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EFFECTS OF LIGHT INTENSITY ON EARLY LIFE DEVELOPMENT OF GILTHEAD SEA BREAM LARVAE (*SPARUS AURATA*)

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Abstract

The effects of different levels of illumination on sea bream *(Sparus aurata*, L. 1758) larvae were examined. The best total length development and highest survival rate were achieved in a dark environment. Illumination affected the relationships between total length and digestive tube length, total length and oil globule volume, and total length and yolk sac volume. The relationships between total length and digestive tube length, and total length and oil globule volume were not significant ly different ($p>0.05$) among groups whereas the relationship between total length and yolk sac volume was significantly different ($p<0.05$) between the group under 450 lux illumination and the group under 30 lux. All the relationships were significantly different ($p<0.05$) between groups kept in complete darkness and those which were illuminated.

Introduction

The gilthead sea bream (*Sparus aurata)* is a common teleost fish in the Mediterranean Sea, where it is one of most commonly used species in aquaculture in both land-based farms and cages at sea (Le-Breton, 1994). Many studies have compared effects of supplying light continually or for very long periods with natural conditions on cultured marine fish larvae (Tandler and Helps, 1985; Ounais-Guschemann, 1989). Among the numerous abiotic factors which regulate fish larvae activity, light plays a major role in aquaculture (Chatain and Ounais-Guschemann, 1991). One of the least understood and most important physical parameters in the rearing environment is light (Palanas and Cunha, 1999).

Light intensity is important for fish and larvae, which must be reared within a light range

that depends on developmental stage and species (Boeuf and Le'Bail, 1999). Light has a great influence on pigmentation and serious developmental abnormalities appear when light is insufficient (Bolla and Holmefjord, 1988). Resorption of the yolk sac and development of the digestive tract and associated organs are all affected by illumination (Sarasquete et al., 1995).

This study investigates the effects of illumination level on survival and growth rates as a result of absorption of endogenous food reserves of gilthead sea bream larvae in the lecithotrophic stage. Greater knowledge of the digestive system and its functional capabilities in relation to age is of much interest for progress in larvae-rearing techniques of marine fish.

Materials and Methods

Five females (2 kg mean weight) and five males (1.1 kg mean weight) of gilthead sea bream (*Sparus aurata)* broodstock were selected from wild breeders and stocked in a 5 m^3 tank with a seawater supply of 25 l/min. The fish were subjected to a natural photoperiod. Water temperature varied throughout the experimental period between 18.5 and 19.5°C. Spawned eggs were immediately collected into a recuparator. Following fertilization, bouyant viable eggs were separated from sinking dead eggs. Eggs were incubated in 30 l incubators supplied with a gentle flow of sea water of 19±0.5°C. The volumetric method was used to determine the survival rate and stocking density of the eggs.

Larvae were stocked at a density of 50/l in 200 l cylindrical-conical tanks. The color of the tanks was dark-gray (Divanach et al., 1996). The water flow rate was adjusted to exchange 5% of the total volume of the tanks every hour. The aeration rate was 40 ml/min. The temperature was kept at 19°C, and the salinity at 38‰. Three different experimental groups totalling nine tanks were established. In these groups, only the illuminating factor changed; other medium conditions were identical. Illumination was applied by using a yellow light source with a rheostat 1 m above the surface of the tanks at 450 lux (group A), 30 lux (group B) and no illuminance (group C) for 24 hours per day. The three illumination levels tested in this experiment are commonly used in commercial aquaculture practices in Turkey. Each experiment was repeated three times for each group. Light intensity was measured by using a luxmeter at the tank surface.

The length of the larvae, the length and width of the yolk sac and the diameter of the oil globule for ten individuals from each tank were measured every eight hours. The first measurement following hatching was made before exposure of the larvae to the different levels of illumination. Therefore, the initial values for all the experimental animals were the same. Total body length, the length of the two axes of the spheroid yolk sac (L, major axis; H, minor axis) and the diameter (d) of the spherical oil globule were measured using a microscope with an ocular micrometer lens and read to the nearest 0.01 mm. The yolk sac (V_{ys}) and oil globule (V_{og}) volumes were calculated using formulae produced by Blaxter and Hempel (1966) and Cetta and Capuzzo (1982) as follows: $V_{ys}=4/3\pi(L/2)(H/2)^2$ and $V_{og}=4/3\pi(d/2)^3$.

The experiment was terminated when the first mouth openings were observed in the larvae. At the end of the experiment, survival rates were determined by counting the number of survivors. Regression analyses of total length/digestive tube length, total length/yolk sac volume, and total length/oil globule volume were carried out for each group, and the degree of significance was found by ANCOVA.

Results

During the experiments, the average temperature and salinity in the tanks were 19.1±0.42°C and 38±0.19‰, respectively. The values did not significantly differ between tanks ($p>0.05$).

