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Effects of Territoriality on Oxygen Consumption in *Tilapia nilotica*

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Abstract

The aggressive behaviour associated with territoriality in case of *Tilapia nilotica* was found to elevate the oxygen consumed to meet standard and routine metabolism energy requirements at 26°C. This was traced for both small immature and big matured fish. On the other hand matured fish showed a decrease of about 50% in the oxygen consumed for specific dynamic action. This suggests an increase in the weight exponent and a decrease on the level of metabolism of the T-line equation. Also, there is a correlation between the available space to meet the territory requirements and hence the magnitude of the aggressive behaviour, and runting of tilapia under culture condition.

Introduction

Many authors studied the territorial behaviour of the genus tilapia[1–5]. These studies mainly concentrated on the descriptive causation category of the behaviour, however, studies about the category of the survival value were very rare. The present study is thus meant to show the possible functional role of the behaviour as reflected to the different energy pathways.

Material and Methods

Fish were reared, grown and sexed; standard, routine metabolism and specific dynamic action were determined as described by the authors[6]. Temperature was kept constant at 26°C±1°C. A study of the effects of territoriality in the case of the small immature sizes, was conducted through fish of almost the same weight but experimented when single, and in groups of different numbers. At this stage these fish do not exhibit any fighting in the rearing tank, only when enclosed inside the oxygen bottle that in most cases one out of the bigger groups started to show a tendency of performing limited chasing movements. In some experiments, these were observed to be injurious to some fish among the group; results of such experiments were simply rejected.

Bigger matured fish were experimented individually, chosen to be also more or less of the same size, but from two different in size rearing tanks. These were 100 liter and 500 liter capacity tanks. As the rate of stocking or the volume of water per fish was maintained almost the same in both tanks, the difference it seems came with the total volume of water containing the fish in each, resulted in less space

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available for the fish in the smaller tank, resulted in turn in pronounced fighting among the fish.

The dominant fighting fish were always selected for respective experiments during resting intervals. When such a fish was removed from the tank, the next bigger one started within a few minutes to aquire the dominance role. This however helped in deciding the size of the fish to be experimented from this tank, and accordingly select the non fighting partner from the other tank.

Under any case, two experiments using two different fish were conducted for each of the sizes, as seen in Table 1 and 2. Furthermore, oxygen bottles of almost double capacity were used in the case of the bigger immature groups (7 and 6 fish groups), compared to those used in the case of small groups (3 fish groups).

Results

Based on the observations of the behaviour of the fish in the smaller tank, a dominant male was found to overrule all the others whether males or females. However, females showed little resistance and then clustered in one of the corners. Among the males, the next in size to the dominant one normally did engage in direct fighting for some time, but at last joined the others helplessly. As such, the dominant fish occupied most of the available space and none of the others could intrude.

On the other hand, the previous behaviour was observed to follow a rythmic manner, so that there were intervals of fighting followed by intervals of rest and so on. While fighting did not exceed from about two to three minutes, intervals of rest did last for about twenty minutes. However, the frequency of fighting approached its minimum late after noon hours.

The oxygen consumed for standard, routine metabolism and specific dynamic action, for the sizes used in the present experiments as shown in Table 1 and 2, is compared with respective values for similar sizes as already determined[6] under normal condition. The non fighting fish in Table 1, and single fish in Table 2, showed values which almost fit with those under normal condition. While fighting fish in Table 1, and excluding values of specific dynamic action, groups rather than single fish in Table 2, showed clearly different values.

The oxygen consumed for standard and routine metabolism differed by showing higher values. This is from a mean value of 75.4±4.4 cc/kg/hr to 86.6

Table 1. *Effects of territoriality on the oxygen consumed for different energy pathways in case of matured Tilapia nilotica at 26°C.*

Condition of fish	Length (cm)	Weight (g)	Sex and maturity	Standard metabolism cc/kg/hr	Routine metabolism cc/kg/hr	Specific dynamic action cc/kg/hr
non-fighting	14	58.5	♂V	74.6	51.2	26.9
non-fighting	16	67.8	♂ooz.	46.3	49.6	27.9
non-fighting	17	90	♂ooz.	46.6	54.9	28.3
fighting	14	57.2	♂ooz.	86.6	69.5	13.1
fighting	15.8	67.4	♂ooz.	57.9	76.2	13.3
fighting	17	92.6	♂ooz.	58	72.6	16.2

cc/kg/hr, and from a mean value of 47.2±1.5 cc/kg/hr to 57.9 cc/kg/hr, to 58 cc/kg/hr, in the case of standard metabolism, for fish of 57.2, 67.4 and 92.6 g in body weight respectively. On the other hand, the corresponding elevation in the case of routine metabolism, is from a mean value of 49.4±6.3 cc/kg/hr, to 69.5 cc/kg/hr to 76.2 cc/kg/hr, to 72.6 cc/kg/hr, for the same previous fish and in the same order, Table 1.

For a 1.2 g fish, the standard metabolism elevated from a mean value of 96.4±4 cc/kg/hr, to 111.2 to 116.7 cc/kg/hr, and routine metabolism increased from 161.5±11.1 cc/kg/hr, to 192 to 227.6 cc/kg/hr, for a 3 and 7 fish group respectively. However, for a 3.2 g fish, the corresponding elevation is from the same previous mean values, to 107 to 116.7 cc/kg/hr, in the case of standard metabolism, and to 201.6 to 212.1 cc/kg/hr, in the case of routine metabolism, with a 3 and 6 fish group respectively, Table 2.

