LIGHT ENVIRONMENT AFFECTING ENDOCRINE AND IMMUNE CIRCADIAN RHYTHMS IN PIKEPERCH (*Sander lucioperca*)

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Introduction

Many biological pathways display circadian and circannual rhythms in response to the light-darkness cycle. Melatonin (MEL) is a key hormone of this signal integration. This indoleamine is well known to play a central role in driving circadian rhythms such as osmoregulation and metabolic activity, and circannual processes as growth and reproduction (Miller et al, 2006; Esteban et al, 2013). A clear relationship, including bidirectional regulations, has been described between the neuroendocrine and the immune systems which show both circadian and circannual activities (Carrillo-Vico et al, 2013). MEL was described in higher vertebrates to act as an immune buffer by stimulating the immunity under basal conditions or to exert an anti-inflammatory action in the event of exacerbated immune responses (Miller et al, 2006). MEL contributes to the regulation of the proliferation and maturation stages of virtually all cells of the hematopoietic and immune cells. However, in fish, the immunomodulation by MEL is still poorly documented. Available results suggest that this hormone has a key role in immune modulation (Esteban et al, 2013).

Light is one of the environmental factors that profoundly affect the life of fish and unsuitable light characteristics may induce high stress which may negatively affects immunity and growth of reared species (Luchiari et al, 2009). Environmental colors may affect the vision of fishes, influencing food intake, reproduction, growth and even survival (Downing et al, 2002), while light intensity can affect many behavioral and biological processes, mainly foraging and learning ability (Luchiari et al, 2009). Light-induced stress may be of particular concern in pikeperch (*Sander lucioperca*). Indeed, this species possesses a *tapetum lucidum* that is a specific anatomo-histological tissue of the retina which greatly amplifies the eye sensitivity to light.

Therefore we hypothesized that unsuitable light characteristics could influence physiology and immune status of pikeperch and, by the way, impact the circadian rhythm of endocrine and immune activities.

Materials & methods

Pikeperch juveniles (mean weight 25 g) were randomly distributed into 24 tanks and maintained for 4 weeks under a 10 lux white light with constant photoperiod (LD 12:12). New light conditions, including 2 light spectra (white *vs* red) and 2 intensities (10 *vs* 100 lux) were then applied. To avoid stress artefact of nocturnal fishing on diurnal samplings, the number of tanks was doubled. Each treatment group had 3 replicates and 4 individuals were sampled for each treatment. Samplings occurred during scotophase (4 am) and photophase (4 pm), at both days 1 and 30. Growth as well as stress (cortisol and glucose) and immune (plasma lysozyme and peroxidase activities) variables were measured.

Results

Any of the light condition led to higher cortisol level at D1 or D30. Plasma cortisol reached about 80ng/ml during the dark phase and significantly dropped to 20ng/ml during photophase, irrespective of the day of sampling and the light condition ($p<0.05$).

A similar day-night variation, with a night activity peak, was also observed for immune parameters (plasma lysozyme and ACH50 activities) for the control group (10lx, white) at day 1. All the groups submitted to light environment variation did not show such rhythm. However, cyclicity of the immune activities was recovered after 30 days for all the conditions. Peroxidase activity was also increased with light intensity ($p<0.05$). Analyses for plasma MEL, brain serotonergic and dopaminergic activities and immune gene expressions in kidney and spleen are still undergoing.

Discussion and conclusion

The present experiment show that light is a crucial factor regulating endocrine and immune activities. Stress and humoral immune variables showed a clear circadian activity in pikeperch. The bi-directional communication between the neuroendocrine and the immune systems has been documented, and different patterns of rhythmicity depending on the fish species were described for immune activities (Esteban et al, 2013). The circadian rhythm of the immune variables may be related to the MEL and cortisol levels. While the effect of cortisol on immunity is well described, the immune regulation by MEL is less documented. Some authors suggest a direct action of MEL on immune target via high specific MEL receptors, and an indirect action through several compounds including steroid hormones, glucocorticoids and prolactin (Esteban et al, 2013).

Our results also showed a clear short-term disruption of the immune circadian rhythm when switching the light conditions, suggesting a short-term endocrine disturbance. Whatever the light condition, the circadian activities of the immune parameters are recovered after 30 days.

According to cortisol and plasma levels, any of the light conditions tested in the present experiment led to short or long-term stress status. As reported for other fish species submitted to acute and chronic stress (Gesto et al., 2016), brain serotonergic and dopaminergic activities may perhaps enable differences in stress response between the experimental light conditions.

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