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EFFECTS OF TANK COLOUR ON BODY COLOUR INTENSITY AND GROWTH OF YELLOW GOURAMI *TRICHOPODUS TRICHOPTERUS*

ASRA NOR IZATY, A.[A] AND NORAZMI-LOKMAN, N. H. [B,*]

[a,b]*Institute of Tropical Aquaculture and Fisheries Research, Universiti Malaysia Terengganu, 21030 Kuala Nerus, Terengganu, Malaysia*

* *Corresponding author: lokhakim@umt.edu.my*

Abstract: Yellow gourami (*Trichopodus trichopterus*) is a species native to Southeast Asia and is famous as ornamental species. However, hobbyists and farmers encounter problems where its body colour easily becomes faded in captivity. Since colour enhancer pellets are expensive, an experiment was performed to determine whether tank colour can influence the body colour intensity and growth of *T. trichopterus*. Four different tank colours (white, yellow, blue and green) with five replicates were tested where fish were kept under natural lighting (outdoor) conditions for two months. The results demonstrated that fish reared in green coloured tank showed an increment in its colour intensity while fish reared in white tanks increased its body weight. It can be concluded that tank colour does affect the body colour intensity and weight of *T. trichopterus*. This study will help farmers and hobbyists to solve colour fading problem using a cheaper way.

Keywords: Ornamental Fish, Colour Enhancement, Tank

Introduction

Growing interest in aquarium keeping has attributed to the increased demand in ornamental fishes, especially *Trichopodus trichopterus* or commonly known as yellow gouramis. Yellow gouramis are one of the popular ornamental species among aquarists. They are famous due to their pretty gold tone and striped pattern along the back with deeper tone colour. Known as omnivorous species, they can literally eat anything and usually do best on a mixed diet of live feeds and pellets such as flake food, micro pellets, brine shrimp, blood worms, and daphnia. These two reasons have made them one of the most wanted ornamental fish and have contributed to the high demand of this species in ornamental industries.

Although ornamental industries keep on developing new technologies in breeding and fish rearing, there is still a lack of appropriate approaches in maintaining body colour of ornamental fish. Most of the aquaculturists nowadays use feed containing carotenoid pigment to enhance the body colour of fish especially ornamental fishes. Carotenoid pigment is an important dietary requirement because of its ability to alter colouration, and it has been well reported in teleost fish as well as many other taxonomic groups (McGraw *et al.,* 2002). However, it is costly and need continuous supplementation to ensure the maintenance of fish body colour.

Colour patterns play an essential part in signalling processes of many fish species (Baron *et al.,* 2008). Fishes use colour basically for signalling during courtship, mating or other intrasexual communication, and for threatening displays, camouflage, and protection from predators by frightening them or alerting that the animal or some part of it is poisonous (Theis *et al.,* 2012). Behavioural correspond with colour patterns proposes that colour pattern signalling may be an important mechanism of communication in fishes with suitable environments such as favourable light and water conditions and also visual systems (Beeching, 1995). Apart from that, previous studies also proved that certain species use colour in choosing their mate such as female guppies *Poecilia reticulata* unveiled strong preferences for males with relatively high levels of carotenoid colouration based on the expression of orange pigmentation (Evans et al., 2004).

Fish maintenance in their natural habitats is very different from artificial environments where it may affect the fish physiology and behaviour (Eslamloo *et al.,* 2015). Among teleost, the key to morphological skin colour changes was demonstrated in terms of alterations in skin structure and pigment accumulation during metamorphosis in different species (Leclercq *et al.,* 2010). In vertebrates, the pigmentation of the skin can be altered by hormonal stimulation, and the colour of the background and the illumination are controlling factors for the intensity and the pattern of skin pigmentation (Masazumi, 1993). Background colour is the most superior environmental factor in managing the skin pigmentation in some fish (Van der Salm *et al.,* 2004).

Fish have colour vision and their capability to recognize feed and hence their food intake, growth and survival rate could be influenced by background colour (Papoutsoglou *et al.,* 2000; Strand *et al.,* 2007). Colour perceptions in fishes are due to the rods and retina in their eyes (Joselevitch *et al.,* 2009; Banan *et al.,* 2011). This is stated by (Sabbah *et al.,* 2010) where fish retinas contain rods and cones that react to a specific wavelength range based on their ecological niche. The capacity for colour vision is mediated by the differentiation of the signal intensities from photoreceptors of two or more types that vary in spectral sensitivity (Collin *et al.,* 2004). This is due to changes in environmental colour affecting Melanin-concentrating hormone and Melanocyte stimulating hormone that acknowledge colouring changes on fish (Amiya *et al.,* 2005; Mizusawa *et al.,* 2013).

