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EFFECT OF PHOTOPERIOD ON PLASMA THYROXINE HORMONE LEVEL OF MIRROR CARP *(CYPRINUS CARPIO)* RAISED AT A LOW WATER TEMPERATURE IN A CONTROLLED ENVIRONMENT

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Abstract

The objective of this study was to examine the effects of various lighting regimes on the plasma thyroxin hormone (T_4) level of mirror carp *(Cyprinus carpio)*. The carp were kept at the low temperature of 9°C to eliminate any influence of water temperature on feed intake, growth, and the hormone level. Treatments were 8 h light:16 h dark, 12 h light:12 h dark, and 16 h light:8 h dark. Plasma thyroxin levels were measured every four weeks for 12 weeks. The levels were significantly higher ($p<0.05$) in the groups exposed to 8 or 12 h light than in the group exposed to 16 h. The T_4 levels significantly dropped with time in all photoperiods.

Introduction

Thyroid hormones play important roles in the physiology of teleost fishes, i.e., in the regulation of metabolism (Gupta and Thapliyal, 1991; MacKenzie et al., 1998), growth and development (Power et al., 2001; Gavlik et al., 2002), energy utilization (Leatherland, 1994), sexual maturation (Monteverdi and Di Giulio, 2000; Mercure et al., 2001), breeding cycle (Volkoff et al., 1999), migration (Matty, 1985), and electrolyte and water metabolism (Peter et al., 2000).

Physiological and morphological characteristics of fish continually adjust to the ever-changing aquatic environment. The circannu-

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al rhythms of hormones seem to be closely associated with circannual variations in ambient temperature, day length, and gonadal steroids (Pavlidis et al., 2000).

Developmental and maturational events are dominated and coordinated by seasonal changes in photoperiod, temperature, food supplies, rainfall, etc. (Porter et al., 1998; Sánchez–Vázquez et al., 2000). Photoperiod and temperature are generally considered the most important factors. Recent data suggest that genotype, hormones, and physiological conditions are equally important endogenous regulators of growth (Dutta, 1994).

Fish growth and food conversion are improved by increasing the photoperiod (Gross et al., 1965). Water temperature is also correlated to food intake, being high in the spring and summer and relatively lower during the winter (Larsen et al., 2001). Changes in temperature and food consumption cause dynamic changes in the seasonal profiles of many physiological parameters, including growth rate and plasma thyroxin (T_4; Tiitu and Vornanen, 2003).

In Atlantic salmon, thyroid hormone production reaches a maximum in summer when the long period of light stimulates growth and plasma T_4 levels without affecting T_3 (McCormick et al., 1987). Low levels of thyroid hormones are found in fish during winter when the light period is short (Samejima et al., 2000). On the other hand, Brown (1988) reported that a short day length or complete darkness stimulated the thyroid gland in freshwater and euryhaline species.

Most of the above studies were concerned with seasonal fluctuations in growth or thyroid hormones while some dealt with the optimum temperature for growth or thyroid hormones. We investigated whether different photoperiods affect the plasma T_4 level of mirror carp at a constant low temperature (9°C).

Materials and Methods

Animals. The study was conducted in the Central Laboratory at the Aquarium Fish Rearing Facility of the Fisheries Department of the Agricultural Faculty at Atatürk University with mirror carp obtained from the Research and Extension Center of the Fisheries Department.

Photoperiod experiments. The carp were randomly sorted into three 70-l circular fiberglass tanks (45 x 45 cm) with a constant water flow of 1.5 l/min of aerated dechlorinated tap water at a density of 10 fish per tank. Three photoperiods were tested in triplicate for a total of nine tanks, i.e., 30 fish in each regime. Mean weights were 63.06±3.83 g, 62.40±3.54 g, and 61.96±3.49 g, respectively for the three regimes.

Fish were acclimated for one week at 12 h light:12 h dark. Then the photoperiods were switched to short (8 h light:16 h dark, lights on at 09:00), medium (12 h light:12 h dark, lights on at 06:00), or long (16 h light:8 h dark, lights on at 04:00) for 12 weeks at a constant water temperature of 9°C.

The fish were fed a daily ration at 1% of their live body weight. Feeding times were centered in the middle of the light period. Growth was expressed as mean weight over the duration of the study and as mean weight gain (% of the initial weight).