The average oil globule volume of the larvae when taken from the incubators (the beginning of the experiment) was 0.00717±0.00030 mm^3 (n=30). In group A (450 lux illuminance), the average oil globule volume was 0.001290±0.00011 mm^3 (n=30) at the 60^{th} hour when the first mouth opening was observed (the end of the experiment). In group B (30 lux illuminance), this value was 0.002353±0.00014 mm^3 (n=30) at the 62^{nd}

hour when the first mouth opening was observed. In group C (no illuminance), the average oil globule volume was 0.002765±0.00017 mm^3 (n=30) at the 62^{nd} hour when the first mouth opening was observed. Analyses of the results show negative allometry in all groups for the relation between total length and oil globule volume. These relationships were y=–0.0034x+0.0163 (r=0.7159, n=270) for group A, y=–0.0034x+0.0164 (r=0.9326, n=270) for group B, and y=–0.003x+0.0156 (r=0.9336, n=270) for group C. Results of the covariance test showed that the relation between group A and group B was not statistically significant (p>0.05), whereas the relationships between group C and the other groups were statistically significant (p<0.05). The results of the analysis are given in Table 1.

The average yolk sac volume of the larvae taken from the incubators was 0.21255± 0.01211 mm^3 (n=30). At the end of the experiment, the average yolk sac volume in group A was 0.004692±0.00051 mm^3 (n=30), in group B was 0.005154±0.00030 mm^3 (n=30), and in group C was 0.008660±0.00036 mm^3 (n=30). Analysis of the results showed a negative allometry for the relationship between total length and yolk sac volume. The value of y was –0.123x+0.5183 (r=0.721, n=270) for group A, –0.1417x+0.5678 (r=0.9125, n= 270) for group B, and –0.1331x+0.557 (r=0.9401, n=270) for group C. Covariance analysis found that the relationships among all groups were significantly different (p<0.05). Results of the analysis are given in Table 2.

The average length of the digestive tube of the larvae at the beginning of the experiment was 0.245260±0.01263 mm (n=30). At the end of the experiment, this value was 0.645910± 0.0314 mm (n=30) for group A, 0.679558± 0.0402 mm (n=30) for group B, and 0.675640± 0.0354 mm (n=30) for group C. Analysis of the results showed a negative allometry for the relationship between total length and vitellus-oil globule volume in all groups. The relationships were y=0.2772x–0.4631 (r=0.800, n=270) for group A, y=0.3208x–0.6204 (r=0.9283, n= 270) for group B, and y=0.3959x–0.5854 (r=0.8572, n=270) for group C. Covariance analysis showed that the relationship between groups A and B was insignificant (p>0.05), but the relationship between group C and other groups was significant (p<0.05).

The average initial total length of the larvae was 2.72590±0.07287 mm (n=30). At the end of the experiment, the average total lengths were 3.96523±0.1749 mm (n=30) for group A, 4.016253±0.1938 mm (n=30) for group B, and 4.12168±0.1391 mm (n=30) for group C. Group C developed faster than the other groups (p<0.05; Table 3).

Average survival rates at the end of the experiment were 84%, 87% and 89% in groups A, B, and C, respectively.

Discussion

It is known that illuminance affects feeding behavior of sea bream larvae (Tandler and Mason, 1983; Kentouri, 1985; Ounais-Guschemann, 1989). Too much light can be stressful or even lethal (Boeuf and Le'Bail, 1999). In our study, the effects of different illuminance conditions on absorption of endogenous food reserves, digestive tube length, total length of larvae and survival were examined.

Yolk reserves of fish contain glycogen, proteins, lipoproteins, lysosomal enzymes and other enzymes related to protein, carbonhydrate and lipid metabolism. Acid and alkaline phosphatase activity were detected in the yolk of *S. aurata* by Sarasquete et al. (1993). Periblast plays an important role in consumption of vitellus and oil globule. Particles of lipoprotein can be seen in golgi body, endoplasmic reticulum and the circulation area of perivitellin (Mani-Ponset et al., 1996). Lipid consumption in the digestive tube starts on the same day as mouth opening (Diaz et al., 1997). Illuminance conditions had an effect on the speed of consumption of the yolk sac when the lecithotrophic phase of sea bream larvae was examined. It has been considered that illuminance has an effect on the use of energy obtained from the yolk sac. The fact that length develops faster in a dark environment seems to support this hypothesis. It is possible that a greater amount of the total energy obtained from yolk absorption is transferred into metabolic energy in illuminated conditions. In this

Table 1. Covariance analysis of results of sea bream larvae grown for 60-62 hours in 450 lux illumination (group A), 30 lux illumination (group B) or no illumination (group C).

