Growth parameters in European sea bass (Dicentrarchus labrax L.): effects of live weight and water temperature

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ABSTRACT

The voluntary feed intake (VFI) and growth rate of sea bass were studied for 147 days, based on different starting live weights, under natural photoperiods and varied water temperatures. Sea bass (n = 720) were divided into five weight classes (60-70, 90-110, 130-150, 160-180 and 230-250 g) and distributed among 20 tanks. Seven different water temperatures were compared: 13, 16, 19, 22, 25, 28 and 31 °C. A commercial extruded diet (N x 6.25, 43.7% DM; crude fat, 25.7% DM) was used. The trial was performed in a closed-circuit plant, with a daily water turnover rate of 10%. Each tank was fitted with an apparatus for collecting the uneaten food. Automatic feeders distributed equal amounts of food for ten meals per day. The daily food allowance was adjusted, based on fish biomass, to permit ad libitum feeding and to leave approximately 20% uneaten. Fish were exposed to natural photoperiod (March-July). Non-linear regression equations were used to calculate the best-fitting curves for the data.

Key words: Voluntary feed intake, Growth rate, Body weight, Temperature, Sea bass.

RIASSUNTO

PARAMETRI PRODUTTIVI NELL’ALLEVAMENTO DEL BRANZINO (DICECENTRARCHUS LABRAX L.):
EFFETTO DEL PESO VIVO E DELLA TEMPERATURA

In un esperimento della durata di 147 giorni vennero studiati l’effetto della temperatura e peso corporeo sull’ingestione volontaria di alimento e tasso di accrescimento del branzino. Settecentoventi branzini, selezionati in cinque classi di peso (60-70, 90-110, 130-150, 160-180 e 230-250g), vennero distribuiti casualmente in 20 vasche e comparate 7 temperature 13, 16, 19, 22, 25, 28 e 31 °C. Durante la prova sperimentale venne usata una dieta estrusa commerciale (N x 6,25, 43,7% SS; EE, 25,7% SS). Per l’allevarimento dei pesci venne utilizzato un sistema a ricircolo con un una sostituzione giornaliera dell’acqua di circa il 10%. Ciascuna vasca era dotata di sistema automatico di raccolta dell’alimento non consumato. L’alimento veniva distribuito in dieci pasti al giorno mediante distributori automatici. La quantità di mangime somministrata venne modificata giornalmente sulla base del peso dei pesci. L’alimento venne distribuito ad libitum con circa il 20% di residui. I pesci vennero allevati in condizioni di fotoperiodo naturale (Marzo-Luglio). Equazioni di regressione non lineare hanno consentito la migliore rappresentazione dei dati sperimentali.

Parole chiave: Ingestione volontaria, Tasso di accrescimento, Peso vivo, Temperatura, Branzino
Introduction

Body weight and water temperature are the main factors influencing the food intake of poikilothermic fish (Brett and Groves, 1979; Jobling, 1994). Growth models are derived from experimental data, to establish feeding schedules for use in fish farming (Cho and Bureau, 1998). Several papers have been published on this topic concerning salmonids, namely the classic works of Elliot (1975), and Brett and Groves (1979). Little information is available for marine fish, with the exception of the studies of Pedritis and Rogdakis (1996) and Lupatsch and Kissil (1998) on sea bass reared in sea cages. The present trial was performed to gather further information on the voluntary feed intake of sea bass of various starting live weights, exposed to different water temperatures.

Material and methods

The trial was performed in a closed-circuit plant using twenty 160 l fiberglass tanks for 147 days. Daily water turnover rate was fixed at 10% of the total volume. Each tank was fitted with an apparatus for collecting food residue, according to the method of Helland et al. (1996), with modifications. Automatic feeders were set up to distribute equal amounts of food, in ten meals per day from 0910 to 1515 h. Daily food allowances were calculated on fish biomass to allow ad libitum feeding plus an estimated 20% residue. A group of 720 sea bass was divided into five different weight classes (starting weight: 60-70, 90-110, 130-150, 160-180 and 230-250 g) and distributed among tanks with four replicates of each weight class. The initial stocking rate was of about 28.7 Kg m$^{-3}$ per tank and in May the number of fish per tank was reduced in order to keep the same stocking rate. All weight classes were subjected to the same water temperature in each of the tanks. Seven different water temperatures (13, 16, 19, 22, 25, 28 and 31°C) were compared (starting from 13°C). Each temperature was tested for 21 days: 3 days of initial adaptation, 13 days as a preliminary period for calibrating food allowances and 5 final consecutive days for measuring food intake. During the experiment, water temperatures were varied to mimic the natural conditions along the Mediterranean coast and in associated lagoons during the year.

