

The OXYGEN Table in FishBase

Metabolism is a physiological process reflecting the energy expenditure of living organisms and hence their food requirements (in heterotrophs). The metabolic rate of fish is usually measured by their rate of respiration, i.e., their rate of oxygen consumption (see Fig. 1). Information on oxygen consumption is not only useful in comparative physiology, but in fish culture and fishery management as well. It provides insights in solving the problems associated with rearing fish or transporting live fish, among others (Froese 1988; see also Box 33).

The OXYGEN table documents the oxygen consumption of fishes based on experiments reported in the published literature, together with factors known or likely to affect metabolic rate, notably body weight, temperature, salinity, oxygen concentrations, activity level, swimming speed and stress. Additional experimental details, such as the number of fish, and other information may be in the **Comment** field. The following fields provide details on the above-listed factors.

Oxygen consumption: Pertains to the amount of oxygen used by fish in mg/kg/h. If the consumption was reported in other units, these were transformed to mg oxygen per kilogram fish per hour. The conversions are shown in Table 1.

Table 1. Transformations used if unit of oxygen consumption X in the original publication was different from mg/kg/h; body weight of fish is in grams.

Unit used for oxygen consumption (X)	Transformation to mg/kg/h
cal/kg/day	$X \times 10000 / 78$
g/kg/day	$X \times 1000 / 24$
mg/fish/day	$X \times 1000 / (\text{body weight} \times 24)$
mg/fish/h	$X \times 1000 / \text{body weight}$
mg/g/h	$X \times 1000$
ml/100g/h	$14.29 \times X$
ml/fish/h	$1429 \times X / \text{body weight}$
ml/fish/min	$1429 \times X \times 60 / \text{body weight}$
ml/g/h	$1429 \times X$
ml/g/min	$1429 \times X * 60$
ml/kg/day	$1.429 \times X / 24$
ml/kg/h	$1.429 \times X$
ml/kg/min	$1.429 \times X \times 60$
mm3/fish/min	$1.429 \times X \times 60 / \text{body weight}$
mm3/g/h	$1.429 \times X$
$\mu\text{mol/g/h}$	$X \times 0.032 \times 1000$
mmol/fish/h	$X \times 32 / \text{body weight}$

A computed field was included in which the oxygen consumption at temperatures between 5 and 30°C was re-expressed as the corresponding consumption values at 20°C, based on the multipliers in Table 3.3 in Winberg (1971).

Sex: A multiple-choice field gives the sex of the specimens as fry, juveniles, female, male, mixed (for both male and female), and unsexed (for unknown sex).

Weight: Refers to the weight in g of the test organism. If there was more than one fish in an experiment, the mean weight in g was recorded.

Number: The total number of individual fish used in the experiment.

Temperature: The mean water temperature, in °C, during the experiment.

Salinity: The mean salinity in ppt during the experiment. If the salinity was not stated, 35 ppt was assumed for marine species and 0 ppt for freshwater species. For diadromous fishes, such assumption was pointed out in the **Comment** field. Erroneous assumptions will affect the calculated oxygen saturation only slightly.