Melanocyte stimulating hormone (MCH) is a pituitary hormone derived by post-translational processing from pro-opiomelanocortin (POMC) and associated in stress and background customizing (Arends *et al.,* 2000). The effects of a-MSH on behaviour and colour body, combined with morph-specific regulation of the stress response and the melanocortin system, suggest that the melanocortin system promotes the polymorphism in behaviour and coloration in *A. burtoni* (Dijkstra *et al.,* 2017). However, fish species and life stages react differently to various background colours (Papoutsoglou *et al.,* 2005). The obvious variations in physiological responses which are stress-induced hormones and melatonin and growth are caused by background colour in white and black backgrounds depending on fish species (Amiya *et al.,* 2005).

Background colour effect differs according to species; blue light or ambient colour was demonstrated to enhance fish growth and alter fish physiological responses (Ruchin, 2004); Karakatsouli *et al.,* 2007) but summer flounder (*Paralichthys dentatus*) and Nile tilapia (*Oreochromis niloticus*) were not affected by blue light colour (McLean *et al.,* 2008). In previous studies, black and red colour as background highly caused stress while green colour as background was recommended in rearing (Luchiari *et al.,* 2008; Imanpoor *et al.,* 2011).

Different background colours' impacts on fish vision and their behaviour can provide one of the most potential methods that can be used to maintain body colour in yellow gourami *Trichopodus trichopterus*. It can be another alternative apart from using colour enhancer for their body pigmentation, and this method can ensure the increase in profit for the aquaculturists by omitting the cost of colour enhancer pellets. This study will help hobbyists and aquaculture industry in maintaining body colouration of fish in captive condition.

Materials and Methods

Fish and rearing protocol

Twenty male yellow gouramis *Trichpodus trichopterus* were bought from a local store in a range of 4cm to 5cm in size and housed in a tank individually. The water of each tank was changed weekly to maintain the water quality. Feeds were given twice daily with artificial feed in the morning at 3% of their body weight and frozen bloodworm in the evening (Saha *et al.,* 2017) as this fish is omnivores. Low aeration was provided continuously and pHs at the range of 6.0 to 7.5 with temperature of 27-28°C were maintained (Baensch and Riehl, 1985). This experiment was conducted in Universiti Malaysia Terengganu's hatchery.

Experimental design

In this experiment, four different of colours were used which were green (Martinez-Cardenas *et al.,* 2007), blue (Imanpoor *et al.,* 2011), yellow (Strand *et al.,* 2007) and white as control. Each colour consisted of 5 replicates where total of tanks would be used where they would be randomly arranged. This study was conducted for 8 weeks (Booth *et al.,* 2004), where the data of body colour intensity was collected every thirty days (Awasthi *et al.,* 2014) and growth of yellow gourami was taken at the beginning and end of this experiment (Eslamloo *et al.,* 2015).

Body colour intensity

For the body colour intensity, each sample was anesthetized using Transmore TS-16 with 35 drops for 1.5 Litre of water. DSLR camera was used to take a photo of the fish (Norazmi-Lokman *et al.,* 2016). Then, images of samples taken were analysed using image J software analysis for each of image intensity (Collins, 2007).

Growth performance

For the growth performance of *Trichopodus trichopterus*, weight and length were measured. The fish was starved overnight, and sample was anesthetized before weight and length measurement was taken. Length of the fish was taken using standard ruler where total length (TL) and standard length (SL) was measured. Several growth parameters for each fish were taken as follows (Mandal *et al.,* 2010):

a) Mean weight gain

$$= \text{Final body weight-Initial body weight}$$

b) Body weight gain (% BWG)

$$= \frac{\text{Final body weight-Initial body weight}}{\text{Initial body weight}}$$

a) Specific growth rate (SGR)

$$\frac{\text{Ln (Final weight)-Ln (Initial weight}}{\text{Number of days}} \times 100$$

Data analysis

All data taken were subjected to normality test. Analyses were run where one-way analysis of variance (ANOVA) was conducted for growth performance and body colour intensity followed by post hoc test by using software SPSS version 23 (Glover & Mitchell, 2004; Laerd, 2017).

Results and Discussion

Body colour intensity

The results of body colour intensity on *Trichopodus trichopterus* indicated that there were significant effects of tank colours on body colour intensity. Green coloured tank provided the best performance ($P<0.05$) while other colours (white, yellow and blue) showed lesser performance (Figure 4.1).

