

## Metabolic rates and quotients in the cichlid fish, *Tilapia mossambica* (Peters) in relation to random activity

M PEER MOHAMED

Central Inland Fisheries Research Substation, 24, Pannalal Road,  
Allahabad 211 002, India

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**Abstract.** Oxygen consumption, carbon dioxide production and  $\text{NH}_3\text{-N}$  excretion increased with increase in random (spontaneous) activity in *Tilapia mossambica* in air-saturated water in tests at 30 and 35°C. The random activity change did not affect the RQ which remained near unity at adequate ambient oxygen. But, the AQ decreased with increase in activity at both 30 and 35°C, suggesting that increased protein utilization in quieter fish when adequate ambient oxygen is available. The routine and standard metabolic rates at 35°C are slightly higher than at 30°C, but, in general, the overall metabolic rates and quotients are significantly in close proximity, suggesting that the temperature range (30-35°C) does not seem to cause a marked metabolic difference in *Tilapia mossambica*.

**Keywords.** Standard metabolic rate ; routine metabolic rate ; respiratory quotient ; ammonia quotient ; random activity ; *Tilapia mossambica*.

### 1. Introduction

Energy utilization for the various biological activities of the whole animal can be relied only if the values of metabolism truly reflect the standard (basal), activity or other activity-spelt-out (e.g., swimming speed in fish) state of the animal. The influence of random activity on metabolic rates and quotients (Respiratory Quotient,  $\text{RQ} = \text{volume of CO}_2 \text{ produced} / \text{volume of O}_2 \text{ consumed}$ ; Ammonia Quotient,  $\text{AQ} = \text{the volume or mole : mole relation of NH}_3\text{-N excreted to O}_2 \text{ consumed}$ ) has been extensively studied only in a few fish (Kutty 1968; Peer Mohamed 1974; Kutty and Peer Mohamed 1975). Under aerobic conditions random activity did not appear to have any effect on the RQ of goldfish and rainbow trout (Kutty 1968), but the AQ might change with random activity (Peer Mohamed 1974; Kutty and Peer Mohamed 1975). Since *Tilapia mossambica* has been subjected to metabolism studies in relation to several factors (Kutty *et al* 1971a; Kutty 1972; Karuppappan 1972; Peer Mohamed and Kutty 1980; Peer Mohamed 1981), there is lack of information on its standard (basal) metabolic rates and quotients. Present observations deal with metabolic rates— $\text{O}_2$  consumption,  $\text{CO}_2$  production and  $\text{NH}_3\text{-N}$  excretion—and quotients (RQ and AQ) in *T. mossambica* during random activity at high ambient oxygen.

## 2. Material and methods

*Tilapia mossambica* (Peters) were collected from freshwater tanks in and around Madurai and acclimated to freshwater at  $30 \pm 0.5^\circ\text{C}$  and  $35 \pm 0.5^\circ\text{C}$  for at least 15 days before the experiments. The fish were fed *ad lib* with a formulated food: fish muscle, goat liver and wheat hearts *pro rata* 2:1:1 (Karupppannan 1972). Experimental fish were starved for 24 hr (Peer Mohamed and Kutty 1980) and subsequently left in the respirometer overnight with a continuous flow of water. Tests were performed at the temperature of acclimation.

The apparatus used was a modification of Fry's respirometer (Kutty *et al* 1971b) in which simultaneous measurements of metabolic rate and random activity can be made. Decarbonated tap water, adjusted to a pH of 8.2, was used as explained by Kutty *et al* (1971a).

### 2.1. Experimental procedure

Each experiment consisted of 7-9 runs of 1 hr in duration, when the respirometer remained closed. Water samples for analyses of dissolved oxygen, total carbon dioxide and ammonia were collected just before and after the closure of the respirometer for individual runs. The respirometer was flushed for 30 min with air-saturated decarbonated water between runs so as to bring the ambient oxygen content near air saturation at the beginning of each run. The random activity of the fish was counted by the difference between the initial and final figure of the activity counter, which was noted immediately after each sampling.

### 2.2. Methods of water analyses

Dissolved oxygen was measured by using the unmodified Winkler technique (American Public Health Association 1955). The sample used for titration was 25 ml.

