The Growth and Production of Mocambique Tilapia (*Oreochromis mossambicus*) Fed on Algae in Small Tanks

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Abstract

Suspended microalgae were fed to *Oreochromis mossambicus* in heated 225 ℓ tanks with aeration over periods of 112 and 43 days. Growth was slow and varied between 0,05 and 0,2 g per fish per day. Individual growth rate was affected by total fish biomass indicating overcrowding. Extrapolation of the results gave stocking densities of between 222 and 444 thousand fish per ha, total biomass of between 5,4 and 13,7 t ha^{-1} and production of 1,1 to 2,5 t over 43 days.

Introduction

If organically and/or nutrient-enriched waste waters could be used to produce economically exploitable materials, the costs of waste water treatment may be reduced, thereby contributing to environmental conservation and water recycling. One possible strategy would be to stabilize the waste water in a system such as a high rate algal pond followed by the use of the algal-laden water to produce filter-feeding fish such as tilapia and silver carp (e.g. Edwards *et al.*, 1981).

The success of such an approach would be dependent on the ability of the filter-feeding fish to utilize suspended algae. Unfortunately, relative little research has been done on this subject and conclusions are usually based on assumed intake rates and known growth rates of filter-feeding fish in ponds. More attention has, however, been paid to the replacement of fish or soybean-meal by algae in commercial fish food pellets (e.g. Sandbank and Hepher, 1978).

Oreochromis mossambicus, a filter-feeding fish, is commonly fed with maize meal and/or commercial pellets by South African fish farmers. Although a relatively high production can be achieved in this way, this approach is not applicable when integrating tilapia into waste water treatment.

Gaigher *et al.* (1982) showed that *O. mossambicus* is capable of efficiently filtering suspended micro-algae from water. Although the conversion ratios in small aquaria varied, it was evident that suspended algae were used for growth. To obtain additional information on the possible use of this fish to convert algae produced in mass algal cultures or waste-water treatment systems, algae were fed to high density cultures of *O. mossambicus* in small outdoor tanks. This allowed calculation of conversion factors and extrapolated yields.

Materials and methods

The fish were kept outdoors in cylindrical 225 ℓ asbestos cement tanks from August to December 1980. Water temperatures were maintained between 20 and 25°C by thermostatically controlled heaters and air was bubbled through continuously to prevent oxygen deficiencies as a result of algal respiration. The tanks were cleaned once a week to remove excretory products. Each tank was fed daily with ~20 ℓ of a 200–500 mg $ℓ^{-1}$ *Scenedesmus* or *Chlorella* suspension from small open high rate algal ponds. Six tanks were stocked but only four yielded useable results due to fish mortalities which occurred because of a number of reasons.

Small numbers of chironomid larvae developed in the tanks and it is possible that some of these were utilized by the fish as well. However, due to the weekly cleaning of the tanks the contribution of these organisms to nutrition was probably negligibly small and was therefore not determined.

TABLE 1
MASS INCREASE OF *OREOCHROMIS MOSSAMBICUS* FED WITH ALGAE IN 225 ℓ TANKS

Tank No	Number of fish	Total and mean (in brackets) mass (g) 15/8/80	9/9/80	8/10/80	23/10/80	6/11/80	20/11/80	4/12/80	Growth period (Days)	Total mass increase (g)	Mass increase per fish per day
1	5	123,0	128,2	143,0	146,4	161,0	163,0	175,3	112	52,3	0,09
		(24,6)	(25,6)	(28,6)	(29,3)	(32,2)	(32,6)	(35,1)	last 43	28,9	0,13
2	10	246,0		279,1	282,8	296,2	302,9	307,8	112	61,5	0,05
		(24,6)	–	(27,9)	(28,3)	(29,6)	(30,3)	(30,8)	last 43	25,0	0,06
3	5				77,2	96,7	107,8	120,5	43	43,3	0,20
					(15,4)	(19,3)	(21,6)	(24,1)			
4	9				135,2	155,4	173,5	19[illegible],8	43	56,6	0,15
					(15,0)	(17,3)	(19,3)	(21,3)			

Results

Fish in all tanks grew very slowly (Table 1). The fish in tank 3, which contained only 120,5 g of fish at the end of the experiment, had the highest growth rate. Tanks 1 and 4 contained roughly the same mass of fish and grew at approximately identical rates while the slowest growth took place in tank 2 which contained 308,8 g of fish. The highest production was obtained in tank 4. Production was 23% lower in the 3rd and much lower in the first two tanks. Individual growth rate seemed to be related to ichthyomass irrespective of mean fish size but production was higher in the tanks that contained smaller fish than in the tanks with fewer larger fish of the same total mass.