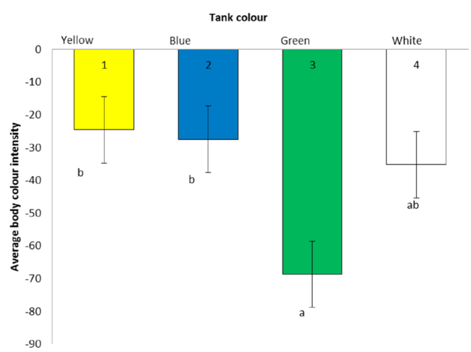

Figure 4.1 The intensity of body colour in yellow gourami, *Trichopodus trichopterus* reared in different tank colours for two months. Data are presented as mean ± SD (n= 20). Bars with different letters are significantly different ($P<0.05$).

Acceptability of consumers is decreased when the skin of fish is paling especially in ornamental fishes (Paripatananont *et al.,* 1999). The intensity of body colour is important to be maintained in order to ensure the continuity of these ornamental fish industries. Many studies have been carried out to investigate the effects of tank colours on the body colour of fish in a variety of species. This is due to the different amount of pigment and its dispersion is caused by the changes in tank wall colours (Masazumi, 1993). The results demonstrated that green-coloured tank had the highest changes of initial body colour intensity and final body colour intensity where the skin of *Trichopodus trichopterus* darkened. Previous studies have proven that some of the skins of fishes darkened when reared in a dark coloured background such as freshwater catfish, *Lophhiosilurus alexandri* (Costa *et al.,* 2017) and false clownfish, *Amphiprion ocellaris* (Yasir *et al.,* 2009).

Apart from that, other coloured (white, blue, yellow) tanks affected the *T.trichopterus* by paling the colour of the skin. Doolan *et al.,* 2008, in his studies of Australian snapper, *Pagrus auratus*, said that culture environment has a strong effect on skin lightness. Changes in morphology of pigmented cells and its density of skin colour in fish are resulted by the long-term adaptation of background colour (Sugimoto, 2002). This was also supported by Bagnara *et al.,* 1973, where fishes become pale in a light background and dark in a dark background in response to fish adapting to the background, including various shades of the background.

According to Guthrie in 1986, vision acts as a source of sensory information for fish where a diversity of different resources of visible objects can be identified (i.e. texture, colour, brightness, etc.) by the fish due to its complex interactions with the environment and physical nature of light; besides, colour contrast or brightness contrast can also be distinguished. In this study, it was demonstrated that fish vision played an important role in changing of body colour in fish as suggested by (Saszik *et al.,* 2001) where the visual system in fish can be developed by environmental factors depending on species.

Physiological colour skin changes have two different types of mechanisms which are “Primary Colour Response” and “Secondary Colour Response”. Primary colour response is a chromatophores personal response to light such as melanophores (black/brown), xanthophores (yellow) and cyanophores (blue) as stated by (Oshima, 2001), while secondary colour response starts off in eyes and run by endocrine or neural system (Roubos *et al.,* 2010). According to Archana *et al.,* 2017, colour changes affected by background colour in most of teleostean fishes have proven that both neural mechanisms and hormonal are combined and also the physiological changes are the combined effect of neurotransmitter working synergistically with hormones. Previous studies stated that brisk alter of skin colour may have been synchronized by the neuro-endocrine system (Van der Salm *et al.,* 2004); Doolan *et al.,* 2007; 2008).

Alpha-melanocyte-stimulating hormone (a-MSH) is the hormone in charge of pigment dispersion (chromatophores) and highly involved in colour changes of fish skin. (Bertolesi *et al.,* 2015) in his studies stated that melanopsin in eyes activates skin pigmentation through a secondary response entailing negative regulation of a-MSH secretion by the pituitary. Apart from involving in action of a-MSH in the skin, it also attaches to other MCRs including those exhibited in the brain, where it adjusts social behaviour, stress physiology and appetite (Cone, 2006; Ducrest *et al.,* 2008). These hormones also have been stated to be involved in increasing the yellowness of cichlid fish by the distributions of xanthophore pigments (Dijkstra *et al.,* 2017).

Thus, the effects of body colour intensity in fishes are controlled by complex interaction of both nervous mechanism and hormonal where they vary among species. In *Fundulus heteroclitus* (Kleinholz *et al.,* 1938) nervous systems shows to be dominant where the mechanism can evolve according to background for adaptation in the animal and the nerve is exclusively controlled by the melanophores. Dark tanks that caused the darkening of skin can be due to the melanophore dispersion that expands its area of pigmentation and density while paling of skin is due to the low dispersion and aggregations of the melanophores (Sugimoto, 2002; Amiya *et al.,* 2005). Skin darkening could be in response to a-MSH being launched and lead to melanin granules dispersion (Papoutsoglou *et al.,* 2000). (Van der Salm *et al.,* 2005) supported this statement in his studies where it has been established that high density of melanophores promoted the skin darkening of *O.mossambicus* reared in a black background.

