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Tank wall colour and light level affect growth and survival of Eurasian perch larvae (Perca fluviatilis L.)

Lakhdar Tamazouzt[a], Béatrice Chatain[b] and Pascal Fontaine[a, *]

[a] Laboratoire de Sciences Animales, INPL-UHP Nancy 1, MAN, 34 rue Sainte Catherine, 54000 Nancy, France
[b] IFREMER, Station de Palavas-les-Flots, chemin de Maguelone, 34250 Palavas-les-Flots, France

*: Corresponding author : Tel.: +33-383-30-28-41; fax: +33-383-32-30-16; E-mail: pascal.fontaine@lsa-man.u-nancy.fr

Abstract:

The influence of interaction between light intensity and tank wall colours on survival and growth of perch larvae (*Perca fluviatilis* L.) was investigated for 15 days after hatching. Three light intensities (250, 400 and 800 lx) and four wall colours (black, dark grey, light grey and white) were used. At the end of the experiment, survival rates ranged between 1% and 26%, and varied according to the different treatments (P=0.0001; df=11). A global effect of light intensity was detected (P=0.0001; df=2) and the highest survival rate was observed under 250 lx. Survival was also influenced by the tank wall colour (P=0.0001; df=3): light grey showed the best result (17%). The greatest growth in weight and length was observed in tanks with light grey and white walls, which were strongly illuminated, while the lowest growth was recorded in the tank with black walls and 250 lx illumination.

Keywords: Eurasian perch; Larvae; Tank colour; Light level; Survival; Growth

1. Introduction

The Eurasian perch *Perca fluviatilis* is a pelagic diurnal predator (Dabrowski, 1982) whose vision is of vital importance in food detection. Within the framework of perch culture development, optimization of the environmental conditions, especially in larviculture, is necessary to facilitate the feeding behavior of fish. Such a process involves, among others, the determination of the best contrast between food particles and nearby environment. To improve visual detection of food, the colour of tank walls (Corraza and Nickum, 1981; Hinshaw, 1986) and the lighting conditions (Ounaïs-Guschemann, 1989), such as light spectral characteristics, ligth position or light intensity, are major factors.

The aim of the study was to establish whether light intensity and tank wall colour influence survival and growth of Eurasian perch larvae raised under controlled conditions and fed with a formulated diet.

2. Materials and methods

2.1. Fish and facilities

Ribbons of fertilized eggs were harvested in Lake Léman (INRA Thonon-les-Bains, France). Twelve thousand newly hatched larvae (average weight and total length: 0.57 mg and 5 mm) were randomly distributed into 12 cylindroconical tanks of 100 l each (10 larvae/l) and reared for 15 days. The internal wall of the tanks was either black, dark grey, light grey or white (3 tanks per colour). Artificial illumination was provided by halogenic spotlights placed above the centre of each tank. The different intensities (250, 400 and 800 lux; Comp A 2010 Luxmeter, Chauvin-Arnaud) were obtained by adjusting the distance (from 1 to 3 m) between the water surface and the spotlight. In order to avoid any interference, each rearing unit was isolated with a black plastic cloth. During the experimental period, a constant photoperiod (L :D 14 :10) was maintained by an electronic clock. The experimental design is presented in table 1.

Table 1
Experimental design carried out during the 15 days rearing of Eurasian perch *Perca fluviatilis* larvae.

Light intensity	250 lux				400 lux				800 lux			
Wall colour	black	dark grey	light grey	white	black	dark grey	light grey	white	black	dark grey	light grey	white
Tank	1	2	3	4	5	6	7	8	9	10	11	12

2.2. Water quality and feeding

Initially, all tanks were filled with tap-water. Every day, food excess was siphoned and 20% of each unitary volume was renewed. Temperature, dissolved oxygen and pH were measured every two days. Water temperature was maintained between 19.7 and 21.6°C (mean: 20.2°C). In average, the dissolved oxygen content was above 4 mg O_2/l. pH fluctuated between 7.1 and 7.8 (mean :

7.3). N-$NH_4^+$and N-NO_2^- were checked twice a week. They were colorimetricaly measured with indophenol blue and sulfanilamid methods, respectively. The values always ranged between 0.01 and 1.45 mg N-NH_4^+/l (mean : 0.83) and between 0.00 and 0.37 mg N-NO_2^-/l (mean : 0.23).