		Source of Variation	*df*	*SS*	*MS*	*Fs*
Digestive tube length (mm) -	Group A	Adjusted means (among ai's)	2	0.008652	0.004326	1.01
Total length (mm)		Error (deviations from a common slope)	266	0.833692	0.003134	
	Group B	Adjusted means (among ai's)	2	0.004537	0.002268	0.66
		Error (deviations from a common slope)	266	0.913329	0.003434	
	Group C	Adjusted means (among ai's)	2	0.002377	0.001163	0.32
		Error (deviations from a common slope)	266	0.966467	0.003633	
Oil globule volume (mm^3) -	Group A	Adjusted means (among ai's)	2	0.000009	0.000001	1.13
Total length (mm)		Error (deviations from a common slope)	266	0.000442	0.000002	
	Group B	Adjusted means (among ai's)	2	0.000001	0.000001	1.35
		Error (deviations from a common slope)	266	0.000093	0.000001	
	Group C	Adjusted means (among ai's)	2	0.000001	0.000001	1.02
		Error (deviations from a common slope)	266	0.000083	0.000001	
Yolk sac volume (mm^3) -	Group A	Adjusted means (among ai's)	2	0.007669	0.003835	1.27
Total length (mm)		Error (deviations from a common slope)	266	0.533334	0.002005	
	Group B	Adjusted means (among ai's)	2	0.000121	0.000061	0.72
		Error (deviations from a common slope)	266	0.224165	0.000843	
	Group C	Adjusted means (among ai's)	2	0.001487	0.000743	1.38
		Error (deviations from a common slope)	266	0.143448	0.000539	

Table 2. Covariance analysis of relationships between results for sea bream larvae grown 60-62 hours in 450 lux illumination (group A), 30 lux illumination (group B) or no illumination (group C).

		Source of Variation	*df*	*SS*	*MS*	*Fs*
Digestive tube length (mm) – Total length (mm)	Relation A-B	Adjusted means (among ai's)	2	0.002377	0.001163	2.81
		Error (deviations from a common slope)	266	0.966467	0.003633	
	Relation A-C	Adjusted means (among ai's)	2	0.004537	0.002268	4.73
		Error (deviations from a common slope)	266	0.913329	0.003434	
	Relation B-C	Adjusted means (among ai's)	2	0.008652	0.004326	1.01
		Error (deviations from a common slope)	266	0.833692	0.003134	
Oil globule volume (mm^3) – Total length (mm)	Relation A-B	Adjusted means (among ai's)	2	0.000001	0.000001	36.20
		Error (deviations from a common slope)	266	0.000083	0.000001	
	Relation A-C	Adjusted means (among ai's)	2	0.000001	0.000001	24.21
		Error (deviations from a common slope)	266	0.000093	0.000001	
	Relation B-C	Adjusted means (among ai's)	2	0.000009	0.000001	1.75
		Error (deviations from a common slope)	266	0.000442	0.000002	
Yolk sac volume (mm^3) – Total length (mm)	Relation A-B	Adjusted means (among ai's)	2	0.001487	0.000743	15.01
		Error (deviations from a common slope)	266	0.143448	0.000539	
	Relation A-C	Adjusted means (among ai's)	2	0.000121	0.000061	2.22
		Error (deviations from a common slope)	266	0.224165	0.000843	
	Relation B-C	Adjusted means (among ai's)	2	0.007669	0.003835	12.71
		Error (deviations from a common slope)	266	0.533334	0.002005	

Table 3. Mean final oil globule volume, yolk sac volume, digestive tube length, total length and survival (± standard deviation) of sea bream larvae grown 60-62 hours in 450 lux illumination (group A), 30 lux illumination (group B) or no illumination (group C).

		Group A	*Group B*	*Group C*
Oil globule volume (mm^3)	Initial	0.007170±0.00030*		
	Final	0.001290±0.00011	0.001353±0.00014	0.002765±0.00017
Yolk sac volume (mm^3)	Initial	0.21255±0.01211*		
	Final	0.004692±0.00051	0.005154±0.00030	0.008660±0.00036
Digestive tube length (mm)	Initial	0.24526±0.01263*		
	Final	0.645910±0.0314	0.679558±0.0402	0.675640±0.0354
Total length (mm)	Initial	2.72590±0.07287*		
	Final	3.96523±0.1749	4.016253±0.1938	4.12168±0.1391
Survival (%)		84	87	89

*Same for groups B and C.

way, it has been thought, energy otherwise reserved for growth is consumed for metabolism instead, in light conditions.

Light increases the consumption of the oil globule and considerably affects development of the digestive tube. The speed of oil globule absorption in light conditions indicates increased lipid absorption from the surface of the digestive tube, suggesting that larvae in light have better digestion ability.

