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# Growth performance and stress response of common sole subjected to varying stocking densities and rearing temperatures

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## ABSTRACT

Earlier short-term studies have shown productivity of intensively farmed common sole (*S. solea*) to be closely dependent on rearing density. Irrespective of fish size, elevating crowding conditions led to declining growth rates while the effect of density on mortality remains controversial. To what extent water temperature could affect productivity of growing sole subjected to varying crowding conditions, warrants investigation as very few studies have tried to quantify the effects of this fundamental rearing parameter on growth and survival in this fish species. This is particularly crucial for developing suitable farming protocols in Italy, where common sole may experience a broad range of water temperatures throughout the rearing cycle. The aim of this study was to evaluate productivity and blood cortisol level as a measure of stress response, in growing sole subjected to different stocking densities and temperature conditions. Six hundred juveniles (ind. weight  $21.8 \pm 1.5$ g) were randomly allotted among eight groups kept in  $0.38\text{m}^2$  ( $0.1\text{m}^3$ ) rectangular vessels, according to a factorial design combining two stocking densities (D, 150 vs 300 ind/m<sup>2</sup>; i.e. 3.3 vs 6.5 kg/m<sup>2</sup>) and two rearing temperature ranges (T, 18-20 vs 22-24°C) with duplicate groups per treatment. Fish were fed over 148 days an extruded dry diet distributed at 1% biomass/d in two meals. After 32 and 134 days on trial, blood samples were obtained after caudal puncture from five specimens per group. Plasma cortisol levels were analysed by EIA. Growth performance, survival, feed conversion rate (FCR) and productivity (biomass gain/m<sup>2</sup>/d) were calculated per group at the end of the trial. All response variables were subjected to a two-factor ANOVA. No significant interaction was found between main factors for the various response parameters. The different rearing temperature did not affect ( $p > 0.05$ ) growth performance (final individual weight,  $59 \pm 11$ g, specific growth rate,  $0.67 \pm 0.11\%$ d<sup>-1</sup>), survival ( $83.5 \pm 11\%$ ), FCR ( $1.6 \pm 0.2$ ), productivity ( $35.5 \pm 5.8$ g/m<sup>2</sup>/d) or plasma cortisol levels ( $6.6 \pm 0.5$ ng/ml). Doubling the initial stocking density resulted in reduced growth (final weight, 49 vs 68.5g; specific growth rate, 0.59 vs 0.75,  $p < 0.05$ ), lower survival (76 vs 91.3%,  $p < 0.05$ ) and impaired FCR (1.8 vs 1.4,  $p < 0.05$ ). On the opposite, productivity was significantly improved at the higher density ( $39.1$  vs  $31.8$ g/m<sup>2</sup>/d) while plasma cortisol levels were unaffected by crowding. The results here obtained confirm a density-dependent growth performance in sole which appears unrelated to rearing temperature. Plasma cortisol levels did not suggest rearing density or water temperature to be chronic stressors within the range of values here investigated. In this study, sole was shown to be able to adapt to a wide range of intensive culture conditions. This could provide clues on possible farming strategies aimed at promoting fast growth and/or high productivity by modulating stocking density.

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