During the first 3 days, larvae were only fed with frozen zooplancton (rotifers, copepods; Midisel Company, France). From day 4 to the end of the experiment, larvae received 6 meals/day (9 :00, 10 :30, 12 :00, 13 :30, 15 :00 and 16 :30) composed of a formulated diet only (dry matter DM : 95%, crude protein : 50.7% DM, total lipids : 10.7%; Pican Company, France). The food, consisting of 80-125 µm particles (Tamazouzt et al., 1998), was yellow-brown. For each meal, food was distributed in excess.

2.3. Survival, growth and data analysis

At day 0, 44 newly hatched larvae were sampled. Then, every two days (from day 2 to day 12), about 10 larvae were caught in each tank. At the end of the experiment, all larvae were counted for survival rate estimation and, according to survival rates, a maximum of 20 larvae was removed from each tank. All samples were conserved in a 10% formalin solution, then each fish was weighed and measured individually.

Analysis of variance, relative to total weight and length measured on days 2, 4, 6, 8, 10, 12 and 15, were carried out. The variability of variances led us to apply a two factor (wall colour and light intensity) non-parametric analysis Friedmann rank sum test (Zar, 1984). The comparison between means was carried out using the Tukey test. Survival rates were compared in a contingency table (Dagnelie, 1975).

3. Results

3.1. Survival

At the end of the experiment, survival rates were comprised between 1 and 26%, and varied according to the different treatments ((^{2} = 602.05; $\underline{P}$ = 0.0001; df = 11). A global effect of illumination was detected ((^{2} = 52.08; $\underline{P}$ = 0.0001; df = 2). The survival rates were higher (13%) among populations subjected to a 250 lux light intensity ((^{2} = 50.33; $\underline{P}$ = 0.0001; df = 2) than those subjected to 800 lux (9%) or 400 lux (10%) ((^{2} = 1.94; $\underline{P}$ = 0.1636; df = 1). Survival was also clearly influenced by the wall colour ((^{2} = 416.439 ; $\underline{P}$ = 0.0001 ; df = 3). Black walls (3%) were clearly worse than other wall colours (13%) ((^{2} = 230.575 ; $\underline{P}$ = 0.0001 ; df = 1). Among the latter, differencies were also present ((^{2} = 158.591 ; $\underline{P}$ = 0.0001 ; df = 2). Dark grey walls induced the lowest survival rate (7%) ((^{2} = 1135.919 ; $\underline{P}$ = 0.0001 ; df = 1), light grey ones the highest rate (17%) and white walls an intermediate rate (13%) ((^{2} = 19.311 ; $\underline{P}$ = 0.0001 ; df = 1).

3.2. Growth

At the end of the experiment, the average weight and total length of fish were respectively 2.5 mg and 8 mm. Until day 10, growth was slow and similar in all batches (Table 2). From day 12, a weight difference appeared between the lighter (white and light grey walls) and the darker (dark grey and black walls) tanks. On day 12, a mean weight of 1.87 mg was recorded in lighter tanks versus 1.21 mg in darker tanks. Growth in length presented the same characteristics with a 6.58 mm mean total length in lighter groups versus 6.45 mm in darker groups. On day 15, the effects of walls colour were confirmed. The highest mean weight was found with white walls (3.11 mg), the smallest one in black and dark grey walls (2.05 mg) and the intermediate one in light grey walls (2.68 mg). The average total length was also higher in lighter tanks (8.17 mm) than in darker tanks (7.51 mm). Light intensity effects were only perceptible at D15 considering the mean total length which corresponded to 7.90 mm (800 lux) versus 7.84 mm (250 or 400 lux). The interaction between light intensity and wall colour was significant. The greatest growth was observed in the lighter tanks, which were strongly illuminated, while the lowest one was recorded in the darker tanks, poorly illuminated.

Table 2
Main data provided by the non-parametric two factor analysis concerning the effects of light intensity (L) and tank wall colours (C) on weight and length growth of *Perca fluviatilis* newly hatched larvae fed with a formulated food during the first 15 days. The averages, classified in decreasing order, were compared using the Tukey test. Df : degree of freedom ; (*) significant to a 5 % threshold; —— homogenous groups.

