 mm TL, sea bass fry grew to fingerling size of more than 40 mm TL within 42 days. The rearing period was about twice as long as that of freshwater pond-reared sea bass larvae stocked at 2 m^{-2} that grew from an initial size of 2.0 cm to 4.3 cm mean final TL in 17 days with average survival of 99% (Barlow *et al.*, 1993). Based on growth and

Table 2. – Specific growth rate, percentage survival and percentage number of shooters in sea bass (*Lates calcarifer*) fry reared in floating cages with different feeding regimes and stocking densities. Percentage data for survival and "shooters" were arcsine-transformed prior to statistical analysis. Means in columns with different superscripts are significantly different at $p = 0.05$ (Duncan's Multiple Range test).

Density (m^{-2})	Feed	Light	SGR (% day^{-1})	Survival (%)	"Shooters" (%)
600	NZ + MFF [1]	Yes	8.5 ± 3.1^{a}	43.2 ± 3.7^{a}	2.3 ± 1.3^{a}
1 200	NZ + MFF	Yes	8.1 ± 2.7^{a}	50.3 ± 4.4^{a}	2.5 ± 1.1^{a}
600	NZ	Yes	6.8 ± 3.4^{ab}	38.4 ± 13.4^{ab}	2.1 ± 1.5^{a}
1 200	NZ	Yes	5.7 ± 3.2^{bc}	20.2 ± 4.4^{b}	1.1 ± 1.9^{a}
600	MFF [1]	No	3.1 ± 0.3^{c}	14.5 ± 0.2^{c}	1.8 ± 0.0^{a}
1 200	MFF	No	3.0 ± 0.3^{c}	13.1 ± 1.3^{c}	1.0 ± 0.2^{a}

[1] Fish in these groups were fed minced fish flesh given *ad libitum* 4x a day.

Table 3. – Ranges and means of zooplankton abundance (number l^{-1}) sampled once weekly at 21:00 h within a 42-day rearing period of sea bass, *Lates calcarifer* in illuminated floating net cages (n = 24 per treatment). (NZ + MFF + natural zooplankton + minced fish flesh; NZ = natural zooplankton alone; MFF = minced fish flesh alone).

Taxonomic group	Lighted cages				Unlighted cages	
	NZ + MFF		NZ		MFF*	
	Range	Mean	Range	Mean	Range	Mean
Copepods:						
Calanoids	3-362	117.7	1-285	74.4	3-12	8.1
Cyclopoid	6-1743	343.1	0-2 896	495.9	7-23	13.2
Harpacticoid	0-8	2.6	0-5	2.1	5-29	12.7
Nauplii	3-232	91.0	0-66	19.3	28-81	48.8
Tintiniids	0-46	12.9	0-4	0.8	0-20	8.9
Pteropods	6-391	97.8	0-63	14.1	12-45	26.3
Brachyurans	2-26	11.1	0-9	2.9	0-0	0.0
Balanus sp.	0-43	10.8	0-20	4.7	0-12	5.2
Polyachetes	0-20	7.7	0-7	1.4	0-3	1.4
Decapods	0-0	0.1	0-2	0.4	0-0	0.0
Oikopleurans	0-0	0.1	0-1	0.2	0-3	1.4

* Fish in these groups were fed minced fish flesh *ad libitum* given 4x daily during daytime.

Table 4. – Percentage composition by number (%CN) of various food items in the stomachs of sea bass fry reared in illuminated nursery cages with different feeding regimes. Percentage contributions of minced fish flesh to the diet of sea bass held both in lit and unlit control cages were arbitrarily designated as + (1-20%), ++ (21-50%) of the total amount of food in the gut). NO = no observations. * Mean feeding incidence (%) = total number of fish with food in their gut/total number of fish examined × 100.

