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**Pauly, D. 1991. Estimation of oxygen and food consumption in *Sarda chiliensis* (Cuvier): a correction. *Journal of Fish Biology* 39: 127-128.**

## BRIEF COMMUNICATIONS

### Indirect estimation of oxygen and food consumption in bonito, *Sarda chiliensis* (Scombridae)

J. MENDO\* AND D. PAULY†

\**Instituto del Mar del Peru (IMARPE), Apartado 22, Callao-Peru* and †*International Center for Living Aquatic Resources Management, MCC P.O. Box 1501, Makati, Metro Manila, Philippines.*

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This paper presents an indirect approach to the estimation of oxygen consumption in the bonito, *Sarda chiliensis* (Cuvier, 1831), kept in aquaria, based on an estimate of the amount of water moved across their gills when swimming and a likely rate of oxygen extraction. The corresponding food consumption is estimated through oxycalorimetric conversion.

Magnusson & Prescott (1966) observed *S. chiliensis* of 56.8 cm mean F.L. (2530 g) kept at a temperature of 22° C at the Palo Verdes Aquarium, California, and reported them to swim an average of 69 km daily (i.e. 1.4 B.L. s<sup>-1</sup>) with an average mouth aperture angle of 10–15°. We have estimated the amount of water that moved across their gills by first measuring, using a caliper, the frontal area of the mouth of *S. chiliensis* (i.e. gape, in cm<sup>2</sup>) when open at various angles (Fig. 1; Table I). From those data we derived the equation

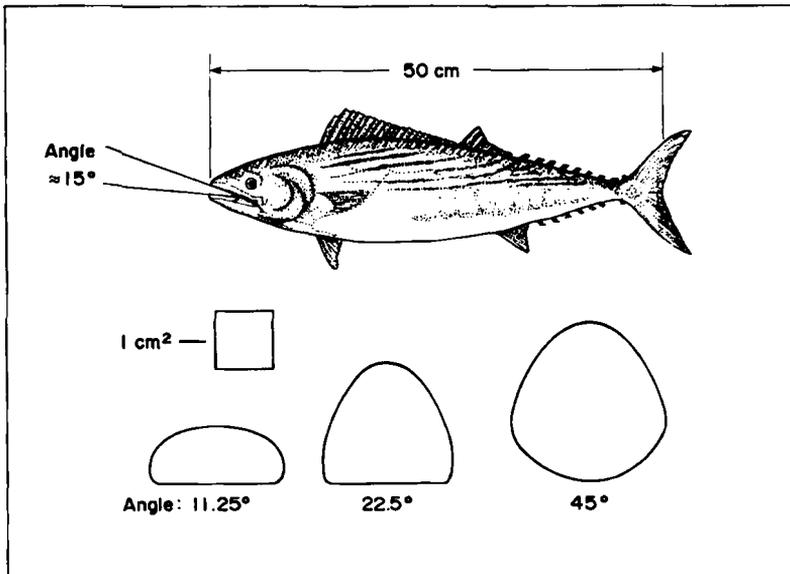


FIG. 1. Representation of a specimen of *Sarda chiliensis*, showing mouth aperture angle as defined in this contribution, and frontal area of mouth (= gape) for three different mouth aperture angles.

†International Center for Living Aquatic Resources Management, MCC P.O. Box 1501, Makati, Metro Manila, Philippines.

$$\text{gape} = 0.000127 F.L.^{2.13} A^{0.705} \quad (1)$$

whose linear form has a high multiple correlation ( $R = 0.993$ ), and which allows a precise prediction of gape for any size (F.L., cm) and mouth opening angle ( $A$ ) likely to occur in bonito.

Using equation (1), we predicted for our aquarium fish (F.L. = 56.8 cm and  $A = 12.25^\circ$ ) a mean gape of  $3.93 \text{ cm}^2$ , which, multiplied by the distance swum and assuming no drag over the gills, corresponds to a value of 27 117 l of water moving daily across the gills of this fish.

We assumed that the sea water was oxygen-saturated (Magnusson & Prescott, 1966), i.e., it contained  $5.22 \text{ cm}^3 \text{ l}^{-1}$  of oxygen (UNESCO 1973), and that 50% of the oxygen content of sea water is extracted from the water passing across the gills of this scombrid (Stevens, 1972; Johansen, 1982). This gives an oxygen consumption of  $27\ 117 \times 5.2 \times 0.5 = 70\ 775 \text{ cm}^3$ , or  $4923 \text{ mg day}^{-1}$ , which using an oxycaloric equivalent of  $3.25 \text{ cal mg O}_2^{-1}$  (Brett, 1985),

TABLE I. Area of mouth opening (gape) as a function of body length and angle of jaw opening in 10 Peruvian specimens of *Sarda chiliensis*.

