Brightness of Koi Carp (*Cyprinus carpio*) Juveniles Reared in Tanks with Different Coloured Backgrounds

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Abstract*—Colour is an important indicator of ornamental fish beauty and value. The koi carp (*Cyprinus carpio*) is a valuable ornamental fish commodity and is in high demand because of its beauty, colour, and attractive body shape. Colour is an important factor in koi carp which are commonly red, white, yellow, black, or a combination thereof. One factor that can affect koi carp colour quality is the colour of the rearing tank background. This study aimed to determine the effect of rearing tank background colour on the brightness of juvenile koi carp (*Cyprinus carpio*). Research was conducted from October to November 2020 at the Laboratory of Water Quality and Aquatic Biota, Faculty of Animal Husbandry and Fisheries, Tadulako University, Palu. This study used a completely randomized design (CRD) consisting of 5 rearing tank background colour treatments (A = red; B = orange: C = purple; D = light blue; E = yellow) with 4 replicates. The variables observed were koi carp colour brightness TCF (Tocca Colour Finder) with values obtained from the average score given by the panellists analysed descriptively; absolute length and weight gain, with analysis of variance (ANOVA) at the 95% confidence level followed by the post-hoc Honestly Significant Difference (HSD) test using Minitab 16. Water quality and survival were analysed descriptively. From the results it was concluded that tank background colour had a significant effect on absolute length and weight gain. Colour was brightest under treatment B (orange tank background) and dullest under treatment E (yellow tank background). Survival rate was highest (100%) in treatment A (red tank background). Water quality parameters were in the optimum range for koi carp throughout the study.

Keywords*—Koi carp, Tocca Colour Finder, brightness, tank colour

I. Introduction

Koi carp (*Cyprinus carpio*) are high-value ornamental fish and are in great demand due to their beauty, colour, and attractive body shape; furthermore, koi lovers in Indonesia believe that they bring good luck to their owners [1]. Quality strongly influences the value and demand for koi carp as ornamental fish. In addition to good health without any defects, the beauty of the body shape, and the colouration including the pattern and colour intensity are also important factors for all ornamental fishes, while growth rates affect the profitability of ornamental fish businesses [2].

The colours that are usually found in koi carp are red, white, yellow and black. As colour is such an important component of the beauty of these ornamental fish, cultivators need to be able to maintain and improve the colour quality of koi carp. One possible way to improve the colour quality of ornamental fish is by rearing them in tanks with certain background colours [3], [4].

The background colour of the environment is a key environmental factor that can control changes in skin pigmentation in some fish [5], with mechanisms including changes in the brightness and opacity due to changes in the pigment cells (chromatophores) [6]. Fish pigment cells can be classified based on their colour in six groups: melanophores (black/brown), iridophores (iridescent), xanthophores (yellow), erythrophores (red), leucophores (white), and cyanophores (blue) [7]. Chromatophores can change to suit the environment and in response to stimuli such as ontogeny, sexual maturity, and mating behaviour [6], [8]. External factors that can influence colour include light intensity and colour, water quality and pigment content in feed [4], [6], [9].

Studies on several ornamental fishes have shown an effect of tank colour on fish colour quality. Research on wild betta (*Betta* sp.) reared under different light intensities and background colours (white, black and blue) showed that low light intensity with a white background gave the best growth and colour quality [10], while in the comets (*Carassius auratus*) blue backgrounds gave the best results [3]. Similar research on koi carp seed [11] found that the colour of the tank (white, orange, blue, green and yellow)

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had an effect on the brightness of the colour of the koi carp' with orange tanks giving the brightest colour. Furthermore' some studies have found that tank colour can influence growth and/or survival of fish larvae and fingerlings [3], [12] [2].

The aim of this study was to determine the effect of the background colour of the rearing tank on the body colour' growth and survival of koi carp (*Cyprinus carpio*) fingerlings. The benefit is to provide information on the best colour to use in tanks used for rearing koi carp (*Cyprinus carpio*) fingerlings in order to maximise colour quality and growth.

II. Methods

A. Study time and place

The research was conducted from 29 October to 27 November 2020. The research took place at the Water Quality and Aquatic Biology Laboratory, Faculty of Animal Husbandry and Fisheries, Tadulako University, Palu, Central Sulawesi.

B. Experimental fish

The experimental animals used in this study were 60 koi carp (*Cyprinus carpio*) fingerlings 3.03-3.40 cm in total length (TL) and 1.81-2.37 g in weight. The fingerlings were obtained from the Wuasa Napu Hatchery, North Lore District, Poso District, Central Sulawesi Province.

C. Experimental design

This study used a completely randomized design (CRD) with five treatments and four replicates per treatment, giving 20 experimental units. The treatments were different tank background colours, as follows: A = red, B = orange, C = purple, D = light blue and E = yellow.