Considering the specific dynamic action, we find that particularly for big sizes, unlike standard and routine metabolism, it showed lower values of oxygen consumption than those referred to under normal condition. Here the decrease is a pronounced one i.e., from a mean value of 28.7±2.5 cc/kg/hr, to 13.1 to 13.3 and to 16.2 cc/kg/hr, for fish of 57.2, 67.4 and 92.6 g respectively.

Table 2. *Effects of territoriality on the oxygen consumed for different energy pathways in case of immature Tilapia nilotica at 26°C.*

Condition of fish	Length (cm)	Weight (g)	Sex and maturity	Standard metabolism cc/kg/hr	Routine metabolism cc/kg/hr	Specific dynamic action cc/kg/hr
single	4.4	1.2	immature	95.1	167.4	39.7
single	6	3.6	immature	96.5	158.1	39.5
3 fish group	4.6	1.5	immature	111.2	192.0	38.6
3 fish group	6	3.4	immature	107	201.6	37.6
7 fish group	4.6	1.2	immature	116.7	227.6	38.2
6 fish group	6.5	3.2	immature	116.7	212.1	39.3

Discussion

Schlaifer[7] showed that in the standard respiration experiments for the goldfish *Carassius auratus*, there was a lowering in oxygen consumption due to a corresponding subsidence in activity, while the fish were held in groups compared to experiments with single individuals, a phenomenon known as group effect. On the other hand, Brett and Sutherland[8] indicated that at low velocities, while studying the active metabolism of the pumpkinseed *Lepomis gibbosus*, with more than one fish present, the elevation of the metabolic rate occurred from the aggressive behaviour of the fish reaching one half the active rate.

Schlaifer[7] suggests that visual contacts and other sensory responses are partly responsible for the subsidence of respiratory rate resulting in the group effect. However, the fact that Schlaifer used a non aggressive fish, makes his results match those of Brett and Sutherland[8] and underline the effects of the aggressive behaviour, possibly as the main factor that caused both elevation of oxygen consumption in the later's experiments and lowering it in the former's.

Tilapia nilotica used in the present study is a hyper-aggressive fish[9]. The study included three energy pathways i.e., standard, routine metabolism and specific dynamic action for both small immature and mature sizes. In both cases evidence for elevation of oxygen requirements for standard and routine metabolism was traced. It seems also that the elevation in the oxygen consumption, and hence expenditure of energy for routine metabolism, is more pronounced than the corresponding elevation occurred to meet standard metabolism. This means that territoriality makes the fish whether immature or mature spend additional energy to maintain their bodies, and still comparatively more energy to be alert to respond to the directive effects of the environmental conditions.

For specific dynamic action, we find that in particular matured sizes, i.e. fish which really got involved in observable fighting and chasing movements, showed a decrease of about 50% in the oxygen consumption for this energy pathway. This means that the fish cease to feed in a normal manner, which suggests a possible effect on the growth rate. However both the elevation in standard and routine metabolism, and the lowering in specific dynamic action suggests an increase in the weight exponent, and a decrease on the level of metabolism of the T line* equation.

Under the present rearing conditions, only males were experimented, due to the fact that females were suffering from injuries caused by the chasing fish. Being the chased ones, the decrease in specific dynamic action oxygen requirements is expected to be even more than in case of males. It is of importance to mention that under any condition in this experiment, availability of food was not a controlling factor, pellets were served in a normal manner regardless of the amount being consumed. Chen[10] stated that even when food availability is not a limiting factor, growth of *Tilapia mossambica* in ponds of half an acre or less may still be poor, probably the outcome of either a social hierarchy of dominance, or a build-up on the level of excretory metabolism. However, this later factor has been checked through biological filters during the present experiments.

On the other hand, Bossman[9] mentioned that the consensus of opinion is that, for cichlid culture, a lot more space for moving about is needed, and Maruyama[11] defined the size of the territory for *Tilapia nilotica* as from 1.8–2.8 meter in diameter i.e., both stressed the importance of the space factor. This is also confirmed in the present study, in the 500 liter tank from which fish for the non fighting experiments were obtained, all rearing conditions were the same as those in the case of the 100 liter tank from which fish for fighting experiments were obtained, except for the fact that more space was allowed in the first tank.

In this respect we have to consider the well known problem in tilapia ponds, that is, the problem of runting. Hyder[12] described it as a progressive decrease in size of the adult fish, besides the production of small sized 8–15 cm fish. Evidence for spending more energy for both standard and routine metabolism for immature and mature fish while declining to feed normally for matured sizes has been indicated in this study. Hence, in conclusion it is possible to relate between the magnitude of the aggressive behaviour associated with territoriality, and the

* Equation relating metabolic rate to body size[13].

available space for the fish from one side, and the degree of runting from the other side.

Aggressive behaviour like other behaviour patterns, is dependant upon a requisite internal physiological state and an external releasing stimulus[14]. In the present study, it seems that both availability of space and certain sex differences e.g. females of smaller size act as external releasing stimuli. However, changes in the metabolic rate as indicated from oxygen consumption for the different energy pathways, could only be looked upon as a resultant change in the physiological state of the fish to meet the energy requirements of the behaviour. The initial requisite internal physiological state can not be understood from this study.

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