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Corrigendum

Corrigendum to “Effects of green light on the growth of spotted halibut, *Verasper variegatus*, and Japanese flounder, *Paralichthys olivaceus*, and on the endocrine system of spotted halibut at different water temperatures” Gen. Compar. Endocrinol. 271 (2019) 82–90



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The authors regret
2.3 Rearing of Japanese flounder under several LED light colors (Experiment
2)

Correct: Fish were reared for 63 days from Aug. 25, 2015 to Oct. 27, 2015.

Incorrect: Fish were reared for 60 days from Aug. 7, 2015 to Oct. 27, 2015.

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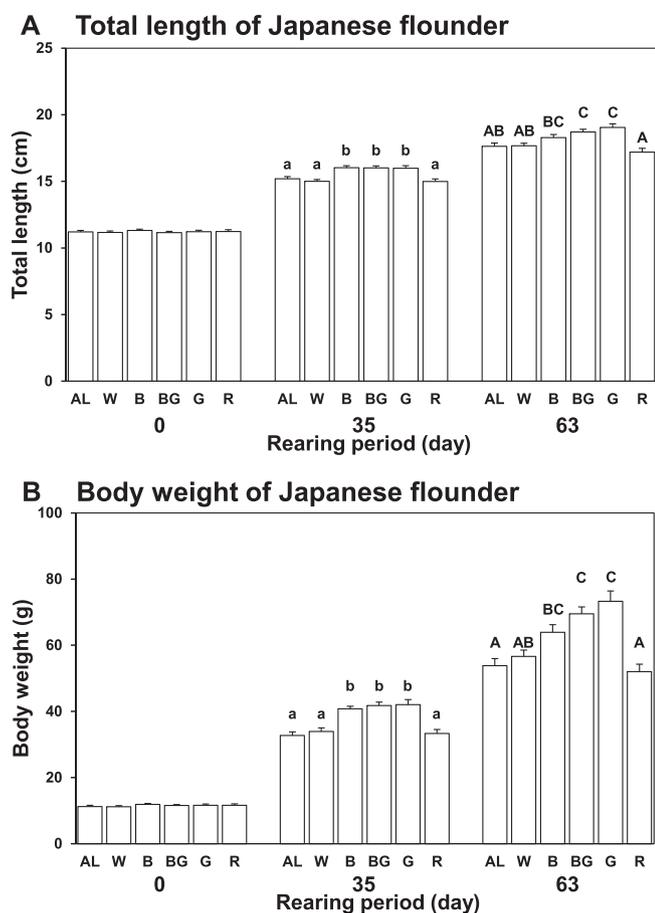


Fig. 2 (corrected)

Correct: Somatic growth of Japanese flounder exposed to the chromatic light from LED. (A) Total length. (B) Body weight. Japanese flounders were reared for 63 days in indoor tanks as described in Fig. 1. Different alphabets indicate statistically significant differences ($n = 30$ for day 0, 26 to 30 for day 35, 20 to 25 for day 63. $P < 0.05$) as determined by one-way ANOVA: Tukey-Kramer test.

Incorrect: Somatic growth of Japanese flounder exposed to the chromatic light from LED. (A) Total length. (B) Body weight. Japanese flounders were reared for 60 days in indoor tanks as described in Fig. 1. Different alphabets indicate statistically significant differences ($n = 30$ for day 0, 26 to 30 for day 30, 20 to 25 for day 60. $P < 0.05$) as determined by one-way ANOVA: Tukey-Kramer test.

3.2 Effects of green light on somatic growth of spotted halibut in various water temperature

Correct: Effects of green light on TL and BW of spotted halibut at four different temperatures after rearing for approximately four weeks are shown in Fig. 3 and Table 3.

Incorrect: Effects of green light on TL and BW of spotted flounder at four different temperatures after rearing for approximately four weeks are shown in Fig. 3 and Table 3.

4. Discussion

4.1. Green light and growth of flounders: Effects of light color and temperature

In a previous study, green light was shown to be the most effective chromatic light that promotes somatic growth in barfin flounder among blue (464 nm), green (518 nm), and red (635 nm) lights in white tanks,

although the efficacy of these lights varied at different water temperatures; green and blue light showed similar growth-enhancement effect at 14.9 °C and 8.6 °C, while green light showed the highest efficacy at 6.6 °C (Takahashi et al., 2016). Herein, we obtained further evidence showing that the green light was the most effective facilitator of somatic growth in flounders using spotted halibut and Japanese flounder. The effects of blue-green and blue light were comparable to those of green light, suggesting that the lights of shorter wavelengths similarly stimulate the growth of spotted halibut, Japanese flounder, and barfin flounder. No growth-promoting effects of red light, similar to those of the control group, suggesting that lights of longer wavelengths produce weak stimulation in the three flounder species.

White LED light consisting of two peaks of wavelength (447 and 550 nm) covers a wide range of wavelengths (Scheme 1). Although the spectrum contains blue (464 nm), blue-green (497 nm), and green light (518 nm) that promoted growth of the fish, the white LED light did not promote growth in spotted halibut and Japanese flounder. There may be at least two possible explanations for this. Firstly, the absence of growth promoting effects would be caused by the absence of majority of blue, blue-green, and green light spectra in the white LED light as shown in the Scheme 1. Secondly, a mixture of different chromatic lights might attenuate the effects of the green light component of the white LED. The latter interpretation is supported by our previous findings, which show that the growth rate of barfin flounders reared in an indoor tank under ambient light was lower than that of those reared in an indoor tank covered with green filter (Yamanome et al., 2009).

