

## SHORT COMMUNICATION

### A COMPARISON OF STANDARD OXYGEN CONSUMPTION OF TEMPERATE AND TROPICAL BOTTOM-LIVING MARINE FISH

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**Abstract**—1. Standard oxygen consumption of two tropical fish, *Cynoglossus* and *Halophryne*, and two temperate counterparts *Pleuronectes* and *Cottus* was measured within temperature tolerance ranges of 15.0–37.5°C and 2.5–25.0°C respectively.

2. At 28°C, the standard oxygen consumption of *Cynoglossus* was 1.2 times that of *Pleuronectes* at 10°C, and *Halophryne* was 1.45 times that of *Cottus*. Substantial temperature compensation is thus indicated in fish which have evolved in temperate and tropical regions.

#### INTRODUCTION

THE WORK described in outline below was undertaken as part of the International Biological Programme, and was a contribution to a joint study of tropical marine food chains by the National Institute of Oceanography (Biological Oceanography Division), Ernakulam, South India, and the Marine Laboratory, Aberdeen. The purpose of this continuing study is to measure energy flow through the trophic levels of the food chains, and to compare this with information already collected on temperate marine food chains at Loch Ewe, Scotland (Trevallion *et al.*, 1969; McIntyre & Eleftheriou, 1968). The area chosen for the tropical study was the shallow coastal water of the Arabian Sea at Cochin, where the Malabar sole (*Cynoglossus* spp.) is an important predator on the populations of polychaetes living on the sea-bed. Of secondary importance is the toad fish [*Halophryne dussumieri* (Val.)], a cottid fish-morphologically similar to *Cottus* spp. of temperate waters. This was observed to be a predator on epibenthic crustaceans and small fish. Metabolic studies included measurements of respiratory rates and of the efficiency of food conversion during growth. The data following, however, concern only comparisons of standard rate of oxygen consumption in one of the *Cynoglossus* species used, viz. *Cynoglossus brevis* Day [*C. puncticeps* (Richardson) according to A. G. K. Menon—personal communication] with a temperate counterpart, the

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plaice (*Pleuronectes platessa* L.), and in the toad fish (*Halophryne dussumieri*) with another temperate counterpart, the short-spined sea scorpion or bullhead (*Cottus scorpius* L.). The flatfish species were very similar in size, but it was only possible to obtain much larger specimens of *Cottus*.

#### MATERIALS AND METHODS

Standard oxygen consumption, defined as oxygen consumption in the absence of spontaneous activity (Beamish, 1964), was measured in a closed-circuit respirometer incorporating a Beckman oxygen electrode (Edwards *et al.*, 1969). Groups of four to six individuals closely matched for size were used together in the respirometer for all tests which lasted for periods up to 1 hr. Fresh aerated sea water was used for each test, and the total volume contained in the apparatus was about 4.8 l. Initial experiments indicated the level to which the oxygen content of the water could be reduced before inhibition of oxygen uptake by the fish occurred. For *Cynoglossus* this was in the region of 50 per cent, and for *Pleuronectes* 30 per cent of air saturation. Periods of 1–2 weeks were allowed for acclimation at each temperature change, although it was observed that each species had reached the next level of standard oxygen consumption within 72 hr of the temperature change.

#### RESULTS

Figure 1 shows the standard oxygen consumption of *P. platessa* over a range of 2.5–25.0°C and *C. brevis* over a range of 15.0–37.5°C. Figure 2 shows *C. scorpius* and *H. dussumieri* for temperature ranges of 5.0–23.0 and 15.0–35.0°C respectively. The mean annual water temperature experienced by each species is indicated. The surface waters of the Arabian Sea at Cochin are fairly constant at 30°C throughout the year, whereas the waters around the coast of Scotland may vary from 5 to 15°C at different times of the year, and hence the monthly mean of 10°C is used. From Fig. 1, the respiratory rate of *Pleuronectes* is almost linear on a logarithmic scale, whereas *Cynoglossus* shows a plateau of temperature-independence above 30°C but is temperature-dependent below this. Job (1969) found a similar situation with *Tilapia mossambica*. The temperature-dependent part of the graph for *Cynoglossus* is almost parallel to the corresponding segment of the graph for *Pleuronectes* which indicates similar  $Q_{10}$  values of about 2.4. For *Halophryne* the  $Q_{10}$  is 2.6 and for *Cottus* 1.7 over this range.

