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RESEARCH PAPER

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The Effect of Light Intensity and Tank Wall Colour on Survival and Growth of Peled *Coregonus peled* Gmelin 1788 Larvae

Roman Sebesta[1],*, Vlastimil Stejskal[1], Jan Matousek[1], Katsiaryna Lundova[1]

[1] University of South Bohemia in Ceske Budejovice, Faculty of Fisheries and Protection of Waters, South Bohemian Research Center of Aquaculture and Biodiversity of Hydrocenoses, Institute of Aquaculture and Protection of Waters, Na Sádkách 1780, 370 05 České Budějovice, Czech Republic

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Corresponding Author
Tel.: +420602423470
E-mail: sebestar@frov.jcu.cz

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Abstract

A 33-day experiment was carried out to investigate the effect of light at 80, 380, and 3800 lux and tank wall colour (black, grey, white, red, green, blue, clear) separately and in combination on growth, survival, yield, and size heterogeneity of peled *Coregonus peled* larvae. 7 groups of larvae in 3 repetitions were transferred to the experimental system. Each group comprised 300 larvae. Larvae were fed fresh live brine shrimp *Artemia salina* and artificial dry food LARVIVA ProWean. Significantly higher ($P < 0.05$) survival was observed in black and white tanks in comparison with grey tanks. Significantly lower ($P < 0.05$) size heterogeneity was observed in red and grey tanks compared to clear, black, green, and blue tanks, and in RD-H compared to WH-H, WH-M, WH-L, CL-H, CL-M, CL-L, BK-H, BK-M, BK-L, GN-H, GN-M, GN-L, BE-H, BE-M, BE-L, GY-H, and RD-M compared to WH-M, WH-L, CL-H, CL-M, CL-L, BK-H, BK-M, BK-L, GN-H, GN-M, GN-L, BE-H, BE-M, BE-L, and RD-L, GY-L, GY-M compared to WH-L, CL-H, CL-M, CL-L, BK-H, BK-M, BK-L, GN-H, GN-M, GN-L, BE-H, BE-M, BE-L. Based on our results, peled larvae are independent of light intensity. Rearing of peled in black tanks can be recommended for the highest survival.

Introduction

Peled *Coregonus peled* (Gmelin 1788) is a promising species for freshwater culture, especially in central and Eastern Europe (Mukhachev & Gunin, 1999). Recently, due to the predation, especially by cormorants *Phalacrocorax carbo* (L., 1758) its production has rapidly declined (Suter, 1997). Establishing stable whitefish production using recirculating aquaculture systems (RAS) requires determination of optimal larviculture conditions. Optimal light intensity (LI), tank wall colour (TWC), photoperiod, and light spectrum are critical factors in fish development (Boeuf & Le bail, 1999) from

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eggs (Prokesova, Stejskal, Matousek, Kouril, & Baras, 2017) to sexually mature fish (Suquet, Omnes, Normant, & Fauvel, 1992).

Many fish species have a minimum threshold of LI (Table 1) as well as optimal TWC (Table 2) for normal development and growth of larvae. Low LI is reported to affect detection and capture of prey (Buchet et al., 1995; Link & Edsall, 1996), searching activity (Ounais-Guschemann, 1989), and swimming speed in European whitefish *Coregonus lavaretus* L. and vendace *Coregonus albula* L. (Gjelland, Bøhn, Knudsen, & Amundsen, 2004) as well as disturbance of diurnal activity in European whitefish (Müller, 1978a) and photo-kinetic responses in lake whitefish *Coregonus clupeaformis* (Mitchill 1818) (Scherer & Harrison, 1988). Conversely, excessively high LI can cause severe retinal damage, as reported in European sea bass *Dicentrarchus labrax* (L., 1758), Atlantic cod *Gadus morhua* (L., 1758) and Atlantic salmon *Salmo salar* (L., 1758) (Vera & Migaud, 2009) and increased aggressiveness in African catfish *Clarias gariepinus* (Burchell 1822) (Britz & Pienaar, 1992). Different TWC induce a variety of responses in relation to growth (Luchiari & Pirhonen, 2008), survival (Raghavan et al., 2013), aggression (Hoglund, Balm, & Winberg, 2002), stress response (Rotllant et al., 2003; Papoutsoglou, 2005), behaviour and feed acceptance (Strand, Alanara, Staffan, & Magnhagen, 2007). The LI and TWC can influence fish survival (Brannas, Alanara, & Magnhagen, 2001) and inflation of larva swim bladder (Martin-Robichaud & Peterson, 1998), and optimal TWC is associated with lower incidence of mouth deformities (Cobcroft, Shu-Chien, Kuah, Jaya-Ram, & Battaglene, 2012). Some levels of LI and TWC has been demonstrated to induce stress in fish (Rotllant et al., 2003).