Growth performance

There are seven mortality of *Trichopodus trichopterus* observed during this experiment. There was significant difference in fish weights between treatments during 2 months after the starting of trial (Figure 4. 1). Specific growth rate (SGR) was significantly increased in fish reared in white tank colours compared to other colour tanks (P< 0.05). The obtained results on growth indicate that white tank colour had the best growth performance in comparison with other tank colours.

Table 4.1: Growth performance of yellow gourami, *Trichopodus trichopterus* reared in different tank colours for two months.

	Tank colour			
Parameters	White	Blue	Yellow	Green
IBW (g)	6.27	8.0	8.8	8.01
FBW (g)	8.06	7.31	7.29	6.79
SGR (% day^{-1})	0.44	-0.16	-0.33	-0.29

Note: IBW, Initial Body Weight; FBW, Final Body Weight; SGR, Specific Growth Rate.

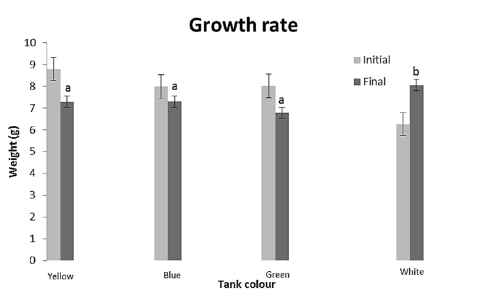

Figure 4.2: The growth performance of yellow gourami, *Trichopodus trichopterus* reared in different tank colours during two months. Data are presented as mean ± SD (n=20). Bars with different letters are significantly different (P<0.05).

The growth performance of *Trichopodus trichopterus* notably improved in white tank colour in contrast with blue, yellow and green coloured tanks. Previous studies reported that white tanks give favourable results on growth rates for a variety of species such as *Onchorhynus mykiss*, *Cyprinus carpio* L (S. Papoutsoglou *et al.,* 2000; Papoutsoglou *et al.,* 2005), *Perca fluviatilis* L (Strand *et al.,* 2007) and *Carassius auratus* (Eslamloo *et al.,* 2015). The increased in growth rate of *T.trichopterus* in this study could be because of the tank colour that was in contrast to the feed given, thereby increasing the probability to be seen by the fish (Jentoft *et al.,* 2006; Strand *et al.,* 2007). The ability of fish to see and eat feed eventually will affect the feed intake and at the same time will impact the growth rate of the fish.

In this study, it can be seen that green-coloured tank had the lowest growth performance due to the highest reduction of final body weight of *T.trichopterus*. Most studies reported that dark coloured background (i.e. green, black, grey, etc.) either gave a negative feedback or no response towards fish growth performance depending on the fish species. Examples of fish species that have been studied are *Salmo salar* (Stefansson *et al.,* 1989) and *Diplodus puntazzo* (Karakatsouli *et al.,* 2015). However, these colour background preferences are different according to species (Imanpoor *et al.,* 2011) because certain species reacted positively towards dark background such as young starlet *Acipenser ruthenus* (Bayrami *et al.,* 2017) and thinlip mullet *Liza ramada* larvae (El-Sayed *et al.,* 2011). The growth performance could be affected by the stress response when reared in different tank colour than their natural habitat.

Generally, decrease in growth of various species is caused by chronic stress where it is incorporated with respiration, osmoregulation, tissues repair and movement that lead to body homeostasis to re-establish its energy consumption (Biswas *et al.,* 2006). Stress response due to rearing fish in appropriate colour also has been reported in (McLean *et al.,* 2008). As suggested by (Bayrami *et al.,* 2017), fish growth also involves complex biochemical process that associates several neuro systems and hormonal interaction in its body regulation. Fish stress response can be measured by the cortisol levels in blood; however, in this experiment the cortisol level was not measured. In (McLean *et al.,* 2008) study, cortisol level was the highest when reared in blue coloured tank compared to black, green and red. This proved the mortality of three fishes in blue tank was due to the stress which affected the behaviour where it caused the fish to jump out of the tank.

Conclusion

This study revealed that yellow gourami *Trichopodus trichopterus* body colour intensity was significantly upgraded when reared in green tank compared to blue, white and yellow coloured tanks. However, growth performance in green tank was in a slower rate compared to *T.trichopterus* in white tank that had the highest positive growth performance. Thus, when growth rate of *T.trichopterus* is not the main concern, they can be reared in green coloured tank in order to avoid the loss of their yellow colour. While white tank colour caused the body colour intensity to increase where skin became paling, further studies on how to revert the colour should be considered. Nonetheless, further studies can also investigate the effects of tank colour on *T.trichopterus* stress response in captivity and their complex behaviour that would help aquaculturists and farmers in the future.

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