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A preliminary study on growth and protein synthesis of juvenile barramundi, *Lates calcarifer* at different temperatures

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Abstract

Temperature is recognized to be the most important environmental factor affecting growth and protein synthesis in fish. The optimal temperature for growth of juvenile barramundi is 31 °C, although culture often occurs at temperatures which are above and below this optimum. Juveniles (2.96±0.46 g) were held at five different temperatures ranging from 21 to 33 °C at 3 °C intervals. Fish were fed to satiation twice daily (504.5 g kg^{-1} crude protein, 190.5 g kg^{-1} lipid, 128.5 g kg^{-1} ash, and 20.2 GE MJ kg^{-1}). Daily feed intake (g), growth (% d^{-1}), growth efficiency, and protein synthesis (measured 24 h after feeding) were determined for each temperature. Feed intake was significantly higher at 33 °C, than at any other temperature. Growth and growth efficiency were not significantly different between the 27, 30 and 33 °C groups but were significantly higher than the 21 and 24 °C groups. In order to take account of the variation in protein synthesis over the 24 h following feeding and model daily protein turnover, daily rates of protein synthesis were estimated from previously determined relationships between white muscle and whole body rates of protein synthesis. This showed that protein synthesis was not significantly different between 27 and 33 °C, synthesis retention efficiency was over 40% at these temperatures, and at 21 °C growth efficiency was poor. Growth efficiency and protein metabolism were optimal over a temperature from 27 to 33 °C.

Keywords: Barramundi; Feed intake; Growth efficiency; *Lates calcarifer*; Protein synthesis; Temperature

1. Introduction

Temperature has been identified as the most important abiotic factor affecting growth in ectotherms, including fish (Brett and Groves, 1979). Temperature has a direct effect on feed intake and metabolism, including protein turnover and therefore on the growth efficiency of fish (Jobling, 1994; McCarthy and Houlihan, 1997). As temperature increases across the thermal tolerance of a species the feed intake and growth follow asymmetric patterns, gradually increasing to a maximum at the optimal temperature (Jobling, 1997; McCarthy et al., 1999). As temperature increases above the optimum, there is a sharp decrease in both of these parameters and therefore in growth efficiency. Metabolism increases exponentially as temperature increases and at any given temperature, the difference between feed intake and metabolic rate will determine the energy available for growth of the organism (Brett and Groves, 1979; Jobling, 1994). There have been numerous studies and reviews documenting the effects of temperature on growth performance of fish, but few studies have

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investigated its effects on protein synthesis (McCarthy and Houlihan, 1997; Carter and Houlihan, 2001).

Barramundi, *Lates calcarifer*, is a commercially important farmed species in Australia and Southeast Asia and aquaculture has recently expanded to North America and Europe. Production of these fish within Australia has steadily increased for the past 15 years and this trend is expected to continue (Boonyaratpalin and Williams, 2002). The wild fishery for barramundi in northeastern Australia is also a major industry grossing more than 6 million dollars annually and is surpassed by the recreational fishery. Barramundi are endemic across northern Australia and extend north to Southeast Asia and west to the Persian Gulf. Barramundi have a wide thermal tolerance range (15 to 40 °C) and they are commercially cultured at temperatures from 22 to 35 °C, however the high and low extreme temperatures which they are cultured at approach the thermal tolerance for this species. Until recently (Katersky and Carter, 2005) studies have not examined temperatures above 30 °C.

The influence of temperature on protein synthesis has been measured in some fish (McCarthy and Houlihan, 1997; Carter and Houlihan, 2001), still few studies have concurrently investigated protein synthesis and growth over a temperature range and attempted to relate changes in protein synthesis to the range of temperatures over which growth is optimal. Growth is a reflection of physiological function and therefore protein synthesis is predicted to also exhibit an asymmetric response to temperature. However, in Atlantic wolfish white muscle rates of protein synthesis did not display such a pattern and showed a linear response with temperature (McCarthy et al., 1999). Protein synthesis has only been measured at a limited number of temperatures above the optimal temperature for growth which makes it difficult to determine the temperature response, this is a component of the present study. With barramundi becoming an increasingly important global aquaculture species, this provides an excellent opportunity to gather data on a fish species which is being cultured in a wide range of temperatures. The aims of the present study were to determine the optimal temperature for feed intake, growth efficiency and protein metabolism in juvenile barramundi.

2. Materials and methods

2.1. Experimental diet

A standard diet was formulated according to known dietary requirements for barramundi (Boonyaratpalin and Williams, 2002). The diet was formulated to contain 50% crude protein and 19.7 MJ kg^{-1} gross energy (Table 1). Fish meal and fish oil were supplied by Skretting (Tasmania, Australia). Vitamins and minerals were supplied by Sigma-Aldrich Pty. Ltd (Sydney, Australia), and vitamin C was supplied as Stay-C from Roche Pharmaceuticals (Roche Vitamins Australia Ltd., Sydney, Australia).

Table 1
Ingredient and chemical composition of experimental diet

Ingredient composition (g kg^{-1})	
Fish meal	730
Fish oil	70
Pre-gelatinized starch	119
CMC	10
Choline chloride	10
Monobasic sodium phosphate (NaH_2PO_4)	10
Vitamin C (Stay-C)	20
Yb_2O_3	1
Vitamin premix [a]	15
Mineral premix [b]	15
Chemical composition (g kg^{-1} DM)	
Dry matter (g kg^{-1})	937.0
Crude protein	504.5
Crude lipid	190.5
Ash	128.5
Energy (MJ g^{-1})	202.5

[a] Vitamin premix (mg kg^{-1}): vitamin A (7.50), vitamin D (9.00), Rovimix E50 (150.00), menadione sodium bisulphate (3.00), riboflavin (6.00), calcium D-pantothenate (32.68), nicotinic acid (15.00), vitamin B-12 (0.015), D-biotin (0.23), folic acid (1.50), thiamin HCL (1.68), pyridoxine HCl (5.49), myo-inositol (450.00), and α-cellulose (817.91).

[b] Mineral premix (mg kg^{-1}): $CuSO_4$ $5H_2O$ (35.37), $FeSO_4$ $7H_2O$ (544.65), $MnSO_4$ H_2O (92.28), Na_2SeO_3 (0.99), $ZnSO_4$ $7H_2O$ (197.91), KI (2.16), $CoSO_4$ $7H_2O$ (14.31), and α-cellulose (612.33).

2.2. Growth experiment

Juvenile barramundi, *L. calcarifer*, (1–2 g) were obtained from WBA Hatcheries (South Australia, Australia). Fish were maintained at the University of Tasmania under constant environmental conditions (salinity: 10‰; photoperiod: 24 h light; temperature: 27 °C) and stocked into 5 150-l aquariums and maintained at 27 °C. Temperatures were adjusted 1 °C d^{-1} towards their experimental temperatures of 21, 24, 30 and 33 °C, with the exception of the 27 °C aquarium that was maintained at a constant temperature. After 6 days all fish were at their experimental temperature. The fish were fed to satiation twice daily for one week at these temperatures. The standard diet was fed to all fish at all times.

At the start of the experiment, 60 fish from each treatment were anesthetized (100 mg l^{-1}, benzocaine) and individual weight (g) and total length (mm) measured. Fish were randomly separated into 3 18-l tanks.