	Source of variation	Variance		Df	H		Homogenous groups	
Age (d)		Weight	Length		Weight	Length	Weight	Length
	L	1263. 5	472.6	2	0.49	0.39		
2	C	602.6	2965.2	3	0.64	2.45		
	L x C	775.6	724.3	6	1.42	0.60		
	L	794.0	1736.8	2	0.65	1.43		
4	C	883.5	1372.2	3	0.73	1.13		
	L x C	1619.2	1068.2	6	1.34	0.88		
	L	627.5	789.8	2	0.52	0.65		
6	C	1325.9	1798.9	3	1.09	1.48		
	L x C	1467.5	1160.1	6	1.21	0.96		
	L	185.6	274.5	2	0.15	0.22		
8	C	495.9	3302.9	3	0.41	2.73		
	L x C	2043.9	574.9	6	1.69	0.47		
	L	4373.0	625.7	2	3.61	0.51		
10	C	7050.3	3720.6	3	5.82	3.07		
	L x C	2606.6	151	6	2.15	0.12		
	L	4034.3	227.8	2	3.33	0.19		
12	C	11881.4	10275.4	3	9.82*	8.5*	Lg W Dg B	Lg W B Dg
	L x C	4890.5	2875.2	6	4.04	2.37		
	L	43381.3	48254.6	2	1.1	11.8*		800 400 250
15	C	132048.0	100778.3	3	32.29 *	24.65*	W Lg Dg B	W Lg Dg B
	L x C	72165.64	58183.17	6	17.65 *	24.65*	@	@

@) : Below, treatments followed by the same letter are homogenous groups for the interaction L x C at day 15.

Weight : $W_{400\mathbf{a}}$ $W_{800\mathbf{a}}$ $Lg_{400\mathbf{ab}}$ $W_{250\mathbf{abc}}$ $Lg_{800\mathbf{abc}}$ $Dg_{800\mathbf{bcd}}$ $Dg_{250\mathbf{cd}}$ $Lg_{250\mathbf{d}}$ $B_{800\mathbf{e}}$ $B_{400\mathbf{f}}$ $Dg_{400\mathbf{fg}}$ $B_{250\mathbf{g}}$

Length : $W_{800\mathbf{a}}$ $Lg_{400\mathbf{a}}$ $Lg_{800\mathbf{ab}}$ $W_{400\mathbf{ab}}$ $W_{250\mathbf{ab}}$ $Dg_{250\mathbf{abc}}$ $Dg_{800\mathbf{bc}}$ $Lg_{250\mathbf{cd}}$ $B_{800\mathbf{de}}$ $B_{400\mathbf{def}}$ $Dg_{400\mathbf{ef}}$ $B_{250\mathbf{f}}$

4. Discussion

This short study showed that tanks with light colour walls (white or light grey) associated to high illumination (400-800 lux) favoured growth and survival of *Perca fluviatilis* larvae. Our results are different from those obtained by Corazza and Nickum (1981) and Hinshaw (1986) respectively on larvae of walleye *Stizostedion vitreum* and yellow perch *Perca flavescens*, two other percids. They found that tanks with dark walls improved the prey perception (rotifers, *artemia nauplii*). They also indicate that white walls highly attracted larvae and inhibited their feeding behavior (mirror effect). In our case, light walls associated with high illumination seems to induce a strong contrast between food particles (brown-yellow) and tank wall and, consequently, improve food perception (Ounaïs-Guschemann, 1989; Bristow and Summerfelt, 1994). The larvae distribution in all the water columns confirms the adequacy of the environmental conditions for perch larvae rearing, no mirror effect was observed. Concerning light intensity effects, our results are in accordance with Dabrowski's observations (1982), who indicates that food consumption of Eurasian perch larvae diminishes at the lowest light intensity. Similar observations were made with yellow perch larvae by Hinshaw (1986), who remarks that weak illumination associated with low contrasts induce a delay of 1 to 2 days in the initial food intake. The effects of tank wall colours and light intensity are related to retinal development (Guma'a, 1982).

For successful Eurasian perch larviculture, illumination such as 400-800 lux at the water surface and the use of tanks with light walls should be recommended. However, our results must be confirmed by further experiments, which will need a longer experimental period (3 to 4 weeks) and a more adapted feeding protocole (using live prey such as *artemia nauplii*).

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