Table 1, Table 2

Larviculture is considered to be the most critical period in fish rearing with light being regarded as a crucial abiotic factor that can limit its quality. Furthermore, the optimal light conditions need to be determined for each fish species and developmental/reproductive stage to facilitate survival and growth and enable efficient management to maximize production and profitability, as well as to provide proper conditions for fish. Previous light studies in coregonids were conducted on European whitefish, vendace, and lake whitefish. However, there is no knowledge on the effect of light in early rearing of peled larvae in intensive culture. This study aimed to assess effects of tank wall colour, light intensity, and their combination on survival and growth of peled larvae.

Materials and Methods

Larvae

Peled larvae were obtained immediately after hatching from Kinský Žďár, a.s (49°58'N; 15º93'E) and transported to storage tanks at the wet laboratory of the Institute of Aquaculture and Protection of Waters (48°97'N; 14°45'N). After absorption of the yolk-sac, 300 larvae (2.12 ± 0.45 mg) were stocked into each of 63 tanks. A total of 18 900 of larvae were used.

Experimental system and design

The experiment was conducted for 33 days in a small recirculating aquaculture system (RAS) comprising two storage tanks (400 L, 480 × 555 × 1500 mm) and 63 rearing tanks (6.8 L, 120 × 190 × 300 mm) with flat bottoms and overflow with mesh size of 0.31 mm. Tanks were divided into a rearing section with water inflow and an aeration section using an air stone, separated to avoid contact of larvae with air bubbles. Water flow was at 3 L $m^{-1}h^{-1}$. Tank wall colours were black (BK), grey (GY), white (WH), red (RD), green (GN), blue (BE), and clear (CL) in combination with three light intensities: 80 lux (low = L), 380 lux (medium = M), and 3800 lux (high = H) provided by LED bulbs (Aquatlantis Easy LED Universal, Portugal). The combinations (experimental groups) BK-L, GY-L, WH-L, RD-L, GN-L, BE-L, CL-L, BK-M,

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GY-M, WH-M, RD-M, GN-M, BE-M, CL-M, BK-H, GY-H, WH-H, RD-H, GN-H, BE-H, and CL-H were tested. The tank bottom and the walls were covered with opaque plastic film. CL, WH and GY were considered light colours and GN, BE, BK and RD dark colours. The lights were positioned approximately 40 cm above tanks. Each experimental group was tested in triplicate. A consistent photoperiod 12D:12L was maintained using automatic timers (Ever Flourish EMT 445-F, Germany).

Culture Conditions

The oxygen level and pH were checked daily at 8.00 and 16.00. The pH range was monitored using a HACH HQ 40 multimeter (Germany) and maintained near neutral 6.8-7.2. Water temperature was kept at 13–15 °C using a HAILEA HC-1000A cooler (China). Oxygenation was near 100% saturation in the rearing aquaria and 80% at the tank outlets using SECOH and AIRMAC pumps (Japan, Taiwan). Ammonia, nitrate, and nitrite concentrations were analysed using HACH, LCK 304, LCK 339, LCK 341 (Germany) with HACH DR2800 spectrophotometer (Germany). NaCl was added at 1 g L^{-1} weekly to maintain a 16:1 chloride:nitrogen ratio. The aquaria were cleaned and dead larvae removed and counted daily.

Feeding

Brine shrimp *Artemia salina* L. metanauplii, 20–24 h old, 0.4-0.5 mm, 240 000 nauplii g^{-1} (Ocean Nutrition Europe, Belgium) were incubated following supplier's instructions. Fresh metanauplii were fed from 4 to 25 days post hatching (dph) at 500–700 $larvae^{-1}$ day^{-1}. Larvae were fed 7 times daily at 2 h intervals during the light phase (7.00 to 19.00).