Total carbon dioxide was estimated by Maros-Schulek technique (Maros *et al* 1961) modified for fish metabolism studies by Kutty *et al* (1971a) was followed. Fifty ml of water sample was used for each determination.

Ammonia was measured by the method of Stroganov (1962) as described by Kutty (1972). Fifty ml of water sample was distilled, the distillate nesslerised and the optical density read in Bausch and Lomb spectrophotometer (Spectronic-20) at a wavelength of  $420 \mu$ . Ammonia-free water (American Public Health Association 1955) was used for blank and to prepare the reagents.

## 3. Results

Plots of routine oxygen consumption, carbon dioxide production,  $\text{NH}_3\text{-N}$  excretion, RQ and AQ against random activity of *T. mossambica* (63.4 g, 16.8 cm) acclimated to and tested at  $30^\circ\text{C}$  at ambient oxygen concentration near air saturation are shown in figure 1. Similar plots for *T. mossambica* (64.1 g, 17.0 cm) acclimated to and tested at  $35^\circ\text{C}$  are given in figure 2. The present plots for *Tilapia* are simple plots through which a single regression line could easily be fitted (table 1). Mean values of routine metabolism and random activity of *T. mossambica* at 30 and  $35^\circ\text{C}$  are given in table 2. The standard metabolic

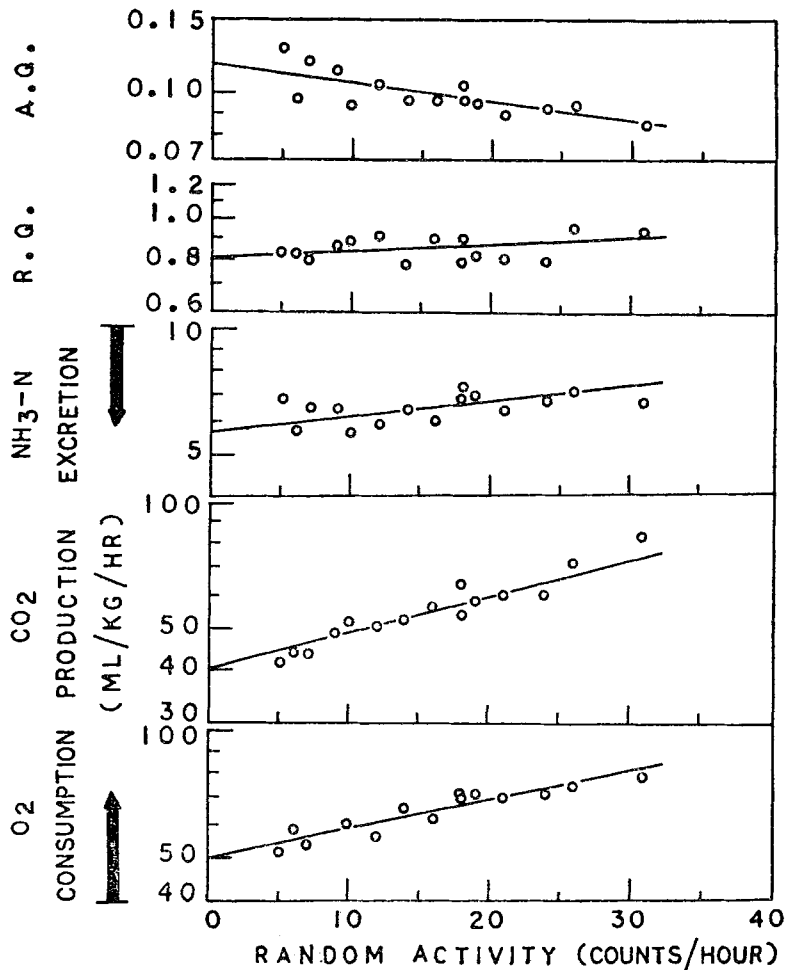


Figure 1. Oxygen consumption, carbon dioxide production,  $\text{NH}_3\text{-N}$  excretion, RQ and AQ in relation to random activity in *Tilapia mossambica* acclimated to and tested in air-saturated water at  $30^\circ\text{C}$ . The lines fitted through the plots are according to the regression equations given in table 1.

rates and quotients (extrapolated values at 'zero' activity) are also included in table 2.

