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Influence of the light spectrum on the daily rhythms of stress and humoral innate immune markers in pikeperch *Sander lucioperca*

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ABSTRACT

This study investigated the daily variations of stress markers namely plasma cortisol and glucose and some humoral innate immune markers, including peroxidase, lysozyme and complement activities, of pikeperch (*Sander lucioperca*) and the effect of light spectrum on these variations. Fish were reared under a white or red light spectrum at a constant photoperiod (12D:12 L). Samples were collected at 22:00, 04:00, 10:00 and 16:00 at days 1 and 42 of the experiment. After 42 days, the use of a red light spectrum led to a significant increase in final bodyweight. Specific growth rate reached 2.1 ± 0.18 and 1.8 ± 0.17% d^{-1} under red and white spectra respectively. The profiles of plasma cortisol followed a cyclic activity with a surge during photophase at 10:00 without any effect of the light spectrum at day 42. Both lysozyme and peroxidase activities in blood followed a day-night variation with a peak at 4:00 corresponding to low cortisol values. No rhythmicity was detected for the complement activity but higher values were observed at 16:00 when cortisol values were lowest. Light spectra also influenced humoral immune markers with an increase in lysozyme activity and a decrease in peroxidase activity in a red light environment. The present results indicate a strong effect of the light environment, including the light-dark cycle and the light spectrum, on pikeperch physiology. Especially, some innate immune status seemed stimulated during the dark phase in relation to a decrease in the stress level markers. Such parallelism in the relationship between the immune status and stress markers may be affected positively or negatively by the light characteristics. Humoral immune markers were also modulated according to the light spectrum without no clear trend (stimulation or inhibition) for the immunocompetence status.

1. Introduction

Due to its fast growth, high quality flesh and high economical expectation, pikeperch *Sander lucioperca* is one of the most promising freshwater fish species for the diversification of European inland aquaculture (Wang et al., 2009; Dalsgaard et al., 2013; Overton et al., 2015). However, its culture is still limited by impairment in growth rate and high mortality rate during the young developmental stages. These failures may be related to inadequate rearing conditions inducing high stress level since the pikeperch aquaculture management has not been optimized yet. It has been shown that percid fish are more sensitive to aquaculture stressors than other species with a longer history of domestication (Jentoft et al., 2005). And since decreased welfare may lead to increased stress level and to disease outbreaks, it is essential to improve its management strategy. In previous studies (Luchiari et al., 2006, 2009; Baekelandt et al., 2018), light was defined as a determining factor affecting physiology and, by the way, culture of pikeperch. However, the effects of the light environment, including light-darkness cycle and light spectrum, on physiology and immunity of pikeperch, are poorly documented and would merit more attention.

The aquatic environment is critical for the maintenance of fish homeostasis. It is well established that a perturbation of the pathogen-host-environment balance favors disease outbreaks that can severely limit aquaculture success (Esteban et al., 2006). From environmental cues, photoperiod is one of the major factors regulating a wide range of biological processes. The light-darkness cycle is perceived by photoreceptors and integrated into a melatonin rhythmic signal. It has been described several times to play in almost all vertebrates, a central role in driving circadian rhythms, including locomotor activity, thermal preferences, rest, osmoregulation and metabolic activity, as well as annual processes such as growth and sexual maturation (Falcón et al., 2007, 2010). Few studies also support a circadian and circannual activity of the immune system (Esteban et al., 2006; Morgan et al., 2008). Esteban et al. (2006) pointed out a variation of some humoral immune markers in seabream and sea bass based on the light-darkness cycle. In addition to vary seasonally, immunity was shown to be influenced by

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