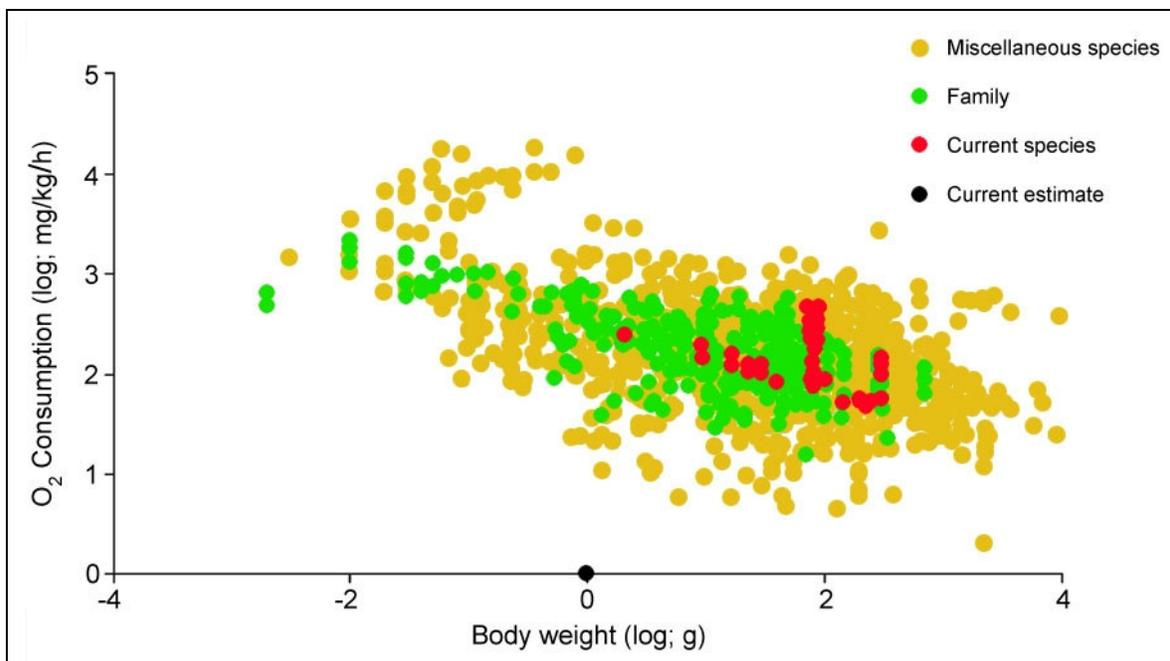


Figure 1. Relative oxygen consumption of *Oreochromis niloticus niloticus* compared with miscellaneous species. Note the relatively straight descending line of standard/routine metabolism vs. body weight and the vertical series of values caused by stresses applied.

Oxygen (mmHg): Refers to the average partial pressure of oxygen in mmHg in the test water. As stated by Thurston and Gehrke (1993), this value was estimated through assumptions based on the description of the test method when not given in the original paper. These assumptions included corrections for test temperature and water salinity.

Oxygen (mg/l): This field pertains to the oxygen concentration of the test water in mg/l. If there is an entry in the oxygen (in **mmHg**) field, the values in **mg/l** were not extracted from the literature but calculated from the **mmHg** values, using the following transformation:

$$\text{mg/l} = \text{mmHg} \times \beta / 0.5318$$

where β is the Bunsen coefficient for oxygen at the given temperature and salinity (Colt 1984).

100% oxygen saturation: This field states, for reference purposes, the calculated maximum oxygen content, in mg/l of the water at the given temperature and salinity.

Saturation%: This field expresses the actual oxygen content of the test water as percent of the maximum possible oxygen content. Typical saturation levels were around 90%. Values below 70% were classified as ‘hypoxia’, values above 105% were classified as super-saturation (see Applied Stress).

Activity level: A choice field that allows accounting for the effect of activity on metabolic rate. The available choices for this field are: standard metabolism (resting fish); routine metabolism (spontaneously active fish); active metabolism (swimming fish).

Swimming speed: Refers to the swimming speed of the fish as another index of activity. Speed was either reported as or converted to body length per second (BL/s) with ‘BL’ usually corresponding to total or fork length.

Applied stress: This is a choice field that pertains to stress applied before or during an experiment. The choices include: none specified; temperature (changes or extreme values); photoperiod (unusual duration or timing of light exposure); feeding (during or right before the experiment); starvation (no food offered for more than 24 h); toxins; hypoxia (insufficient oxygen); hypercapnia (excessive amount of carbon dioxide in the blood resulting from their being forced to swim rapidly); (changes in) salinity; high pH; low pH; sedative; transport; other stress. If the choice is ‘other’, the stress should be specified in the **Comment** field.

Uses

The OXYGEN table can be used to test hypotheses on the relationships among different activities and stresses to which fish are exposed, to estimate energy (food) consumption for trophic modeling and to connect growth, morphology and metabolic rate, among other things.

Status and Sources

The OXYGEN table probably contains the largest collection of data on oxygen consumption of fish, with close to 7,000 records for over 300 species. The information was obtained from over 400 references such as Winberg (1960), Congleton (1974), Gorelova (1977), Marais (1978), Subrahmanyam (1980), Neumann et al. (1981) and Clarke & Johnston (1999). Of these records,

more than 6,100 stem from the database 'OXYREF' compiled by Thurston and Gehrke (1993). The remainder have been added by FishBase staff.

Verification was done by going back to the original literature and checking the values and other relevant information reported. However, this has been done only for few of the entries to date. FishBase staff will continue to add new records and to verify the information entered so far.

Internet

On the Internet, select a species at www.fishbase.org. You then get to the OXYGEN table by clicking on the **Metabolism** link in the 'More information' section of the 'Species Summary' page. You can create a list of all species with available data by selecting the **Metabolism** radio button in the 'Information by Topic' section of the 'Search FishBase' page. If you select the **Graphs** radio button in the 'Information by Family' section of that page, you can create **Relative oxygen consumption** graphs for different families.

Acknowledgments

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