Artificial dry food was fed from day 26-37 dph without co-feeding, since peled larvae easily adapt to artificial food (Stejskal et al., 2017). LARVIVA ProWean (BioMar, France) of particle size (80-200 µm) was provided six times per day at 2 h intervals. Composition of commercial feed was crude protein 58%, crude lipids 12%, crude ash 11.1%, crude cellulose 0.5%, vitamin C 1000 mg kg^{-1}, vitamin E 800 mg kg^{-1}, vitamin A 2.6 mg kg^{-1}, vitamin D3 0.044 mg kg^{-1}, phosphorus 1.64%, and n-3 HUFA 2.50% (manufacturer's data).

Sampling and Measurements

Dead larvae were removed from each tank during daily cleaning, counted, and preserved in 4% formalin. At completion of the experiment (37 dph), effect of LI, TWC, and their combination, on survival rate (SR), larval yield (LY), and size heterogeneity (SH), final weight (FW), total length (TL), standard length (SL), body height (BH) was assessed as follows:

SR (%) = $100 \times Nf\,(Ni - Ns)^{-1}$

in which Ni and Nf = initial and final number of larvae, respectively, Ns = number of dead larvae and sampled larvae per tank (day 7, 14, 21, 28)

LY was calculated using following formula:

$$LY\ (g) = \left(\left(\frac{initial\ number\ of\ larvae}{100}\right) \cdot survival\right) \cdot weight$$

with survival and weight = % surviving and mean weight (g) of larvae

SH was defined as coefficient of variance of weight, calculated as follows:

CV (%) = $100 \times (SD / W_m)$

in which CV = coefficient of variance; SD = mean standard deviation of weight of 30 randomly selected larvae per tank; W_m = mean weight (mg) of 30 larvae per tank.

At the conclusion of the experiment, 30 larvae from each tank were preserved in 4% buffered formalin and weighed on a digital microbalance (Mettler Tolledo, Excellence Plus, Switzerland, d = 0.0001 g). Larvae were digitally photographed, and TL, SL, BH were measured using image analysis in MicroImage 4.0 (Olympus, Japan).

Statistical Analysis

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The data are presented as mean ± SEM. Statistical analyses were performed using STATISTICA 12.0 (StatSoft, Praha, Czech Republic). The effects of tank conditions on body weight, total length, standard length, total height, survival rate, larval yield, and size heterogeneity were analysed by two-way ANOVA with TWC and LI as fixed variables. The level of significance used for all tests was α = 0.05 (Zar, 1999). Prior to ANOVA, survival percentages were arcsin-transformed. All data were tested for homogeneity of variance using the Cochran, Hartley, and Bartlett test, and for normality with the Shapiro-Wilk normality test. The parametric Tukey test was used for assessing differences among groups.

Results

Survival rate

A significantly ($P < 0.05$) higher survival rate was observed in black (69.0 ± 3.43%) and white (66.4 ± 1.64%) compared to grey (49.9 ± 1.96%) tanks (Figure 1a). No significant differences were observed in grey compared to red, clear, green, blue or white compared to black. Light intensity and combined effect of LI*TWC showed no significant effect on survival rate (Figure 1b and Figure 1c) (Table 4).

Figure 1a, Figure 1b and Figure 1c, Table 4

Growth

Light intensity, TWC, and their combination were not associated with significant differences $P < 0.05$) in body weight, total length, standard length, body height, or larval yield (Table 3 and Table 4). Tank wall colour was associated with significantly higher size heterogeneity in black (52.4 ± 1.77%), green (50.9 ± 3.27%), clear (46.6 ± 1.16%), blue (46.5 ± 1.51%), white (38.5 ± 1.66%) compared to red (20.5 ± 4.55%), and black, green, clear, blue compare to grey (27.3 ± 4.55%) and red (Figure 2a). No differences ($P < 0.05$) were observed in SH in the LI groups (Figure 2b). Significantly lower SH ($P < 0.05$) was found in RD-L, RD-M, RD-H, GY-L, GY-M compared to WH-L, CL-H, CL-M, CL-L, BK-H, BK-M, BK-L, GN-H, GN-M, GN-L, BE-H, BE-M, and BE-L and in RD-H compared to WH-L, WH-M, WH-H, CL-H, CL-M, CL-L, BK-H, BK-M, BK-L, GN-H, GN-M, GN-L, BE-H, BE-M, BE-L, and GY-H (Figure 2c).

