ISSN: 0001-5113 AADRAY	ACTA ADRIAT, 40 (1): 3-6, 1999	UDC: 597.583.1 Original scientific paper

Respiration rate in relation to body size and oxygen saturation threshold for juveniles sea bass (*Dicentrarchus labrax* L.) mortality

Mladen TUDOR

Institute of Oceanography and Fisheries
P.O. Box 500, 21000 Split, Croatia

Respiration rate of juveniles sea bass was measured on 55 individuals with weight of 0.06 to 5.47 g. Respiration rate (Vo_2 in $mgO_2\ h^{-1}$) at 20°C in relation to body mass is $Vo_2=0.888(mass)^{0.82}$. The mortality of juveniles sea bass begin when the oxygen saturation is under 30% at a partial pressure of oxygen below 45 mm Hg.

Key words: sea bass, respiration rate, mortality

INTRODUCTION

The fish oxygen consumption can be expressed as weight-specific (mass O_2 mass fish^{-1} time^{-1}) or as absolute rate of oxygen consumption (mass O_2 time^{-1}) (WINBERG, 1961; POST and LEE, 1996). Oxygen consumption-mass relationships are reported in the literature as $Vo_2=a(mass)^b$.

Metabolic rate of fish may be standard, routine and active (FRY, 1957). Oxygen consumption of inactive, unfed fish is standard metabolic rate, while the one at the maximum sustainable swimming speed, is active metabolic rate (BRETT, 1964). Oxygen consumption at routine metabolism is obtained during spontaneous activity of unfed fish (LUCAS and PRIEDE, 1992).

In this study the metabolic allometry and oxygen saturation level or the partial pressure for juveniles sea bass mortality were determined.

MATERIAL AND METHODS

Oxygen consumption of sea bass juveniles

Oxygen consumption in sea bass (*Dicentrarchus labrax* L.) juveniles from 0.06 to 5.47 g body weight was measured on 55 individuals. Fish were obtained with induced artificial hatching in the Institute of Oceanography and Fisheries, Split, Croatia.

Before measuring the oxygen consumption, fish were starved for 10 to 24 hours depending on fish size. Fish were individually placed in a respiratory jar with volume of about

300 ml. Initial oxygen concentration was measured before than the jar was closed and put in the thermostatic bath at temperature of 20±0.2°C. Salinity of seawater was $38 \cdot 10^{-3}$. After a definite incubation time (1 to 3 hours, depends of fish weight) concentration of oxygen was measured again with an oxygen probe (WTW Oxy 92).

Oxygen consumption measured in this way can be denoted as routine oxygen consumption. The data may be put in the form $Vo_2 = a(mass)^b$ as proposed by WINBERG (1961), where Vo_2 is given in a mass (or volume) of oxygen consumed per time, *mass* is the wet weight and *a* and *b* are constants. More commonly, linear regression equations are reported using a double log transformation $\log Vo_2 = a + b \log(mass)$ where *a* is the intercept in units of log O_2 per fish per unit time, and *b* is the slope (POST and LEE, 1996).

Oxygen threshold for sea bass juveniles mortality

Concentration of oxygen for sea bas juveniles mortality was determined by a time course incubation of 55 individuals of the average body weight (±standard deviation) 4.21±1.16 g and length 7.05±0.71 cm. The juvenile sea bass were put in open vessel with 17 liters of sea water in contact with the air (temperature 24°C and salinity $38 \cdot 10^{-3}$). In definite time intervals depletion of oxygen in the vessel was measured and number of dead individuals was recorded. The criterion of death was the absence of any opercular activity.

RESULTS

Oxygen consumption of juveniles sea bass

Linear regression of oxygen consumption of sea bass juveniles at 20°C on body weight is shown in Fig.1. Oxygen consumption (Vo_2 as mg O_2 h^{-1}) and the body weight (in grams) in log-log functional relationship, with 95% confidence limits of parameters, is:

$$\log V_{O2} = -0.0517(\pm 0.0092) + 0.8188(\pm 0.0168) \log(mass)$$

$n = 55$; $r^2 = 0.994$.

Coefficient of determination (r^2) indicates that 99.4% variance of oxygen consumption can be explained with the fish weight.

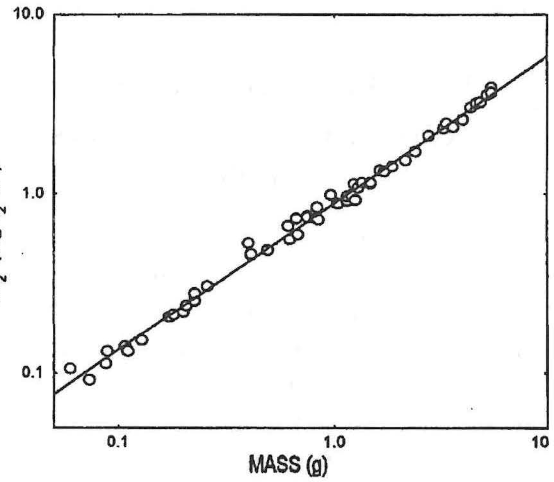

Fig.1. Regression line relating mass respiration rate to body mass of sea bass juveniles