There were considerable differences in total length development of larvae in different illuminance conditions ($p<0.05$). Total length was greater in tanks with low illuminance. This finding may be because larvae have more frequent 2-3 second spasmodic movements in light conditions. The need for metabolic energy increases as a result of the convulsions, negatively affecting the development of the larvae. The total length development observed in our study is similar to that in the study carried out by Kentouri and Divanach (1982).

The highest survival was observed in the tanks kept in the dark. This result has been related to the increased stress in tanks with illumination. In experiments in which 15-20 lux illuminance was applied, there were no negative effects of light on the survival rate (Chatain and Ounais-Guschemann, 1991).

Survival in tanks with 450 lux intensity was lowest, survival in tanks with 30 lux illuminance was relatively higher, but the best results were achieved in the dark. Total length, also, was greatest in the tanks with no illumination. This has been related to the decrease in strain caused by light and the use of endogenous food reserves for development rather than movement. In our study, the positive effects on development of spending the early larval stage in a dark environment have been proved.

References

Blaxter J.H.S. and G. Hempel, 1966. Utilization of the yolk by herring larvae. *J. Mar. Biol. Assoc*. (U.K.), 46:219-234.

Boeuf G. and P.Y. Le'Bail, 1999. Does light have an influence on fish growth? *Aquaculture,* 177:129-152.

Bolla S. and I. Holmefjord, 1988. Effect of temperature and light on development of Atlantic halibut larvae. *Aquaculture,* 74:355–358.

Cetta C.M. and J.M. Capuzzo, 1982. Physiological and biochemical aspects of embriyonic and larval development of the winter flounder, *Pseudopleuronectes americanus. Mar. Biol.*, 71:327-337.

Chatain B. and N. Ounais-Guschemann, 1991. The relationships between light and larvae of *Sparus aurata*. pp. 310-313. In: *Larvi'91 - Fish & Crustacean Larviculture Symp.*

Diaz J.P., Guyot E., Vigier S. and R. Connes, 1997. First event in lipid absorption during post-embryonic development of the anterior intestine in gilthead sea bream*. J. Fish Biol.,* 51(1):180-192.

Divanach P., Boglione C., Menu B., Koumoundoros G., Kentouri M. and S. Cataudella, 1996. pp. 45-66. In: *Sea Bass and Sea Bream Culture: Problems and Prospects.* E.A.S.

Kentouri M., 1985. Comportement larvaire de 4 sparides mediterranees en elevage: *Sparus aurata, Diplodus sargus, Lithognathus mormyrus, Puntazzo puntazzo.* These de doctorat d'etat, Univ. Sciences et Techniques du Languedoc, Montpelier. 492 pp.

Kentouri M. and P. Divanach, 1982. Differences et similitudes dans la genese des comportements locomoteur et tropque des stades prelarvaires de *Sparus aurata*, *Diplodus vulgaris* et *Diplodus sargus*. *Aquaculture,* 27:355-376.

Le-Breton A.D., 1994. Marine fish breeding in the Mediterranean: rearing techniques actual situation and prospects. *Rec. Med. Vetet. De L'Ecole d'Alfort.*, 170:121-128.

Mani-Ponset L., Guyot E., Diaz J.P. and R. Connes, 1996. Utilization of yolk reserves during post-embryonic development in three teleostean species: the sea bream *Sparus aurata*, the sea bass *Dicentrarchus labrax* and the pike-perch *Stizostedion lucioperca. Marine Biol.,* 126(3):539-547.

Ounais-Guschemann N., 1989. Definition d'un modele d'elevage larvaire intensif pour la daurade, *Sparus auratus*. These de doctorat de l'Univ. d'Aix-Marseille II. 184 pp.

Planas M. and I. Cunha, 1999. Larviculture of

marine fish: problems and perspectives.. *Aquaculture,* 177:171–190.

Sarasquete M.C., Pascual E., Polo A. and M. Yufera, 1993. Histochemistry of proteins, lipids and carbohydrates in the constituent of ooctes, eggs and larvae of *Sparus aurata* L. pp. 31-314. In : B.T. Walther and H.J. Fyhn (ed.). *Physiology and Biochemistry of Marine Fish Larvae*. Univ. Berge, Bergen.

Sarasquete M.C., Polo A. and M. Yufera, 1995. Histology and histochemistry of the development of digestive system of larval gilthead sea bream, *Sparus aurata. Aquaculture,* 130:79-92.

Tandler A. and S. Helps, 1985. The effect of photoperiod and water exchange rate on growth and survival of gilthead sea bream (*Sparus aurata*, Linnaeus; *Sparidae*) from hatching to metamorphosis in mass rearing systems. *Aquaculture,* 48:71-82.

Tandler A. and C. Mason, 1983. pp. 237-248. *Light and Food Density Effects on Growth and Survival of Larval Gilthead Sea Bream (Sparus aurata, Linnaeus; Sparidae).* World Maricult. Soc. Spec. Publ. Ser., Vol.3.