Blood sampling. Every four weeks, the fish were captured, anesthetized in MS-222 (200 mg/l) during the scotophase, and individually weighed. At the same time, blood samples were obtained from the caudal vasculature of each carp with a heparinized syringe. The blood samples were kept on ice for up to 30 min until the plasma was separated by centrifugation. Plasma samples were stored at –80°C until analysis. Plasma T_4 concentrations were determined according to the method of Dickhoff et al. (1982).

Statistics. All data were subjected to a one-way analysis of variance followed by Duncan's multiple-range test to determine significant differences among the regimes at the 0.05 level. Results are presented as means ± standard deviation.

Results

There were no significant differences in weight gain among treatments (Fig. 1). Plasma T_4 levels were significantly higher in the groups exposed to 8 or 12 hours of light than in the group exposed to 16 (Fig. 2). Plasma T_4 levels

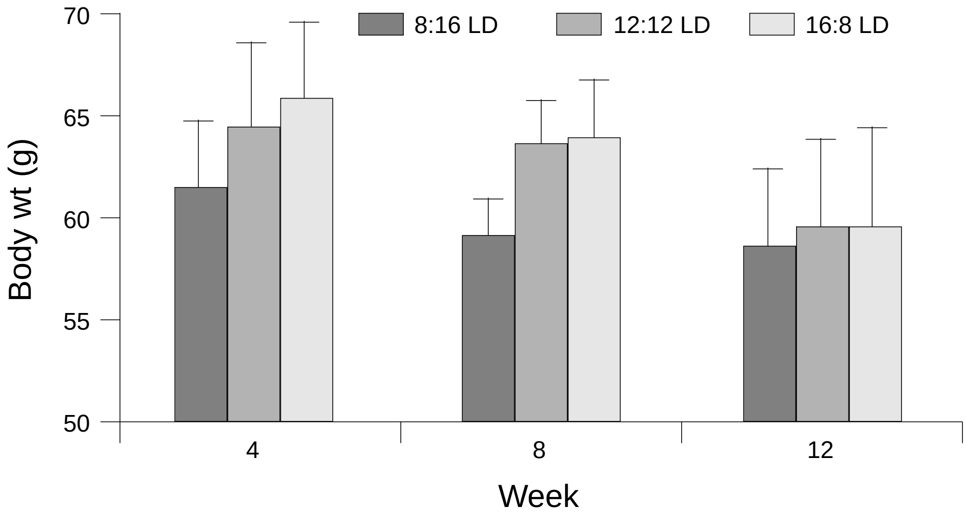

Fig. 1. Growth of mirror carp kept at 8 h light:16 h dark, 12 h light:12 h dark, or 16 h light:8 h dark for twelve weeks at a low water temperature (9°C).

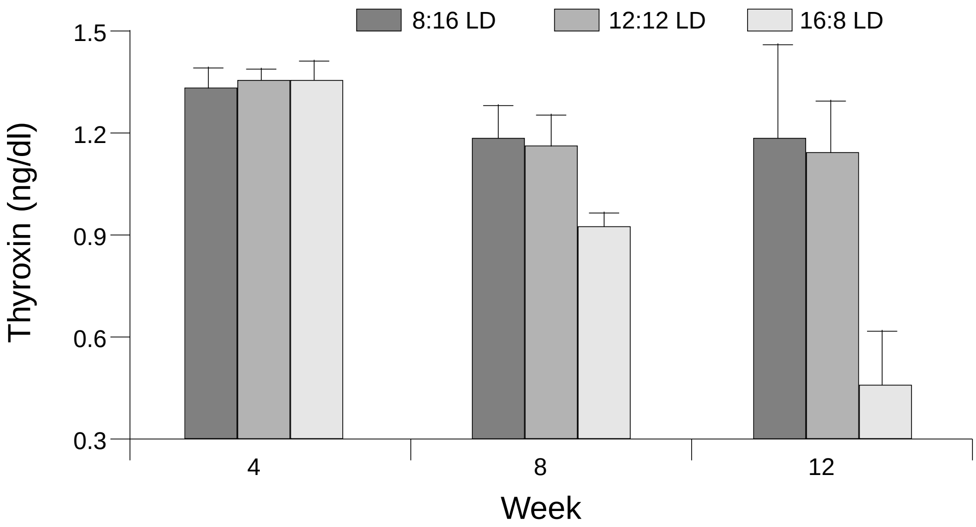

Fig. 2. Plasma thyroxin hormone (T_4) of mirror carp kept at 8 h light:16 h dark, 12 h light:12 h dark, or 16 h light:8 h dark for twelve weeks at a low water temperature (9°C).