| Specimen* | F.L. (cm) | Angle of mouth ( $^\circ$ ) | Gape ( $\text{cm}^2$ ) |
|-----------|-----------|-----------------------------|------------------------|
| 1         | 10.4      | 11.25                       | 0.088                  |
|           | 10.4      | 22.50                       | 0.125                  |
|           | 10.4      | 45.00                       | 0.250                  |
| 2         | 13.0      | 11.25                       | 0.125                  |
|           | 13.0      | 22.50                       | 0.375                  |
|           | 13.0      | 45.00                       | 0.438                  |
| 3         | 17.0      | 11.25                       | 0.375                  |
|           | 17.0      | 22.50                       | 0.625                  |
|           | 17.0      | 45.00                       | 0.750                  |
| 4         | 19.1      | 11.25                       | 0.338                  |
|           | 19.1      | 22.50                       | 0.875                  |
|           | 19.1      | 45.00                       | 1.000                  |
| 5         | 40.5      | 11.25                       | 1.750                  |
|           | 40.5      | 22.50                       | 3.375                  |
|           | 40.5      | 45.00                       | 4.625                  |
| 6         | 43.5      | 11.25                       | 3.125                  |
|           | 43.5      | 22.50                       | 3.500                  |
|           | 43.5      | 45.00                       | 5.875                  |
| 7         | 50.5      | 11.25                       | 3.125                  |
|           | 50.5      | 22.50                       | 4.625                  |
|           | 50.5      | 45.00                       | 7.250                  |
| 8         | 53.5      | 11.25                       | 3.625                  |
|           | 53.5      | 22.50                       | 6.375                  |
|           | 53.5      | 45.00                       | 9.625                  |
| 9         | 59.5      | 11.25                       | 3.750                  |
|           | 59.5      | 22.50                       | 6.625                  |
|           | 59.5      | 45.00                       | 11.875                 |
| 10        | 64.0      | 11.25                       | 3.750                  |
|           | 64.0      | 22.50                       | 6.750                  |
|           | 64.0      | 45.00                       | 13.375                 |

\*Specimens 1-4 from IMARPE collection (courtesy Mr Juan Velez); 5 and 9 from Callao fish market; 6-8 from a Cuban vessel operating off Peru (courtesy Mr Juan Rubio); 10 from Trujillo fish market; 5-10 all collected in October 1986.

corresponds to 160 000 cal day<sup>-1</sup>. Using the figure of 1000 cal g<sup>-1</sup> wet weight of prey (Winberg, 1956), the amount of food assimilated daily is calculated as 160 g, which, assuming an assimilation efficiency of 85% (Winberg, 1956), can be turned into an approximate value of food ingested of 160/0.85 = 188 g. The latter value corresponds, for fish of 2530 g, to a ration of 7.4% of body weight per day (%BWD).

Pauly *et al.* (1987) derived, based on stomach content analyses of bonito and metabolic considerations wholly independent of those above, the model

$$\%BWD = 1.45W^{-0.15}e^{0.115T}, \quad (2)$$

where  $W$  is bonito weight in g and  $T$  is the temperature in °C. This model predicts for  $W = 2530$  g and  $T = 22^\circ$  C a daily ration of 5.6% per day, which is close to the independent estimate based on gape measurements and oxycalorimetric conversion.

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## BRIEF COMMUNICATIONS

### Estimation of oxygen and food consumption in *Sarda chiliensis* (Cuvier): a correction

D. PAULY

*International Center for Living Aquatic Resources Management, MC P.O. Box 1501,  
Makati, Metro Manila, Philippines*

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Professor Dr K. Becker (University of Hohenheim, Stuttgart, Germany) recently brought to my attention various errors in Mendo & Pauly (1988). The present note is to correct these errors; it should be read in conjunction with Mendo & Pauly (1988).

Based on the data in Table I of the earlier paper, the equation for predicting the gape ( $\text{cm}^2$ ) from the length (cm) of bonito, *Sarda chiliensis* (Cuvier), and its mouth opening angle ( $A$ ) should be

$$\text{gape} = 0.000124 \cdot \text{F.L.}^{2.13} \cdot A^{0.716}$$

(and not  $\text{gape} = 0.000127 \cdot \text{F.L.}^{2.13} \cdot A^{0.705}$ ); the gape of fish of 56.8 cm, with  $A = 12.25^\circ$ , should thus be  $4.067 \text{ cm}^2$  (and not  $3.93 \text{ cm}^2$ ).

This, multiplied by the distance swum daily (69 km) corresponds to 28 062 l of water moving daily over the gills of the fish (and not 27 117 l). Given an oxygen extraction rate of 50%, an oxygen content of water of  $5.22 \text{ cm}^3 \text{ l}^{-1}$ , and a specific weight of  $\text{O}_2$  of  $1.429 \text{ mg cm}^{-3}$ , this corresponds to an oxygen consumption of  $73\,242 \text{ cm}^3 \text{ day}^{-1}$  (and not  $70\,775 \text{ cm}^3$ ), or  $104\,663 \text{ mg day}^{-1}$  (and not  $4923 \text{ mg day}^{-1}$ ).

With an oxycaloric equivalent of  $3.25 \text{ cal. mgO}_2^{-1}$ , a food assimilation efficiency of 0.85 and a prey energy content of  $1000 \text{ cal g}^{-1}$  (wet weight), this corresponds to a ration of  $400 \text{ g day}^{-1}$ , or, for a bonito weighing 2530 g, to 15.8% BWD (and not  $188 \text{ g day}^{-1}$  and 7.4%, respectively).

This corrected ration may still underestimate true food consumption, since, as also pointed out by Professor Becker, the oxycaloric equivalent given above assumes a respiratory quotient of 0.7 (i.e. starving fish) and not the value near unity appropriate for fish fed continuously.

Considering this latter point would lead to a ration estimate of 23% BWD, near the upper range of estimates for active tunas (Kitchell *et al.*, 1978).

However, the point to emphasize here is that we erroneously implemented the indirect approach we proposed for the estimation of ration in bonito.

With hindsight, we realize that we would probably have spotted the combination of simple computational and typographical errors which led to our underestimate of ration, had it not been for the fact that it appeared to confirm an earlier, low estimate, derived from stomach content data (Pauly *et al.*, 1987).

Thus, besides having to thank Professor Becker for pointing out these errors, and to apologize to our colleagues for our carelessness, we have to admit having fallen victim to confirmatory bias—still a plague, despite widespread awareness that one should attempt to *refute* propositions, not strive to confirm them.

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