Table 3 and Table 4, Figure 2

Discussion

Peled *Coregonus peled* is a recent addition to intensive aquaculture. Ensuring optimal breeding conditions is a basic precondition for successful larva rearing. The present study provided evidence that peled larvae can be cultured at a wide range of light intensities without significant effects on growth, survival rate, or larval yield. Whitefish larvae reared at 380 lux showed slightly higher survival rate compared to larvae reared at 80 lux and at 3800 lux, suggesting that LI in the intermediate range may be suitable for rearing peled larvae, although this is only speculation. Determining the proper light regime for peled culture systems is important from an economic standpoint. This study was unique, and we cannot extrapolate the effects of LI on growth, survival rate, and size heterogeneity to other coregonids. A wide range of intensity has been used in other research: Stejskal et al. (2017) used 200-400 lux in peled; Scherer and Harrison (1988) employed 1800 lux for whitefish *Coregonus clupeaformis*; Beier (2016) used 1 and 10 lux for vendace *Coregonus albula*; and Link and Edsall (1996) used 2, 5, 10, 40, 100, 400, 1000, and 1500 lux for lake herring *Coregonus artedi* (Lesueur 1818). Our results are similar to findings obtained by Kestemont et al. (2003), who stated that LI did not significantly affect survival rate and size heterogeneity of Eurasian perch *Perca fluviatilis* (L. 1758) larvae. Perch reared under 400 lux showed slightly higher survival rate than those reared under 5 lux. Hinshaw (1986) reported that yellow perch *Perca flavescens* (Mitchill 1814) larvae reared under 250 lux

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exhibited slightly higher survival rate compared to those reared at 75 lux. An intermediate level of LI seems to be optimal for peled and other visual feeders (Kestemont et al., 2003), whereas Hecht and Appelbaum (1987) stated that a low level of LI appears to be optimal for nocturnal feeders, which rely little on vision.

Tank wall colour had no significant effect on peled total length, standard length, body height, final weight, or larval yield. A significantly higher survival rate was observed in white and black tanks compared to grey. Size heterogeneity in red and grey tanks was significantly lower than in clear, black, green, and blue variations. Information regarding TWC and its effects on growth, survival rate, and size heterogeneity of other coregonids is scarce, and published reports do not provide detailed description of TWC in their experimental designs. Results similar to those of the present study regarding growth and size heterogeneity have been reported: Monk, Puvanendran, and Brown (2008) observed no significant difference in growth rate of Atlantic cod *Gadus morhua* larvae in tanks with black walls and dark bottoms compared to tanks with black walls and light bottoms. Jentoft, Øxnevad, Aastveit, and Andersen (2006) reported values of size heterogeneity for Eurasian perch *Perca fluviatilis* larvae reared in black tanks (51.1 ± 23.8%) similar to our findings (52.4 ± 27.3%) for the same colours.

We found no significant LI/TWC combined effects on growth parameters or on survival. Significant differences were observed only in size heterogeneity. Our results are similar to those of Downing and Litvak (2000) who reported no significant differences in survival rate of haddock *Melanogrammus aeglefinus* (L., 1758) larvae with LI 100 and 1500 lux combined with black or white TWC.

Fish growth rate and survival are affected by biochemical and neuro-hormonal processes with complex interactions (Papoutsoglou, 1998). Tank wall colour and LI may correlate with stress levels, especially plasma cortisol response (Rotllant et al., 2003). Stress can increase catabolic processes of cultured fish and may reduce growth (Strand, Alanara, Staffan, & Magnhagen, 2007; El Sayed & El Ghobashy, 2011) and survival rate (Okada et al., 2015). Papoutsoglou, Mylonakis, Miliou, Karakatsouli, and Chadio (2000) reported that fish reared in black tanks had significantly higher plasma cortisol levels than those reared in white tanks, and specific growth rate and final weight was significantly higher and feed conversion ratio significantly lower in white tanks. This was also observed by Eslamloo, Akhavan, Eslamifar, and Henry (2015), Rahnama, Heydarnejad, and Parto (2015), Wang et al. (2016), and Wang et al. (2017). On the contrary, Downing and Litvak (2000) and Martin-Robichaud and Peterson (1998) found larvae reared in dark coloured tanks to show lower stress levels, higher food intake, and less body damage.