The routine metabolic rates ( $\text{O}_2$  consumption,  $\text{CO}_2$  production and  $\text{NH}_3\text{-N}$  excretion) at  $35^\circ\text{C}$  are slightly higher but the metabolic quotients (RQ and AQ) are remarkably close to each other at  $30$  and  $35^\circ\text{C}$ .

Regression coefficients of metabolic rates and quotients at  $30$  and  $35^\circ\text{C}$  were statistically tested by applying *t*-test and it was observed that the regression coefficients are not significantly different ( $P > 0.05$ ), suggesting that the temperature range ( $30\text{-}35^\circ\text{C}$ ) does not cause a marked metabolic difference in *T. mossambica*.

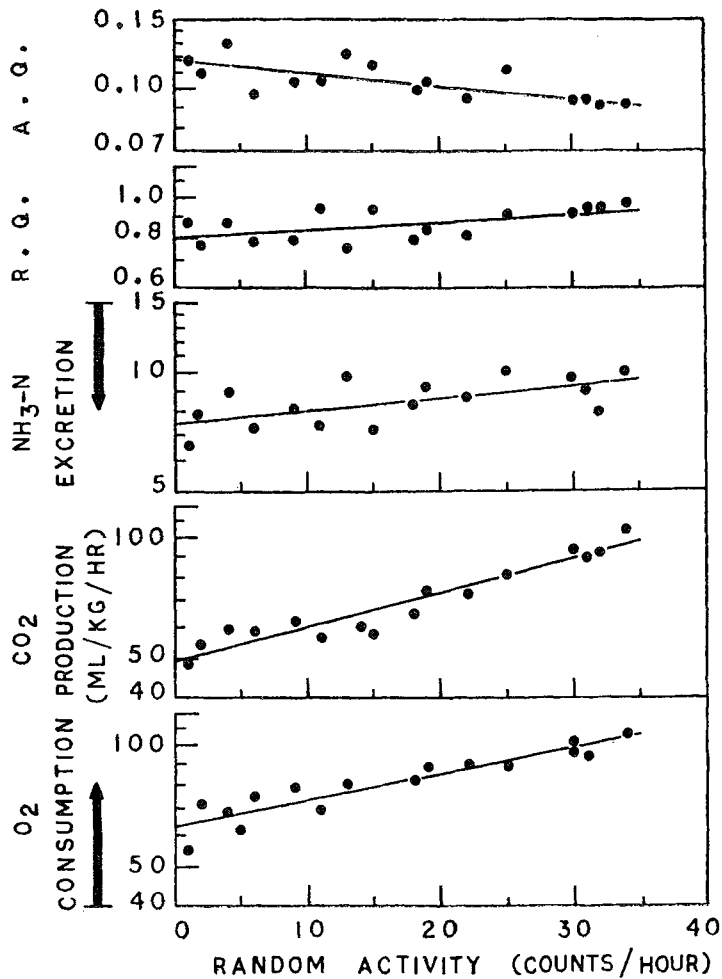


Figure 2. Oxygen consumption, carbon dioxide production,  $\text{NH}_3\text{-N}$  excretion, RQ and AQ in relation to random activity in *Tilapia mossambica* acclimated to and tested at  $35^\circ\text{C}$ . The lines fitted through the plots are according to the regression equations given in table 1.

#### 4. Discussion

In the results presented (figures 1 and 2), extrapolation of a line drawn through such plots of metabolism against random activity to 'zero' activity indicates the standard metabolic rate of the fish (Kutty *et al* 1971b; Kutty and Peer Mohamed 1975; Peer Mohamed *et al* 1978). The regression lines fitted for plots of  $\text{O}_2$  consumption and  $\text{CO}_2$  production at 30 and  $35^\circ\text{C}$  are almost parallel, suggesting the change in RQ with changes in random activity as observed earlier in the mullet, *Rhinomugil corsula* (Kutty and Peer Mohamed 1975). The slopes of the RQ plots in figures 1 and 2 are positive (table 1). The  $\text{NH}_3\text{-N}$  excretion plots show positive trends at 30 and  $35^\circ\text{C}$ , but the AQ plots at both temperatures

Table 1. Regression equations ( $\log Y = a + bX$ ) of  $O_2$  consumption,  $CO_2$  production,  $NH_3$ -N excretion (ml/kg/hr in each case), RQ and AQ (Y) on random activity (counts/hr) (X) in *Tilapia mossambica* at ambient oxygen concentration near air saturation.