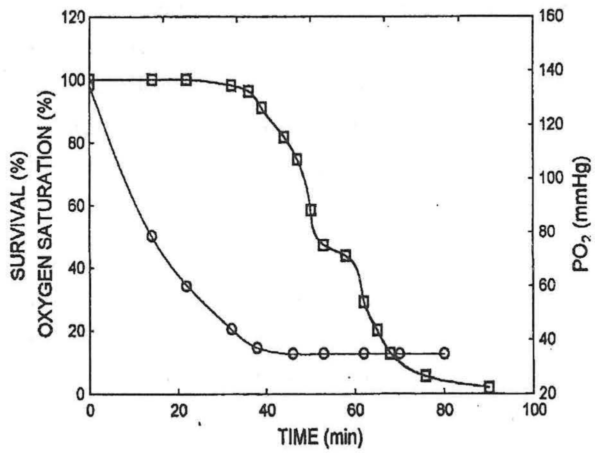

Fig.2. Survival (□) of sea bass juveniles as a result of decreasing of the oxygen saturation or partial pressure (o) in the water

Oxygen threshold for sea bass juveniles mortality

The sea bass juveniles mortality starts when the saturation of oxygen is less than 30% at a oxygen partial pressure in sea water of about 45 mm Hg (Fig. 2). Forty minutes after the start of the mortality the concentration of oxygen in the jar remains constant at 20% saturation.

DISCUSSION

Oxygen consumption can be expressed as weight-specific (mass O_2 mass fish^{-1} time^{-1}) or as absolute rate of oxygen consumption (mass O_2 time^{-1}). In the last case consumed oxygen can be expressed as a function of fish body weight in the form $Vo_2=a(mass)^b$ (WINBERG, 1961). It was found that the exponent (b), which shows increasing rate of oxygen consumption with fish weight, is generally around 0.8 for fish species (WINBERG, 1961; FRY, 1957; PALOHEIMO and DICKIE, 1966; URSIN, 1967; POST and LEE, 1996). The exponent of sea bass juveniles is 0.82 and it agrees with this universal rule.

POST and LEE (1996) found on the base of the literature data that the early life-history stages had mass-independent or nearly mass independent metabolic rate and older life history stages had mass dependent metabolic rate. The inflection point between metabolic phases differs among species and does not correlated to size of metamorphosis. The first phase in mass-specific respiration rate versus mass for larval and juveniles stages of fish has the slope (b_1) -0.05, while the slope of the second phase is (b_2) -0.18. The inflection point that separates phase 1 from phase 2 is 0.29 g. This biphase was not found in the present study although 14 of the sea bass juveniles had individual mass less then 0.3 g.

The second parameter (a) in functional relation of the rate of oxygen consumption and fish weight can depend on a lot of factors. First of all it depends on metabolic status at which the oxygen consumption was measured, especially on fish locomotor activity (FRY, 1957; BRETT, 1964; EDWARDS *et al.*, 1971; LUCAS and PRIEDE, 1992; Van der LINGEN, 1995). Food and feeding have an influence on oxygen consumption (LUCAS and PRIEDE, 1992; YAGER and SUMMERFELT, 1994; LINGEN, 1995). Abiotic factors as temperature and salinity, also have a significant importance in oxygen consumption (FRY, 1957; BRETT, 1964; PALOHEIMO and DICKIE, 1966; URSIN, 1967; EDWARDS *et al.*, 1971; LINGEN, 1995).

The sea bass juveniles mortality begins when saturation of oxygen at 24°C decreases below 30% (partial pressure of oxygen below 45 mm Hg). In fish the internal oxygen tension (ca. 50-110 mm Hg) is lower than the external tension therefore oxygen diffuses across the gills into the blood (DAVIS, 1975). According to DAVIS (1975) most of the fish species in the sea water show the symptoms of oxygen distress below oxygen partial pressure of 90 mm Hg, while the pressure of 60 mm Hg has destructive effects on majority of population.

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Accepted: 2 November 1998

Potrošnja kisika u odnosu na masu tijela i prag zasićenja kisika za mortalitet mlađi lubina *Dicentrarchus labrax* L.

Mladen TUDOR

Institut za oceanografiju i ribarstvo, P.P. 500, 21000 Split, Hrvatska

SAŽETAK

Potrošnja je kisika mlađi lubina izmjerena kod 55 primjeraka s masom tijela od 0,06 do 5,47 g. Odnos je brzine trošenja kisika (Vo_2, u $mgO_2\ h^{-1}$) i mase tijela (m, u gramima) pri 20°C prema jednadžbi $Vo_2=0{,}888m^{0{,}82}$. Za eksponent jednadžbe vrijedi pravilo da je kod riba potrošnja kisika proporcionalna masi tijela na potenciju 0,8. Mlađ lubina ugiba kada zasićenje kisika padne ispod 30% odnosno kada je parcijalni tlak kisika 45 mmHg.