Conclusion

Our results showed peled total length, standard length, body height, final weight, and larval yield to be independent of TWC, LI, or their combination. Survival rate in black and white tanks was higher than in grey tanks, and larvae in red and grey tanks showed significantly lower size heterogeneity compare to clear, black, green, and blue tanks. Based on our results, intermediate LI combined with black TWC can be recommended. The combined effect of LI and TWC needs to be further studied considering additional biotic and abiotic factors such as prey perception, the mirror effect (Hinshaw, 1986), retinal development (Guma'a, 1982), and walling behaviour (Cobcroft & Battaglene, 2009). Further studies investigating chronic effects of background colour on peled growth, survival, stress, and immune reactions are recommended.

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Table 1. Minimal light intensity thresholds for normal development and growth of different fish larvae

LI (lux)	Species	Source
< 1	*Clupea harengus* (L., 1758)	(Blaxter, 1975)
1	*Morone saxatilis* (Walbaum 1792)	(Chesney, 1989)
1-10	*Hippoglossus hippoglossus* (L., 1758)	(Hole & Pittman, 1995)
50	*Salvelinus alpinus* (L., 1758)	(Wallace, Kolbeinshavn, & Aassjor, 1988)
50-150	*Sparus aurata* (L., 1758)	(Ounais-Guschemann, 1989)
150	*Clarias gariepinus* (Burchell 1822)	(Almazan-Rueda, Schrama, & Verreth, 2004)
200-600	*Salmo salar* (L., 1758)	(Mortensen & Damsgard, 1993)
350	*Paralichthys lethostigma* (Jordan & Gilbert, 1884)	(Daniels, Berlinsky, Hodson, & Sullivan, 1996)
600	*Dicentrarchus labrax* (L., 1758)	(Barahona-Fernandes, 1979)
1000	*Siganus guttatus* (Bloch 1787)	(Duray & Kohno, 1988)

*LI = light intensity

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Table 2. Optimal tank wall colour for development and growth of different fish larvae

TWC	Species	Source
YE	*Oreochromil niloticus* (L., 1758)	(Luchiari, Duarte, Freire, & Nissinen, 2007)
BE	*Oncorhynchus mykiss* (Walbaum 1792)	(Ustundag & Rad, 2015)
RD	*Danio rerio* (Hamilton 1822)	(Spence & Smith, 2008)
BE	*Lates calcifer* (Bloch 1790)	(Ullmann et al., 2011)
WH	*Carrasius auratus* (L., 1758)	(Eslamloo, Akhavan, Eslamifar, & Henry, 2015)
WH	*Epinephelus coioides* (Hamilton 1822)	(Zhang et al., 2015)
DBE	*Pelteobagrus fulvidraco* (Richardson 1846)	(Rahnama, Heydarnejad, & Parto, 2013)
BK	*Pelteobagrus fulvidraco* (Richardson 1846)	(Rahnama, Heydarnejad, & Parto, 2013)
BE	*Scophthalmus maximus* (L., 1758)	(Li et al., 2016)

*TWC = tank wall colour – YE = yellow, BE = beige, RD = red, BE = blue, WH = white, DBE = dark blue, BK = black, GN = green, BE = blue

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Table 3. Effects of light intensity, tank wall colour and interaction of light intensity and tank wall colour on growth of *Coregonus peled* (Gmelin 1788) larvae in a 33 day growing trial.