Food items	Lighted cages		Unlighted cages
	NZ + MFF	NZ	MFF
Decapods	1	7	1
Brachyurans	6	5	1
Pteropods	nil	nil	nil
Amphipods	nil	nil	nil
Copepods	43	88	59
Barnacles	nil	nil	nil
Tintinnids	NO	nil	NO
Oikopleurans	NO	nil	NO
Vertebrates	nil	nil	NO
Polychaetes	nil	NO	nil
Minced fish fesh	++	NO	++
* Mean feeding incidence, (%)	92.2	94.3	82.4
Fish examined, no.	232	316	165

survival of sea bass fry grown in illuminated cages, a stocking density of 600 m^{-2} seemed to be optimal when fish were reared on wild zooplankton alone. However, increasing the stocking density to 1 200 m^{-2} would indicate the need for supplemental feeding in the form of minced fish flesh. Under lit-cage, conditions with supplemental feeding, mean SGR (8% day^{-1}) of fish was significantly higher than the other two groups, although this was still lower compared to the SGR (13-16% day^{-1}) obtained in the freshwater pond-reared sea bass juveniles.

All throughout the rearing period, mean feeding incidence was generally higher for fish kept in lit cages (92-94%) than that of fish held in the unlit control cages (82%). This could be explained by the significantly higher mean zooplankton abundances (up to 343 l^{-1} in NZ + MFF cages and 496 l^{-1} in NZ cages) in lit cages than in the unlit control cages. Increased zooplankton density in lit cages was attributed to artificial illumination provided during the normal dark period (18:00- 05:30 h). Under freshwater pond conditions, Barlow *et al.* (1993) demonstrated that potentials for growth and survival of *L. calcarifer* with body size of 10-40 mm TL can be maximized when there is abundant zooplankton. Furthermore, since young sea bass is a particulate feeder which swallows prey whole by effecting a powerful sucking action of the buccal cavity (Davis, 1985; Barlow *et al.*, 1993), constant illumination is needed to enable the fish to locate its food. This also explains why supplemental feeding in fish kept in the unlit control cages was carried out during daytime which is similar to the traditional practice of pond nursery (Kungvankij *et al.*, 1986). Lammens (1985) described a two-mode feeding in the bream, *Abramis brama*, *i.e.* particulate-feeding wherein there is visual prey selection and then swallowing them one by one, and filter-feeding where several prey are engulfed by a series of undirected snaps. In other fish species, several studies seemed to support the observation that increased daylength enhanced fish feeding efficiency resulting in improved growth and survival. In the Atlantic salmon, *Salmo salar*, continuous or extended daylength increased feeding activity and growth while short daylength caused a restricted feeding time which resulted in the inhibition of growth (Stefansson *et al.*, 1990; Krakenes *et al.*, 1991; Berg *et al.*, 1992). In the 30-day-old European sea bass, *Dicentrarchus labrax*, larvae feeding and swimming activities stopped during the dark period (9L/15D) resulting in slower growth and poor survival compared to fish reared under a 24-h photoperiod (Ronzani-Cerqueira and Chatain, 1991). However, recent studies by Barlow *et al.* (1993) suggested that growth and survival of metamorphosed *L. calcarifer* fry reared under a 24-h light regime did not differ significantly from fish exposed to a normal photoperiod (12L/12D) although daily food consumption of the former group was 40% higher than the latter. Both groups, however, were fed to excess with wild zooplankton harvested from ponds. The present results therefore seemed to indicate that the significantly slower growth and poor survival of sea bass fry reared in the unlit control cages was due to the lower zooplankton food availability that resulted in reduced fish feeding activity. Another contributing factor was the fact that minced fish flesh as main food source for sea bass fry was nutritionally inferior to live or frozen zooplankton (Fermin and Bolivar, 1994).

Results of the stomach-content analysis revealed that fish kept in the lit cages fed sufficiently on light-attracted wild zooplankton which comprised mainly the planktonic crustaceans such as copepods. This was evidenced by the high percentage composition (range: 86-94%) of copepods in the diet of fish in all cages. The present observation was in agreement with the feeding habits of wild (Patnaik and Jena, 1976; Davis, 1985) and freshwater pond-reared (Barlow *et al.*, 1993) young sea bass (4-40 mm size class) which showed an ontogenetic progression in their diet from microcrustacea to macrocrustacea. Moreover, copepod adults and their nauplii constituted about 67-96% of the total zooplankton abundance (range: 614-687 individuals l^{-1}) in the lighted cages as well as in the unlit control cages (mean total = 123 ind. l^{-1}) throughout the duration of the study. Under pond nursery conditions, 53-85% and 75-100% of sea bass larvae ranging from 10-40 mm TL fed on copepods and *Moina* sp. (Barlow *et al.*, 1993).