	Acclimation and test at 30° C	Acclimation and test at 35° C
$O_2$	$\log Y = 1.69888 + 0.00677 X$	$\log Y = 1.79633 + 0.00644 X$
$CO_2$	$\log Y = 1.60628 + 0.00852 X$	$\log Y = 1.68797 + 0.00877 X$
$NH_3$ -N	$\log Y = 0.75565 + 0.00342 X$	$\log Y = 0.87070 + 0.00308 X$
RQ	$\log Y = -0.08831 + 0.00128 X$	$\log Y = -0.09903 + 0.00203 X$
AQ	$\log Y = -0.92576 - 0.00451 X$	$\log Y = -0.92552 - 0.00335 X$

Table 2. Routine and standard  $O_2$  consumption,  $CO_2$  production,  $NH_3$ -N excretion (ml/kg/hr in each case), RQ, AQ and random activity (counts/hr) in *Tilapia mossambica* at ambient oxygen concentration near air saturation. Results of experiments at 30 and 35° C are shown separately. In the case of routine values mean and one standard error ( $N = 15$  and 16 for 30 and 35° C respectively) is indicated in each case. The standard values are estimates obtained by extrapolation of the regression lines to zero activity through the plots in figures 1 and 2.

Metabolic rate/quotient	30° C		35° C	
	Routine (Mean $\pm$ SE)	Standard	Routine (Mean $\pm$ SE)	Standard
$O_2$ consumption	64.4 $\pm$ 2.1	50.0	81.8 $\pm$ 3.7	62.6
$CO_2$ production	55.6 $\pm$ 2.4	40.4	70.6 $\pm$ 4.3	48.7
$NH_3$ -N excretion	6.5 $\pm$ 0.06	5.7	8.4 $\pm$ 0.27	7.4
RQ	0.86 $\pm$ 0.02	0.82	0.87 $\pm$ 0.02	0.80
AQ	0.101 $\pm$ 0.003	0.119	0.105 $\pm$ 0.003	0.119
Random activity	15.7 $\pm$ 2.0	..	17.0 $\pm$ 2.8	—

yield regressions which have negative slopes (figures 1 and 2, table 1) thereby suggesting that lower random activity was associated with higher AQ, i.e., the less active the fish, the proportionally higher its protein use and/or a greater involvement of protein degradation. This observation is in agreement with earlier reports on *R. corsula* (Kutty and Peer Mohamed 1975) and also on smolting Atlantic salmon (Saunders and Kutty 1973). But there is also a variance in the results of study on the influence of forced activity on AQ which increased with increase in activity (Kutty 1972; Karuppannan 1972; Sukumaran and Kutty 1977). In *T. mossambica*, it was observed that the initial AQ (first hour of 5-hour exercise) at lower swimming speed was even less than the routine AQ (Kutty 1972; Karuppannan 1972) and it was suggested that in this case there might be a

protective action of carbohydrates on protein. This might be the reason why the steady AQ (after 2-3 hours swimming) is correlated well with the initial RQ of fish under long-term exercise. It is possible that random activity (spontaneous random movement) and forced activity (intense exercise) have different relations to protein degradation and utilization, as indicated by  $\text{NH}_3\text{-N}$  excretion. A quieter fish would utilize more proteins but with increase in random activity relatively more energy is required by the fish for several breaks and starts in swimming overcoming inertia each time (Smit 1965; Kutty 1969). In this case utilization of carbohydrates could be higher as long as adequate oxygen is available, thereby indicating lower AQ at higher random activity, more or less similar to the low initial AQ during the beginning of intense activity (continued exercise). In both these cases, fish under high random activity and initial phase of intense swimming (forced activity), the protective action of carbohydrates on proteins may be operative (Phillips 1969).

The validity of the present observations lies in the fact that the estimations of metabolic rates and quotients are made in single fish as was usually done in earlier studies (Kutty *et al* 1971b; Peer Mohamed 1974). It is clear from the statistical tests of the regressions that the estimates at 30 and 35° C are remarkably significant, suggesting that the temperature effect is minor. This is possible, probably because these temperatures are close to each other and are within the upper range to which *T. mossambica* is normally exposed during a good portion of the year. The present method described here, which enables separation of the interfering influence of activity on metabolism is of much importance in organismal physiology.

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