TWC	LI	Group	BW (mg)	TL (mm)	SL (mm)	BH (mm)	LY (g)
RD	H (3800 lux)	RD-H	53.5 ± 1.60	22.2 ± 0.08	19.6 ± 0.06	3.2 ± 0.03	8.40 ± 0.31
	M (380 lux)	RD-M	58.0 ± 1.61	22.5 ± 0.08	19.5 ± 0.07	3.3 ± 0.03	10.1 ± 0.31
	L (80 lux)	RD-L	64.6 ± 1.64	22.5 ± 0.08	19.5 ± 0.06	3.2 ± 0.03	11.0 ± 0.32
WH	H (3800 lux)	RD-H	64.0 ± 1.69	22.1 ± 0.08	19.0 ± 0.06	3.3 ± 0.03	10.4 ± 0.33
	M (380 lux)	RD-M	69.6 ± 1.74	22.7 ± 0.08	19.5 ± 0.06	3.4 ± 0.03	12.1 ± 0.34
	L (80 lux)	RD-L	65.5 ± 1.78	22.5 ± 0.07	19.4 ± 0.06	3.3 ± 0.03	11.1 ± 0.35
CL	H (3800 lux)	RD-H	60.8 ± 1.71	23.1 ± 0.06	19.9 ± 0.04	3.6 ± 0.03	10.2 ± 0.33
	M (380 lux)	RD-M	58.3 ± 1.52	22.7 ± 0.03	19.6 ± 0.03	3.3 ± 0.02	9.50 ± 0.30
	L (80 lux)	RD-L	60.8 ± 1.56	22.3 ± 0.03	19.4 ± 0.03	3.3 ± 0.02	10.4 ± 0.32
BK	H (3800 lux)	RD-H	62.6 ± 1.55	22.1 ± 0.03	19.1 ± 0.03	3.2 ± 0.02	9.80 ± 0.31
	M (380 lux)	RD-M	70.3 ± 1.61	22.5 ± 0.03	19.4 ± 0.03	3.3 ± 0.03	10.5 ± 0.32
	L (80 lux)	RD-L	74.2 ± 1.57	22.6 ± 0.03	19.7 ± 0.03	3.2 ± 0.02	13.2 ± 0.34
GN	H (3800 lux)	RD-H	55.5 ± 1.66	23.1 ± 0.03	19.7 ± 0.03	3.5 ± 0.02	9.90 ± 0.36
	M (380 lux)	RD-M	59.7 ± 1.76	22.7 ± 0.03	19.4 ± 0.03	3.4 ± 0.02	10.2 ± 0.38
	L (80 lux)	RD-L	53.3 ± 1.75	22.7 ± 0.03	19.7 ± 0.03	3.1 ± 0.02	7.80 ± 0.38
BE	H (3800 lux)	RD-H	48.9 ± 1.90	21.6 ± 0.03	18.6 ± 0.03	3.2 ± 0.02	7.40 ± 0.41
	M (380 lux)	RD-M	63.8 ± 2.07	22.6 ± 0.03	19.5 ± 0.03	3.3 ± 0.02	10.2 ± 0.45
	L (80 lux)	RD-L	65.2 ± 2.39	22.5 ± 0.02	19.7 ± 0.01	3.1 ± 0.01	10.0 ± 0.51
GY	H (3800 lux)	RD-H	46.2 ± 1.69	21.6 ± 0.02	19.0 ± 0.01	3.0 ± 0.01	7.60 ± 0.24
	M (380 lux)	RD-M	52.9 ± 2.24	22.3 ± 0.01	19.4 ± 0.02	3.3 ± 0.01	8.40 ± 0.20
	L (80 lux)	RD-L	50.6 ± 1.60	22.5 ± 0.08	19.6 ± 0.06	3.1 ± 0.03	8.80 ± 0.31

Data are presented as mean ± S.E.M.

*BW= final body weight; TL= total length; SL, standard length; BH= body height; LY= larval yield

*LI = light intensity – H = H (3800 lux), M = M (380 lux), L = L (80 lux)

*TWC = tank wall colour – RD = red, white = WH, CL = clear, BK = black, GN = green, BE = blue, GY = grey

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Table 4. Two-way ANOVA results for the factors light intensity and tank wall colour and their interaction on final SR, BW, TL, SL, BH, LY, SH of *Coregonus peled* (Gmelin 1788) larvae.