significantly dropped with time in all three photoperiods. At 12 weeks, weight gain dropped 4.78±5.11%, 7.57±1.51%, and 8.72±1.37% while plasma T_4 dropped 12.1%, 15.8%, and 66.9% in the 8:16, 12:12, and 16:8 photoperiods, respectively.

Discussion

Despite the fact that the fish were fed at a ratio of 1% of their body weight daily, they did not grow at the low temperature of 9°C. Reduced growth at this temperature is expected, due to bioenergetic considerations (Hepher, 1988).

Similar to our findings, reduction in growth was reported in trout kept at a low water temperature of 2.5°C (Larsen et al., 2001).

Although no significant differences were observed in the present study with respect to weight gain, it has been reported that photoperiod and temperature affect growth in some species. Boehlert (1981) showed that 16 h light:8 h dark enhanced growth in *Sebastes diploproa* compared to 12:12, and is probably related to a lower metabolic rate. Gilthead seabream raised in longer light periods (in an experiment testing 8:16, 12:12, 16:8, 24:0, and natural photoperiods) grew better (Silva-Garcia, 1996). Boeuf and Le Bail (1999) reported that water temperature ranges from less than 10°C (December-February) to as high as 20°C (June-August); thus, the fluctuation in temperature also affects the growth rate. Multiple mechanisms undoubtedly are involved in promoting tolerance to low temperatures. In goldfish, for example, acclimation to temperatures below 10°C evokes a highly regulated reduction in the metabolic rate, membrane phospholipid reorganization, and alterations in enzyme-substrate affinity relative to warm-acclimated individuals (Ganim et al., 1998).

In fish, the secretion of thyroid hormones is influenced by photoperiod, temperature, and food intake (Cyr et al., 1998; Tiitu and Vornanen, 2003). Food intake depends on temperature and is high in spring and summer when light effects better food conversion efficiency and, thus, better growth (Boeuf and Le Bail, 1999). Contrary to the effects on growth, it is difficult to distinguish how photoperiod affects the thyroid hormone level. We raised the carp in a low water temperature to assure that any fluctuation in thyroid level could not be attributed to an increased feed intake resulting from a warmer environment. Differences in T_4 level could result only from differences in the photoperiod. Indeed, we found that T_4 levels were significantly reduced by a longer period of light throughout the study period.

Similarly, Larsen et al. (2001) reported that during the winter, when day lengths are short and temperature is low, T_4 levels are relatively unaffected by manipulations in feeding and temperature compared with insulin or insulin-like growth factor-I (IGF-I) and suggested that photoperiod has a more significant effect on the plasma profile of T_4 than temperature or ration. However, the 8:16 and 12:12 treatments significantly differed from the 16:8 treatment, showing that low water temperature had a lesser impact on T_4 in a short photoperiod than in a long photoperiod. In other words if the water temperature had been optimum, fish exposed to longer periods of light would have grown better (Silva-Garcia, 1996; Boehlert, 1981) and thyroxin secretion would have increased. Similarly, Brown and Stetson (1985) showed that 14 h light increased and 8 h light decreased the negative feedback sensitivity of the hypothalamus–pituitary axis to TH in killifish *Fundulus heteroclitus*. They proposed that such a photoperiod-induced change could aid in the year-round maintenance of thyroxin levels necessary for seasonal adaptation and survival. Eales and Fletcher (1982) also observed seasonal changes in plasma TH levels in laboratory and wild fish while Osborn and Simpson (1978) obtained seasonal variations in plasma circulating T_3 and T_4, with *maxima* reached in winter and summer. Obviously, these changes, even if related to light as in the present study, can also be linked to temperature changes as mentioned in the above studies.

There were no significant differences in growth while the T_4 value was much lower at 16:8. These results suggest that future aquaculture studies, especially off-season studies, should not be based on a photoperiod of 16 light:8 dark. Further studies should be conducted at optimum and high temperatures to test various photoperiods in other fish species.

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