Sea bass reared under the NZ + MFF feeding regime were found to have both zooplankton and minced fish flesh remains in their stomachs at the time of sampling. This observation was consistent with the findings of Barlow *et al.* (1993) that sea bass of about 37 mm TL reared under continuous feeding conditions took a longer time to evacuate food in their stomachs. Furthermore, smaller fish (16 mm) during conditions of insufficient food availability took a much longer time to evacuate their stomachs. This could explain why fish kept in the unlit cages still have minced fish flesh remains in their stomachs at the time of sampling which have to be egested until the next feeding time. However, the present results were limited by the lack of data on food consumption which would indicate if the amount of food ingested approximates that of the optimal daily ration for sea bass reared in nursery cages. Barlow *et al.* (1993) were able to determine the daily ration for freshwater pond-reared sea bass fry of 16 mm and 37 mm TL to be 19-86% and 38-56% of the body weight, respectively.

The present results showed that the occurrence of shooters was neither a result of the differences in stocking density nor by the lack or use of supplemental feeds. Nevertheless, fish mortalities can also be attributed to cannibalism by these significantly faster growing cohorts. In the intensive rearing of the European sea bass, *Dicentrarchus labrax*, cannibalism-induced mortality occurs due to high stocking density resulting in inadequate or insufficient food supply (Katavic *et al.*, 1989).

This study therefore concluded that nursery rearing of sea bass fry in illuminated floating net cages installed in coastal areas is practicable and can be an alternative to the traditional method of pond nursery. Natural zooplankton (mainly copepods) attracted to the cage by artificial illumination at night can be sufficient sources of food for sea bass nursery rearing. A stocking density of 600 m^{-2} can be used when fish are fed zooplankton alone. However, supplemental feeding in the form of minced fish flesh given *ad libitum* during daytime is needed when stocking density is increased to 1 200 m^{-2}.

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REFERENCES

Barlow C.G., M.A. Rimmer 1993. Larval and juvenile culture of barramundi *Lates calcarifer* (Bloch). Final Rep., Fish. Ind. Res. Dev. Council Proj, 89/67, 163 p.

Barlow C.G., L.J. Rodgers, P.J. Palmer, C.J. Longhurst 1993. Feeding habits of hatchery-reared barramundi *Lates calcarifer* (Bloch) fry. *Aquaculture* **109**, 131-144.

Berg A., T. Hansen, S. Stefansson 1992. First feeding of Atlantic salmon (*Salmo salar* L.) under different photoperiods. *J. Appl. Ichthyol.* **8**, 251-256.

Champigneulle A., R. Rojas-Beltran 1990. First attempts to optimize the mass rearing of whitefish (*Coregonus lavaretus* L.) larvae from Leman and Bourget Lakes (France) in tanks and cages. *Aquat. Living Resour.* **3**, 217-228.

Davis T.L.O. 1985. The food of barramundi, *Lates calcarifer* (Bloch), in coastal and inland waters of Van Diemen Gulf and the Gulf of Carpentaria. *Austr. J. Fish Biol.* **26**, 669-682.

Duray M.N., J.V. Juario 1988. Broodstock management and seed production of rabbitfish, *Siganus guttatus* (Bloch) and *Lates calcarifer* (Bloch). In: Perspectives in Aquaculture Development in Southeast Asia and Japan, J.V. Juario, L.V. Benitez eds., 195-210.

Fermin A.C. 1991. Freshwater cladoceran *Moina macrocopa* (Strauss) as an alternative live food for rearing sea bass *Lates calcarifer* (Bloch) fry. *J. Appl. Ichthyol.* **7**, 8-14.