Fish were weighed at the beginning and end of each period. The same extruded concentrate pellets (N x 6.25, 43.7%; crude fat, 25.7%; 3 mm diameter) were used during the trial. Water salinity was on average 17 ± 0.1 P.S.U. and the dissolved oxygen content was 6.69 ± 0.81 mg L$^{-1}$. Fish were exposed to natural photoperiods, with the light duration varying from 11 h 23 min in March to 15 h 36 min in June. Data were evaluated using NLIN procedures (SAS, 1990) and the figures were drawn using the Matlab package (Dabney and Harman, 1998).

Results and discussion

The following non linear equation:

$$ y = a \cdot BW^{b} \cdot \exp^{cT} $$

where $y =$ VFI, either as percentage live weight increment or as growth rate per day (g.d$^{-1}$); BW = body weight; T = temperature; and a, b and c are coefficients, gave better results in terms of R$^2$ and residual error in estimating the voluntary food intake and growth rate in sea bass. A similar approach was used by Pedritis and Rogdakis (1996), and by Lupatsch and Kissil (1998) for sea bass.

Table 1. Non linear prediction equations of feed intake and growth rate using the body weight and temperature as independent variables.

| Equation Type | Prediction Equation | R$^2$ Value | MSE Value | df |
|---------------|---------------------|-------------|-----------|----|
| Voluntary feed intake (VFI) (g.d$^{-1}$) | $0.0006 \cdot BW^{0.82} \cdot \exp^{0.07T}$ | 0.9751 | 0.033 | 119 |
| Voluntary feed intake (VFI) (% l.w.) | $0.51 \cdot BW^{-0.15} \cdot \exp^{0.07T}$ | 0.9780 | 0.15 | 119 |
| Growth rate (g.d$^{-1}$) | $0.010 \cdot BW^{0.68} \cdot \exp^{0.05T}$ | 0.8530 | 0.21 | 119 |
bream reared in sea cages. The formulae of equations are given in Table 1. The general trends (Figures 1 to 3), are shown either as increments in the percentage of live weight or as growth rates (g.d⁻¹). A positive effect of higher temperatures up to 28 °C on food intake and growth performance is clear. As initial fish size increased, voluntary food intake expressed as a percentage of live weight decreased, following a pattern common to all fish.

The effects of temperature on VFI, growth rate, and FCR for sea bass fingerlings subjected to different water salinities and temperatures were investigated by Alliot et al. (1983). Fingerlings grew faster at a higher temperature (22 °C), than at a lower one (15 °C), and had higher food consumption and a better FCR. Similar results were obtained by Zanuy and Carrillo (1985) for sea bass of 240 g starting live weight exposed to natural thermoperiods and photoperiods. Hidalgo et al. (1987) tested the effect of two temperatures (15 °C vs 20 °C) on juvenile sea bass at different feeding levels. In a more recent trial, sea bass fingerlings reared at 18 °C and 25 °C (Peres and Oliva-Teles, 1999) showed a better growth rate, FCR and food intake at the higher temperature.

In the present study, VFI and daily weight gain both showed a significant improvement over the range (22 to 28 °C). These findings are in agreement with those of Barnabé (1990) who reported an optimal temperature range (23 to 27 °C) for the growth of sea bass. Requena et al. (1997) studied sea bream, and found increases in oxygen consumption, metabolic rate (mainly due to the increase of SDA), and energy requirements, but without any reduction of growth when the temperature rose from 20 to 28 °C. Above this temperature, according to the general trend described by Brett and Groves (1979), a sharp increase is expected in the active metabolic rate due to the high energy requirements for ventilation and blood circulation. Furthermore, at high temperatures, oxygen content becomes a limiting factor because of its reduced water solubility. Concerning the growth rates (g.d⁻¹), the values obtained by the present equation are lower than those calculated using the formula proposed by Lupatsch and

Figure 1. Effect of body size and temperature on VFI (g.d⁻¹).
Figure 2. Effect of body size and temperature on VFI (% l.w.).

Figure 3. Effect of body size and temperature on growth rate (g.d⁻¹).
Kissil (1998) for sea bream reared in sea cages. There are several reasons for this discrepancy: the food characteristics and quality, species and genetic differences and stocking densities all differed.

The equations presented in this paper can be used to prepare feeding charts for the most important Mediterranean species, although additional data will need to be gathered in the future to validate these results.

Conclusions

Results of the present research confirm the main role of temperature and body weight on sea bass growth parameters. By means of non linear regression equations it is possible to calculate accurate predictions of VFI and growth rate for practical purposes.

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