The growth promoting effects of green light were examined in spotted halibut at four different water temperatures. No water temperature-dependent differences were observed in TL and BW. These results indicate that green light effectively stimulates the growth of spotted halibut at least between 12 °C and 21 °C. In these experiments, CF significantly increased at 15 °C and 18 °C under green light. These results suggest that the anabolic pathway enhanced by green light to facilitate BW gain would be maximized around these water temperatures. Increase in CF may be a common effect of green light in flounders, because similar increase was also observed in barfin flounder (Takahashi et al., 2016, 2018).

4.2. Green light and endocrine functions associated with growth

MCH has been suggested to be associated with somatic growth of barfin flounder based on the enhanced food intake, and because high MCH production together with high growth was observed under white background (Amiya et al., 2005, 2008; Takahashi et al., 2004; Yamanome et al., 2005). Spotted halibut possesses two types of *mch* genes (Supplementary Fig. 1) as in the case of barfin flounder (Mizusawa et al., 2015; Takahashi et al., 2004). The genes *mch1* and *mch2* code for teleost type MCH1 and mammalian type MCH2, respectively. These genes showed differential expression profiles in response to green light at different water temperatures. Specifically, green light stimulated the increase in *mch1* gene expression at all water temperature examined, while the increase in the expression of *mch2* gene under green light was observed only at 21 °C. It is, therefore, conceivable that the roles of these peptides in mediating the effects of green light are different from each other. MCH1 and MCH2 would be differentially associated with food intake under green light, based on their transcription levels, and the association of MCH1 would be much greater than MCH2. Increase in the gene expression levels in response to green light was also observed in *orx*, *npv*, *pacap*, and *pomc-c* at some but not all water temperatures. Taken together, MCH1 is suggested to be a major hormone that transmits the green light stimulus to fish system to enhance food intake and subsequent somatic growth.

Contrary to the neuropeptide gene expression in brain, no difference was observed in the expression of pituitary hormone genes and plasma profiles of INS and IGF-I under green light. These hormones mediate a variety of functions associated with somatic growth. Firstly, among the

members of GH family, GH is the prominent pituitary hormone stimulating growth by direct effect and indirect effect via IGF-I (Björnsson, 1997; Mommsen, 2001; Pérez-Sánchez et al., 2002). PRL has also been shown to stimulate body growth and to be associated with GH-like functions (Nicol, 1993). SL has been shown to be responsible for lipid metabolism (Fukada et al., 2005; Sasano et al., 2012). INS is crucial for anabolic pathway (Andoh, 2007; Navarro, 2006). Melanocortin peptides, derived from a common precursor POMC, inhibit food intake and exhibit lipolytic activities, and endorphin—the other POMC-derived peptide—stimulates food intake (Takahashi and Kawauchi, 2006). However, absence of difference in gene expression under green light suggest that these pituitary hormones and members of INS family may contribute less to the mediation of green light stimulus to somatic growth, compared to the hormones produced by hypothalamus.

With regard to water temperature and PFD of green light, the effects at 12 °C and $10 \mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$, respectively, are comparable to that observed at 10.2 °C and $7 \mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ in a previous experiment using barfin flounder (Takahashi et al., 2018), when the fish were reared in a dark room. Apparent increase in the expression of *mch1* gene among several brain and pituitary hormone genes was also observed in the barfin flounder under similar green light and water temperature conditions. In the barfin flounder, increase in *mch2* gene expression was also observed. These results support the importance of MCH with regard to growth promoting effects of green light in both spotted halibut and barfin flounder.

4.3. Effects of water temperature on hormone gene expression

The profiles of mRNA content observed in the control groups in experiment 3 indicate that the expression of hormone genes does not change uniformly in response to water temperature in spotted halibut, an ectotherm. Among several genes examined, the expression levels of

prl constantly increased with the increase in water temperature. Changes in PRL levels have been reported in several ectotherms. In the common carp, *Cyprinus carpio*, *prl* gene expression is enhanced at higher water temperature, which is related to adjustment of fish to seasonal changes (Figueroa et al., 1997). Plasma PRL levels increase in a newt, *Cynops pyrrhogaster*, as the ambient temperature drops; this change is related to spermatogenesis arrest (Yazawa et al., 1999). Plasma PRL concentrations in another newt species, *Triturus carnifex*, rise when the environmental temperature decreases; this change seemed to be associated with the organism's reproductive biology (Mosconi et al., 2002). The most prominent role of PRL in fishes is osmoregulatory adaptation of euryhaline fish to low salinity (Manzon, 2002). Many flounders are euryhaline fish that can survive in low-salinity water or even in fresh-water (Hart et al., 1996; Hiroi et al., 1997; Sampail and Bianchini, 2002). Spotted halibut has also been shown to survive in low-salinity water and the percentage of PRL-cell volume to pituitary volume is higher in fish maintained at 4 ppt salinity than control fish (Wada et al., 2004). Therefore, the enhanced *prl* gene expression at higher water temperatures suggests that the low salinity tolerance of spotted halibut was improved via increased PRL production at relatively high temperatures.

In conclusion, we demonstrated that green light promotes somatic growth in the spotted halibut and Japanese flounder, in addition to barfin flounder as we reported previously (Takahashi et al., 2016, 2018). Detailed studies on spotted halibut showed that the growth promoting effects of green light could be observed at a variety of water temperatures. Among the genes of hypothalamo-pituitary system, *mch1* gene emerged as an important endocrine factor associated with increased food intake.

The authors would like to apologise for any inconvenience caused. We deleted subsection 4.1.2 of discussion in the original version.