The fish tanks used were plastic jars. These were coloured using "pilox" spray paint according to the treatment colour' (red, orange, purple, light blue or yellow). Each tank was filled with 3L water that had been allowed to settle. Each tank was equipped with aeration and lighting from a 145 LUX lamp at a distance of 15 cm from the tank. The experimental fish (three per unit) were fed twice daily with a commercial feed, in the morning at 08.00 and in the afternoon at 16.00. Feed was given at a rate of 5% of the weight of the fingerlings per day.

D. Parameters and Data analysis

The colour enhancement (C) over the study period was calculated using the Tocca Colour Finder [13] and the equation:

$$C = Ct - C0$$

Where :

C0 = mean initial colour of the fish

Ct = average colour of the fish at the end of the study

Absolute Length Growth

The net increase in length (P, in cm), net weight gain (W, in g), and survival rate (SR, in %) of the fingerlings were calculated using the following formulae:

$$P = Pt - P0$$

$$W = Wt - W0$$

$$SR = Nt/N0 \times 100\%$$

Where :

Pt = length of the fish at the end of the study (cm)

Po = initial length of the fish (cm)

Wt = weight of the fish at the end of the study (g)

W0 = initial weight (g)

Nt : number of live fish at the end of the study

N0 : initial number of fish per unit (N0 = 3)

The data were analysed descriptively. Colour and growth (length and weight) data were tested for normality and for equal variance (Bartlett's and Levine's tests). One-way analysis of variance (ANOVA) was applied to test for significance of between-treatment differences followed by post-hoc Tukey tests where significant differences were found. Statistical analyses were conducted in SPSS at the 95% confidence level ($\alpha = 0.05$). Graphics were produced in Microsoft Excel 2010.

III. Results and Discussion

A. Changes in colouration

The ANOVA found significant between-treatment differences in the colour enhancement of koi carp (Cyprinius carpio) fingerlings over the study period (Figure 1). Treatment B was significantly different from treatments A, C, D and E; treatment C was significantly different from treatments D and E but not from treatment A; treatment A was significantly different from treatment E but not from treatment D.

After rearing for 30 days in tanks with different background colours, there was a physiological colour change in the quality of the orange colour of the dorsal fin and surrounding dorsal area of the koi carp fingerlings, as can be seen in the examples shown in Figure 2.

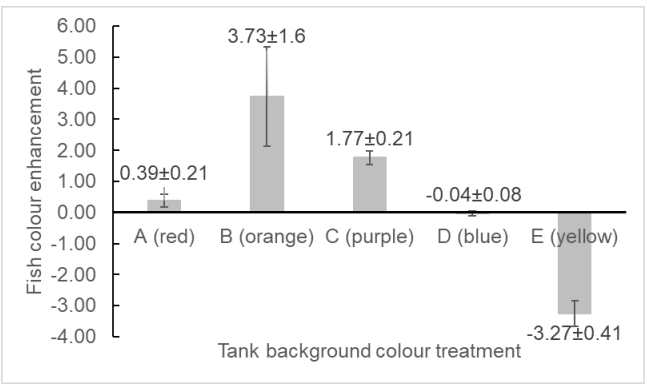

Fig. 1. Colour enhancement of koi carp (*Cyprinus carpio*) fingerlings reared in tanks with different background colours

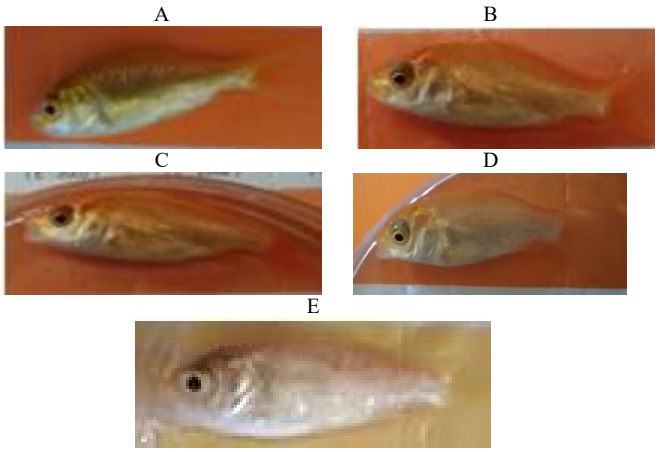

Fig. 2. Examples of final colour of koi carp (*Cyprinus carpio*) fingerlings reared in tanks with different background colours: A. red; B. orange; C. purple; D. pale blue; E. yellow.

Both internal and external factors can determine the intensity and pattern of skin pigmentation; the former include hormones and the latter include the colour and light intensity in the environment, including changes for the purposes of camouflage [5], [6]. In captive fish, both the background colour of the tank and the intensity of light can affect the depth and brightness of the colour of the fish [4], [5]. Skin colour may become brighter and more attractive when the fish are kept in bright conditions compared to fish reared in dark conditions because of the reaction of melanophore pigments to light stimuli [5]. In this study, the colouration of the tank will alter the quality of light in the rearing environment. Furthermore, the deepening of the orange colour in treatment B with an orange tank background could be related to camouflage.