Further information was collected (not reported here in full) using large numbers of each species from as wide a size range as possible at temperatures of 28°C for *Cynoglossus* and *Halophryne* and 10°C for *Pleuronectes*. Unfortunately only a restricted size range of *Cottus* was available. A relationship between standard oxygen consumption and live weight was then derived, using the formula:

$$Q = aW^b,$$

where  $Q$  is oxygen consumption in mg/hr, and  $W$  is live weight in g. The equation denotes a straight-line relationship between body weight and oxygen consumption on a double logarithmic plot, where  $a$  is the intercept value of  $Q$ , and  $b$  is the regression coefficient. The  $b$  value for many fish species is in the region of 0.8 (Winberg, 1956). These values for *Cynoglossus* and *Halophryne* at 28°C were 0.734 and 0.701 respectively, and for *Pleuronectes* at 10°C this was 0.724. The  $a$  values for

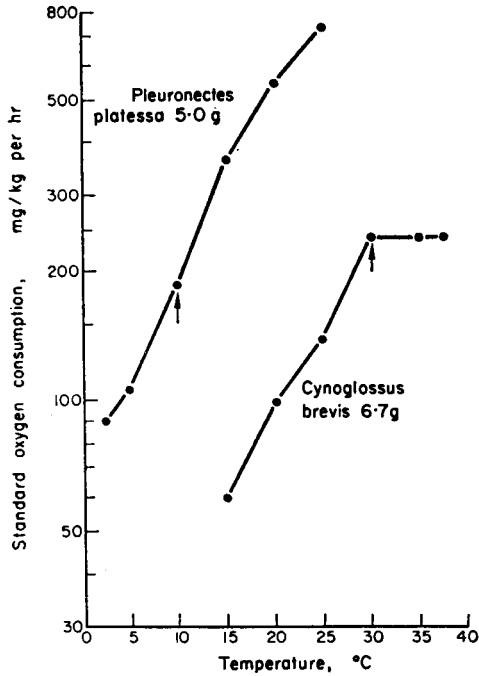


FIG. 1. The effect of temperature on standard oxygen consumption of *P. platessa* and *C. brevis* (arrow indicates environmental temperature).

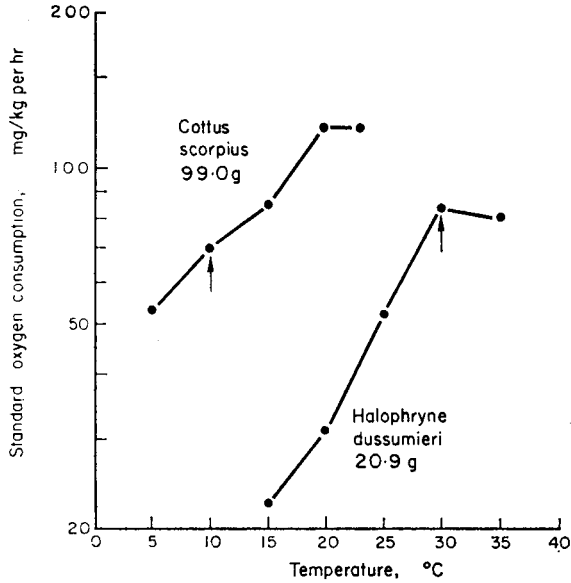


FIG. 2. The effect of temperature on standard oxygen consumption of *C. scorpius* and *H. dussumieri* (arrow indicates environmental temperature).

*Cynoglossus* and *Halophryne* at 28°C were 0.372 mg/hr and 0.246 mg/hr respectively, and for *Pleuronectes* at 10°C this value was 0.309 mg/hr. Thus *Cynoglossus* at 28°C has a standard oxygen consumption of about 1.2 times that of *Pleuronectes* at 10°C.

Measurements made at 10°C on two groups of *Cottus* of 59.0 and 98.4g mean live weight gave values for  $Q$  of 2.84 and 4.41 mg/hr respectively. These compare with calculated values for *Halophryne* of the same weights at 28°C of 4.29 and 6.14, which in the first instance is 1.51 and the second 1.39 times as high. Thus for these sizes of fish at their respective temperatures a mean difference of 1.45 times is indicated when comparing the tropical with the temperate fish.

"Temperature compensation" (Bullock, 1955; Scholander *et al.*, 1963) is thus partial in both the cottids and flatfish. This supports observations in the literature of adaptations of respiratory rate in poikilotherms at different latitudes.

#### DISCUSSION

To the knowledge of the authors the standard respiratory rates of *Cynoglossus* and *Halophryne* are lower than any reported in the literature to date for tropical fish. This may reflect the suitability of quiescent bottom-living fish for experiments on standard rates of oxygen consumption.

The existence of these relatively low respiratory rates in bottom-living fish from tropical seas poses some interesting questions, which it is hoped that this study will eventually answer. For example, does the respiratory rate of these fish reflect the low oxygen-holding capacity of sea water at high temperatures or the availability of energy from the food supply? It may be argued that there exists strong competition for the food supply by large numbers of fish, and that the energy available to each individual is limited, but the present authors were of the opinion that the catches of *Cynoglossus* at Cochin were of the same order as those for temperate flatfish for the same fishing effort. Work done by Krishnan Kutty (1967) on the growth rate of *Cynoglossus macrolepidotus* (Bleeker) in the Arabian Sea suggests that the growth rate of this fish during its first year of life is 1.5 times that of *P. platessa* (Wimpenny, 1953) in the North Sea. *Cynoglossus*, however, becomes sexually mature in its second year of life at small size; *Pleuronectes* matures in its third or fourth year at a greater size; thus the former fish will utilize energy for reproduction earlier in life than the latter.

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*Key Word Index*—*Cynoglossus*; *Pleuronectes*; *Halophryne*; *Cottus*; oxygen consumption; temperature compensation.