Parameters	Source of variation	SS	DF	F	MS	*P*
SR	LI	500.10	6	250.10	2.37	0.11
	TWC	2170.50	6	361.70	3.43	0.01
	LI × TWC	573.80	12	47.80	0.45	0.93
BW	LI	0.00	2	0.00	0.11	0.90
	TWC	0.11	6	0.02	0.97	0.46
	LI × TWC	0.16	12	0.01	0.75	0.70
TL	LI	1.07	2	0.54	1.36	0.27
	TWC	2.94	6	0.49	1.24	0.30
	LI × TWC	4.97	12	0.38	0.97	0.49
SL	LI	0.98	2	0.49	1.84	0.17
	TWC	1.06	6	0.18	0.66	0.68
	LI × TWC	3.15	12	0.26	0.98	0.48
BH	LI	0.03	2	0.01	2.51	0.09
	TWC	0.04	6	0.01	1.01	0.43
	LI × TWC	0.04	12	0.00	0.51	0.90
LY	LI	21.64	2	1.85	1.85	0.17
	TWC	63.61	6	1.81	1.81	0.12
	LI × TWC	40.20	12	0.57	0.57	0.85
SH	LI	28.50	2	14.30	0.33	0.72
	TWC	8084.50	6	1347.40	31.32	0.00
	LI × TWC	1080.60	12	90.00	2.09	0.04

*SR = survival rate; BW = body weight; TL = total length; SL = standard length; BH = body height; LY = larval yield; SH = size heterogeneity.

*SS = sum of squares; DF = degrees of freedom; F = distribution fitting; MS = mean squares, *P* = probability

*LI = light intensity; TWC = tank wall colour; LI × TWC = interaction of light intensity and tank wall colour

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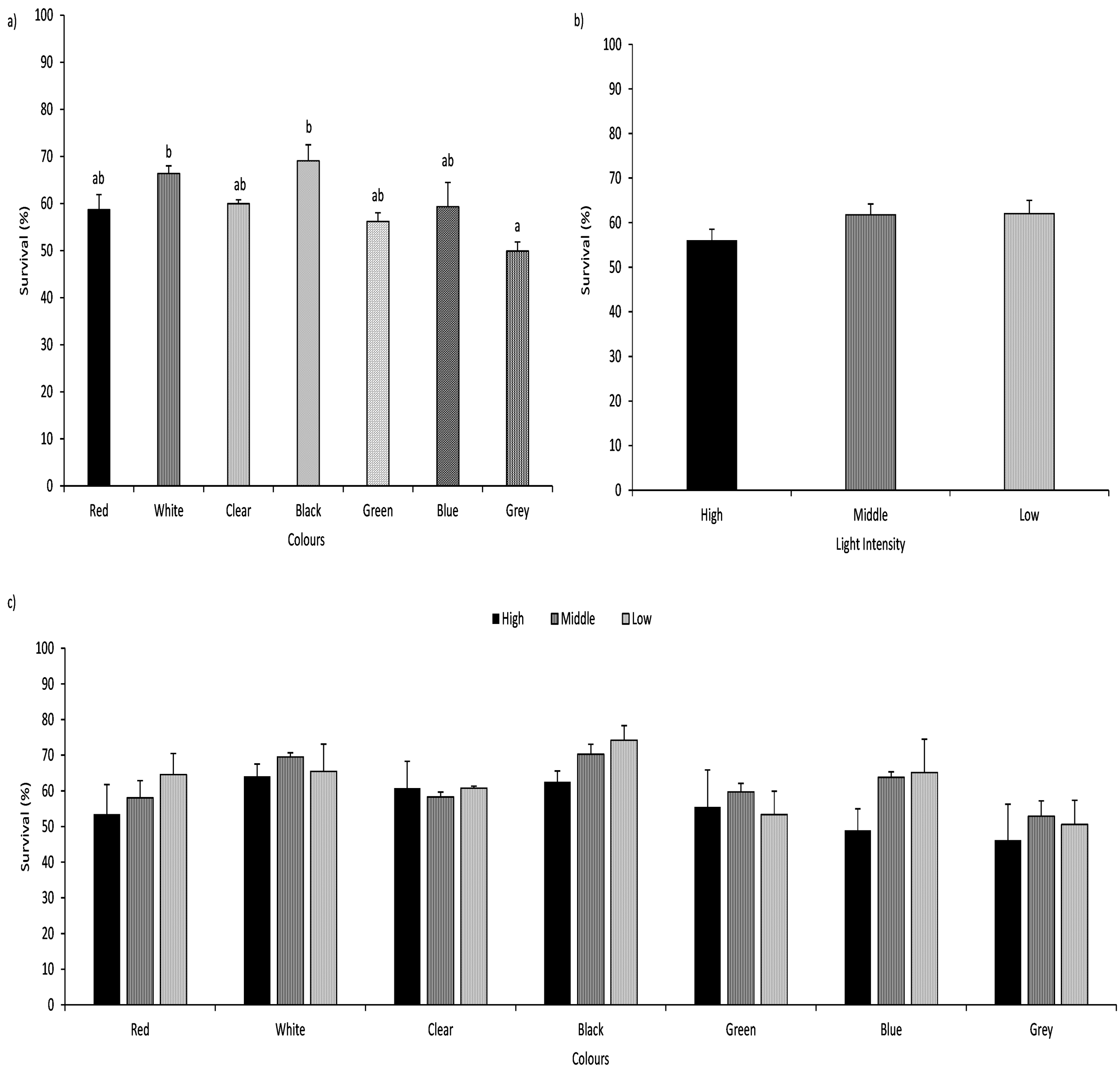