B. Net increase in length and net weight gain

The ANOVA indicated significant between-treatment differences in the growth of koi carp (*Cyprinus carpio*) reared in tanks with different coloured backgrounds for 30 days, in terms of both length and weight (Figure 3).

Overall, growth in terms of both length and weight was best under treatment B, the orange-coloured tank background, followed by treatment C, the purple-coloured tank background. Growth was similar between treatments A, D and E, and considerably less than under B or C. These results indicate that tank background colour can affect the growth of koi carp fingerlings. One possible mechanism is related to the feeding efficiency of the fish, as catching and eating more food will result in a higher growth rate [14]. There is evidence that visual cues are important in triggering or stimulating feeding behaviour in many fish [6]). In this respect, the colour of the environment can influence fish eating patterns, due to the effect of background colours on the ability to detect food visually; therefore certain colours result in increased or decreased growth [15]. The similarity in between-treatment patterns in terms of increase in length and weight gain indicate that the growth pattern of the fingerlings remained similar under all treatments, although growth rate was influenced by the tank background colour.

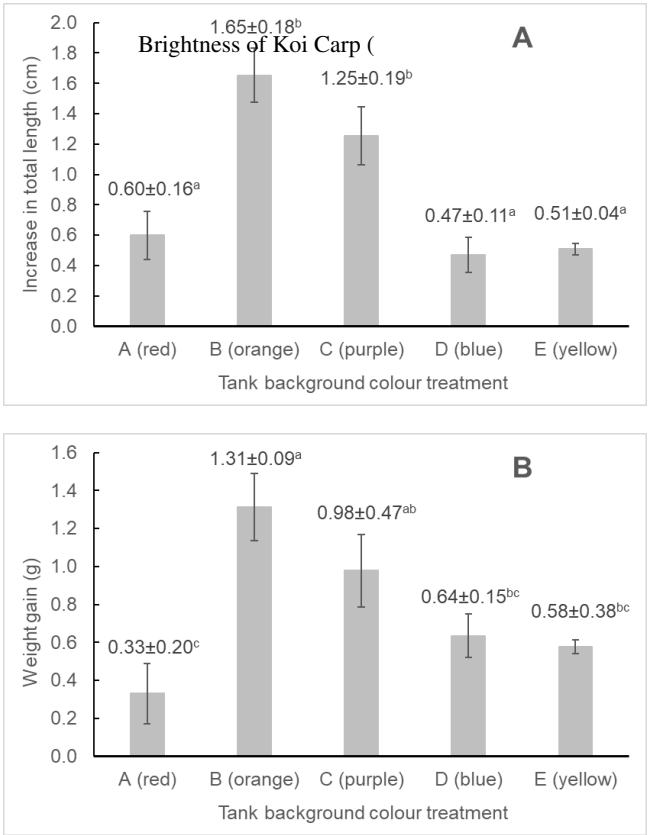

Fig. 3. Net increase in length (A) and weight gain (B) of koi carp fingerlings reared under different background colour treatments

Treatments A, D and E did not differ significantly from each other for either growth parameter but differed significantly from B. The increase in length was greatest under treatment B, however the difference between B and C was not significant. The difference in weight gain between B and C was not significant, and the difference in weight gain under treatment C did not differ significantly from D and E.

C. Survival rate

The survival rates (%) of koi carp (*Cyprinus carpio*) fingerlings at the end of the experiment show that survival rate varied between the background colour treatments. Mean survival rate at the end of the 30-day research period ranged from 92% -100%. Treatments A (red container), B (orange container) and C (purple container) had the highest survival rate (100%) with no fatalities. In treatments D (blue container) and E (yellow container) the survival rate was 92% with one specimen dying in one replicate.

Overall, the koi carp fingerling survival rate was high under all treatments and the differences were not statistically significant. A study on barramundi (*Lates calcarifer*) also found a significant effect of tank colour on fingerling growth but not on survival rate [12]. However, it is possible that the observed mortality under treatments D and E could be due to differences in the ability of koi carp to see well and distinguish objects against the background in tanks with different coloured backgrounds.

Fish can distinguish certain colours due to the photoreceptors and pigments in fish eyes [16], and many fish use vision to detect their food [6]. Furthermore, fish vision and sensitivity to certain colours or light intensity can vary between life-stages [8], so that the best colour for husbandry could differ between larval, fingerling/juvenile and adult stages. In this study, the survival rate of fingerlings could be affected by the contrast of the feed against the tank walls and the intensity and colour of the light; this in turn could affect the ability of the fingerlings to detect and consume food which in turn could lead to poor nutrition or other stressors and eventually death [15].

IV. Conclusion

The colour of the tank background had a significant effect on the colour quality (depth and brightness of colour) as well as the growth in both length and weight of koi carp (*Cyprinus carpio*) fingerlings. Survival rates were high (92%-100%) under all treatments. The colour enhancement and growth were highest under treatment B (orange tank background) with a colour score of 14.40 (reddish orange) and a 100% survival rate. The purple background gave the next best results for all parameters. Colour enhancement was minimal or negative and growth was poor under the red, blue and yellow tank background treatments.

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