Extrapolation of the results to production per ha (assuming that a one hectare one metre deep fish pond would contain 10^7 ℓ of water) is presented in Table 2. Stocking densities, final fish mass and production figures obtained in this way are relatively high considering that the experiment only extended over 43 days.

The fish spawned in tanks 1, 3 and 4.

TABLE 2
EXTRAPOLATION OF PRODUCTION FIGURES OBTAINED BY FEEDING *OREOCHROMIS MOSSAMBICUS* WITH ALGAE IN 225 ℓ TANKS OVER A PERIOD OF 43 DAYS

Tank No	N	N ha^{-1}	Total mass at end of experiment (t)	Production (t ha^{-1})	Daily production (kg ha^{-1})
1	5	222 000	7,8	1,1	25,8
2	10	444 000	13,7	1,3	29,8
3	5	222 000	5,4	1,9	44,4
4	9	400 000	8,5	2,5	58,7

N = number of fish

Discussion

The growth rates obtained compare poorly with recorded rates in normal culture experiments. For example, according to Chimits (1955) *O. mossambicus* reaches a mass of 130 – 150 g in ten months while Chen (1976) reports an average daily growth rate of 0,59 g. In local experiments this species grew as fast as 1,4 g per day without artificial feeding in cages suspended in plankton rich waste water (Gaigher and Krause, 1982).

However, the results comply with the limited published information on the conversion of phytoplankton by filter feeding fish. For example, Opuszynski (1979) calculated that silver carp only convert 2 – 6% of their food to ichthyomass. Tang and Chen (1966) found the conversion ratio in milkfish to be 13:1. Conversion efficiencies of 8 and 11% were determined for *O. mossambicus* by Mironova(1974 and 1975). Gophen(1980) calculated that 10 g (dry mass) of *Peridinium* must be consumed by *Sarotherodon galilaeum* to produce 1 g (live mass) of fish.

Although the species and conditions differed, the extrapolated production figures of this study are roughly comparable to those of Edwards *et al.* (1981). At a stocking density of 20 – 25 fish per m^3 and a retention time of 10 days, they obtained extrapolated annual production figures of approximately 10 t per ha per year at a stocking density of 37 fish per m^3 and a retention time of 7 days. The highest stocking density of 37 fish per m^3 of Edwards *et al.* (1981) yielded 19 t per ha per year compared to 11 t and 21 t obtained at stocking densities of 44 and 40 fish per m^3 during the present study. However, Edwards *et al.* (1981) obtained better conversion ratios of between 1,3 and 6,2 for algae added compared to between 5 and 15 of this study (dry algae to live fish).

The results suggest that the low growth rates can be attributed not only to poor conversion of algae and invertebrates in the tanks, but to overcrowding as well. Edwards *et al.* (1981) also found a decrease in growth rate as the stocking density increased. Growth rate was also affected by retention time. They suggest a stocking density of 10 fish per m^3 and retention time of 3,3 days for optimal production.

Another factor that might have restricted growth is limited space. Chen and Prowse (1964) and Edwards *et al.* (1981) are also of the opinion that limited space might restrict production.

The extrapolated production figures are high but it should be kept in mind that the tanks were heated and aerated and that the retention time was relatively low. However, continuous throughflow instead of weekly emptying and filling of the tanks would probably have yielded better results because buildup of excretory products still took place. Spawning activities probably also restricted production.

Bearing the dangers of extrapolation in mind, it seems feasible to use algae from pure algal culture or waste-water treatment units directly or indirectly for tilapia production. However, more research should be done to determine the influence of space, dissolved oxygen concentration, retention time, stocking density and to investigate the advantages of a polyculture.

Acknowledgements

The author would like to thank the following: Professor D.F. Toerien, Director of the Institute for Environmental Sciences, for guidance and many valuable discussions; Dr J.U. Grobbelaar who provided the algae; Miss R. Barkhuizen and Mr G. Potgieter for technical assistance; the Director of Nature Conservation of the Transvaal Provincial Administration who supplied the fish free of cost; and Mrs R. Koch for typing the manuscript.

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