LASTING TEMPERATURE EFFECTS ON THE MUSCLE TISSUE, BODY GROWTH AND FILLET TEXTURE OF ADULT TURBOTS, *Scophthalmus maximus*, L.

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Introduction

In the teleosts, several factors can influence the muscle growth patterns of fish by a modulation of the hypertrophy and hyperplasia. The temperature (T) is one of the most important environmental factors. Thus, the T history of fish influences on their potential growth, as it has been observed in Salmon, *Salmo salar* (Johnston et al., 2003) and other species. The T imprinting can influence on the muscle cellularity throughout the advanced stages of life due to the lasting T effects on myogenic cells precursors (MPC) (Steinbacher et al., 2011). In different teleost species, a correlation between texture and muscle fibre size has been demonstrated (Hatae et al., 1990). Hence, the thermal history can also influence in the flesh texture. In the present work we study the lasting T effects in adult turbots reared at different Ts during the early phases. This species reaches ≈ 1.5 kg at 18-20 months of age and the first sexual maturity takes place at ≈ 24 months.

Materials and methods

This experiment was carried out with turbot specimens proceeding of a stock of spawners of the Instituto Español de Oceanografía (Centro Oceanográfico de Vigo, Spain). At hatching the larvae were divided into three tanks and then maintained during 150 days at 15-16ºC (cold group), 17-18ºC (ambient group) and 21-22ºC (warm group). Later on, all the specimens were kept at ambient T. Muscle samples were obtained at 1 year and at 1.8 year of age, which coincides with the commercial size: ≈ 1.5kg and 40 cm. At each stage, the following parameters were studied in 8-10 turbots (4-5 females and 4-5 males per stage): body length, body weight, epaxial dorsal fillet weight, transverse area of the red and white muscles of the fillet and number, size and density of the white muscle fibres. The size was estimated from ~ 800-1000 fibres from the epaxial fillet in each specimen. The textural parameters were also measured (springiness, hardness, cohesiveness, chewiness and gumminess). The statistical analysis was performed with Statistical Package SPSS 15.0. ANOVA, Tukey test and Pearson´s correlation coefficient were used, for $P < 0.05$.

Results

At 1 year of age, almost all the muscle and body parameters were greater in the warm than in the rest of groups, followed by the ambient and the cold groups. However, the body length was greater at ambient than at warm T. At 1.8 years of age (commercial stage) the reverse situation was found, such that almost all the muscle and body parameters were higher in the cold than in the rest of groups. By comparison among the muscle parameters, the hypertrophy was the fibrillar parameter more significantly influenced by the T, being higher in the cold than in the rest of groups ($P<0.05$) (Table I). In relation to the texture parameters, these did no show significant differences among the groups nor did show correlation with the muscle cellularity.
In relation to the sex influence, the muscle fibres size was lower in the female fish in the three groups in both stages of age, although it was only significant at 1.8 years. In contrast, the number and density of fibres was higher in the female than in the male at the commercial stage. The texture parameters did no show significant sex influence.

Table 1. Minor axis length (μm) (mean ± SEM) in the three thermal groups of 1.8 years old turbot (commercial size).

Cold group	Ambient group	Warm group
85.9 ± 0.65	74.12 ± 0.5	78.9 ± 0.65

Discussion y conclusion

At 1 year of age, the muscle and body growth were usually higher in the warm group. Similar results were found in three groups of turbots larvae reared under the same conditions than in the present work until 80 days posthatching (unpublished results), showing the warm group the highest muscle and body growth. The results found in the present work show a lasting effect of the thermal history in this species, as found in juvenile turbot by Imsland et al. (2007). In contrast, at 1.8 year of age (commercial size), the cold group showed the highest values of the muscle and body growth. These results show that fish with colder T in early stages present a compensatory growth in advanced stages, as observed by Steinbacher et al. (2011) in pearlfish, *Rutilus meidingeri* Heckel incubated at different Ts. The 16ºC embryos reduced MPC proliferation but increased differentiation and thus gave rise to larger hatchling. However, their limited MPC reserves lead to smaller adults. By contrast, embryos of 13º fish and, to a lesser extent, 8.5ºC fish showed enchanced MPCs proliferation but reduced differentiation, thus leading to smaller hatchlings but resulting in larger adults. This can explain, at least in part, our results. Thus, even though the warm T is optimal for the growth in juvenile and 1 year old turbots, the cold group reached greater growth at commercial stages. In relation to the muscle cellularity, the cold T increased both hypertrophy and hyperplasia, but it was only significant for the hypertrophy. Similarly, Steinbacher et al. (2011) found that cold imprinting favoured hypertrophy over hyperplasia. On the other hand, the texture values did not show correlation with the muscle cellularity, which differs of found in other species (Hatae et al., 1990). The sex influence was significant at 1.8 years of age, with lower values of hypertrophy in female than in male specimens, that could be related with the beginning of the sexual maturation in this stage.

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