Fermin A.C., Ma. E.C. Bolivar 1994. Feeding live or frozen *Moina macrocopa* (Strauss) to Asian sea bass, *Lates calcarifer* (Bloch), larvae. *Isr. J. Aquac.-Bamidgeh* **46**, 132-139.

Ganzon-Naret E.S., A.C. Fermin 1994. Effect of delayed feeding of *Artemia salina* and partial replacement by *Moina macrocopa* on growth and survival of sea bass, *Lates calcarifer* (Bloch), larvae. *Isr. J. Aquac.-Bamidgeh* **46**, 48-52.

Katavic I., J. Jug-Dujakavic, B. Glamuzina 1989. Cannibalism as a factor affecting the survival of intensively cultured sea bass (*Dicentrarchus labrax*) fingerlings. *Aquaculture* **52**, 11-19.

Krakenes R., T. Hansen, S. Stefansson, G.L. Taranger 1991. Continuous light increases growth rate of Atlantic salmon (*Salmo salar* L.) postsmolts in sea cages. *Aquaculture* **95**, 281-287.

Kungvankij P., L.B. Tiro Jr., B.J. Pudadera Jr., I.O. Potestas 1986. Biology and culture of sea bass (*Lates calcarifer*). NACA Training Manual Series No. 3 SEAFDEC Aquaculture Department and FAO-UN. 70 p.

Lammens E.H.R.R. 1985. A test of a model for planktivorous filter-feeding by bream, *Abramis brama. Environ. Biol. Fishes* **13**, 288-296.

Mamcarz A., J.A. Szczerbowski 1984. Rearing of coregonid fishes (Coregonidae) in illuminated cages I. Growth and survival of *Coregonus lavaretus* L. and *Coregonus peled* Gmel. *Aquaculture* **40**, 135-145.

Mamcarz A., M. Nowak 1987. New version of an illuminated cage for coregonid rearing. *Aquaculture* **65**, 183-188.

Mamcarz A., J. Kozlowski 1992. Rearing peled (*Coregonus peled* Gmel) larvae in illuminated cages with supplemental utilization of artificial feed. In: Biology and Management of Coregonid Fishes, T.N. Todd and M.L. Luczynski, eds. *Pol. Arch. Hydrobiol.* **39**, 703-711.

Parazo M.M., D.M. Reyes Jr., E.M. Avila 1991. Hatchery rearing of sea bass *Lates calcarifer* Bloch. *Philipp. Sci.* **28**, 65-76.

Patnaik S., S. Jena 1976. Some aspects of biology of *Lates calcarifer* (Bloch) from Chilka Lake. *Indian J. Fish.* **23**, 65-71.

Rimmer M., B. Rutledge 1991. Extensive rearing of barramundi larvae. Queensland Department of Primary Industries Information Series Q191012, Brisbane, Queensland, Australia, 5 p.

Ronzani-Cerqueira V., B. Chatain 1991. Photoperiodic effects on the growth and feeding rhythm of European sea bass, Fish & Crustacean Larviculture Symposium. P. Lavens, P. Sorgeloos, E. Jaspers, F. Ollevier eds. European Aquaculture Society, Spec. Publ. 15, Gent, Belgium, 304-306.

Rösch R., R. Eckmann 1986. Survival and growth of prefed *Coregonus lavaretus* L. held in illuminated net cages. *Aquaculture* **52**, 245-252.

SAS Institute Incorporated 1991. SAS Systems for Linear Models, Third Edition, Cary, NC, 329 p.

Schmitt P.D. 1986. Feeding by larvae of *Hypoatherina tropicalis* (Pisces: Atherinidae) and its relation to prey availability in One Tree Lagoon, Great Barrier Reef, Australia. *Environ. Biol. Fishes* **16**, 79-94.

Stefansson S., R. Nortvedt, T.J. Hansen, G.L. Taranger 1990. First feeding of Atlantic salmon, *Salmo salar* L., under different photoperiods and light intensities. *Aquac. Fish. Manage.* **21**, 435-441.