Figure 1. Mean survival rate (%) at tested tank wall colours (red, white, clear, black, green, blue, grey) (a) light intensities (high - 3800 lux, middle - 380 lux, low – 80 lux) (b) and light intensity*tank wall colours (c). The same letters indicate no significant differences (*P* > 0.05) among tank wall colours. Bars show the mean and whiskers indicate S.E.M. (n = 63).

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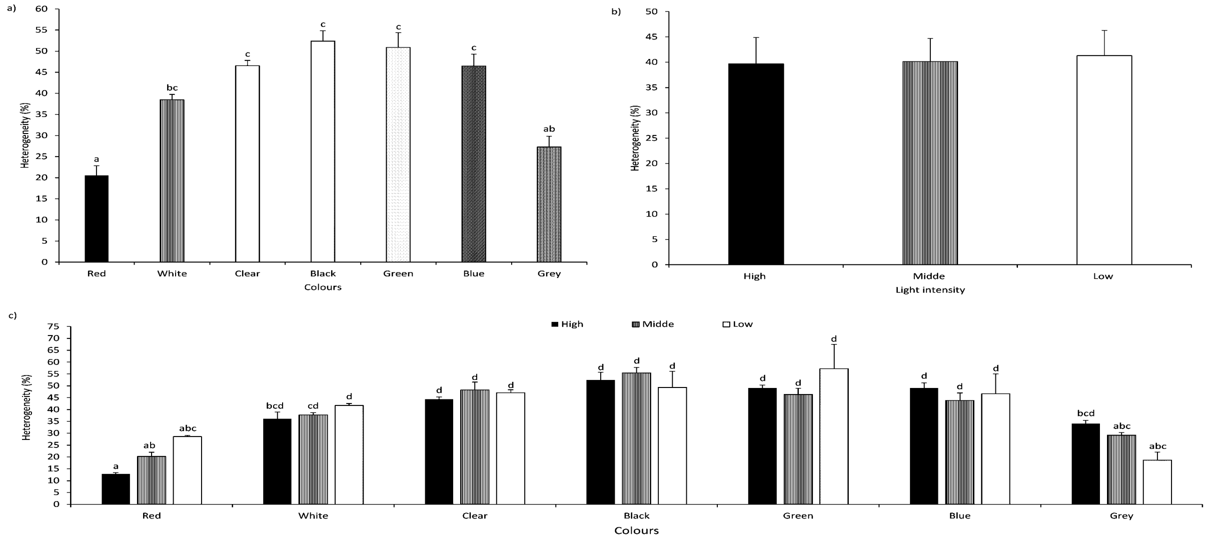

Figure 2. Size heterogeneity (%) at tested tank wall colours (red, white, clear, black, green, blue, grey) (a) light intensities (high - 3800 lux, middle - 380 lux, low – 80 lux) (b) and light intensity*tank wall colours (c). The same letters indicate no significant differences ($P > 0.05$) among tank wall colours. Bars show the mean and whiskers indicate S.E.M. (n = 63).