JOURNAL OF THE
WORLD AQUACULTURE SOCIETY

Vol. 24, No. 3
September, 1993

Filtration Rates of Catfish Pond Phytoplankton by Nile Tilapia *Oreochromis niloticus*

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Filter-feeding fishes have been examined as biological controls of phytoplankton populations. Although increased phytoplankton biomass resulted in approximately 50% of studies and no effect in 25% (Smith 1988), changes in species composition and dominance have been noted. For example, blue tilapia *Oreochromis aureus* reduce or eliminated blue-green (Cyanobacteria) and green (Chlorophyta) net phytoplankton in fertilized, earthen ponds (Perschbacher 1975) and green and golden-brown (Chrysophyta) net plankton in unfertilized, concrete pools (Drenner et al. 1984). In a 24 h aquarium test fingerling blue tilapia removed 66–100% of blue-green and 74–90% of green net plankton (Perschbacher 1975).

Nile tilapia *Oreochromis niloticus* also has the ability to filter-feed on phytoplankton (Northcutt and Beveridge 1988), as do all tilapiine congeners (Trewavas 1983) and *Haplochromis* species (Greenwood 1953) that possess pharyngeal jaws. At sizes above 50 mm TL, Nile tilapia in ponds consumed primarily phytoplankton (Yashouv and Chervinski 1961). Diet-related research indicated Nile tilapia prefer blue-green algae. The diet of Nile tilapia is primarily *Microcystis* (a blue-green alga) and *Botryococcus* (a green alga) in the Ethiopian lakes Aswa and Zwai, respectively (Getachew 1987), and *Microcystis* in Ugandan Lake George (Moriarty and Moriarty 1973). Carbon assimilation by Nile tilapia was 70–80% from the blue-green genera *Microcystis* and *Anabaena*, and the diatom *Nitzchia*, and about 50% from the green alga *Chlorella* (Moriarty 1973). Filtering trials of Nile tilapia have been conducted with a variety of unialgal and bacteria stocks in the laboratory (Beveridge et al. 1989; Robinson et al. 1990; Northcott et al. 1991), but not with whole pond samples.

A series of laboratory tests was conducted to determine the filtering rates of fingerling Nile tilapia on catfish production pond algae, including known and suspected off-flavor producing species of blue-green algae. Two of the pond samples contained high levels of the algae-produced off-flavor compound 2-methylisoborneol (MIB).

Materials and Methods

This study was conducted at the USDA/ARS Aquaculture Research Project, Tishomingo, Oklahoma, in eight 15 L glass aquaria supplied with aeration. Water temperatures were approximately 25 C and low-level fluorescent illumination was continuous. Two sizes of Nile tilapia were obtained from the stock maintained by Dr. William Shelton at University of Oklahoma, Norman, Oklahoma, and collected in Ivory Coast, West Africa. Medium-sized tilapia averaged 116 ± 10.2 mm TL and 29.6 ± 7.9 g and small tilapia averaged 78.2 ± 3.8 mm TL and 8.7 ± 1.4 g. Acclimation was 3 d without food for two small fish in each of three aquaria and one medium fish in each of three aquaria. Small fish biomass was 1.2 g/L or 12,000 kg/ha and medium fish levels were 2 g/L or 20,000 kg/ha (assuming an average pond depth of 1 m). Phytoplankton sources were nearby experimen-

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TABLE 1. *Mean percentages (relative to fishless controls) and numbers of phytoplankters filtered in 24 h by either two Nile tilapia averaging 78 mm TL (small fish) or one 116 mm TL medium fish.*

Trial/algae	Small fish		Medium fish		Control
	(%)	(*N*/ml)	(%)	(*N*/ml)	(*N*/ml)
#1 7 September Totals	75	11,138	88	13,071	14,767
Oscillatoria c.f. *chalybea*	92	7,269	94	7,395	7,867
Scenedesmus spp.	34	860	82[a]	2,093	2,559
Pediastrum spp.	65	1,442	85	1,884	2,222
Coelastrum sp.	48	407	78	652	840
Raphidiopsis mediterranea	100	573	100	573	573
Microcystis aeruginosa	83	393	100	474	474
O. agardhii	84	194	0[a]	0	232
#2 8 September	4	12,182	16	43,743	277,993
O. agardhii	4	12,182	16	43,743	276,857
R. mediterranea	0	0	0	0	1,136
#3 14 September	66	9,619	68	9,789	14,458
M. aeruginosa	87	7,767	80	7,109	8,897
O. agardhii	33	1,852	48	2,680	5,561
#4 15 September	94	12,279	96	12,502	13,076
R. mediterranea	94	11,664	96	11,862	12,395
Anabaena sphaerica	90	615	94	640	681

[a] Row means significantly different ($P \leq 0.05$).

tal and production ponds stocked with channel catfish. Those ponds with phytoplankton communities composed predominately of blue-green genera were chosen, especially pond waters containing species known or suspected to have produced off-flavor, and all waters exhibiting the camphorous, MIB off-flavor odors.

Four trials were conducted. In each trial, three aquaria containing each size of acclimated fish and two control tanks were filled with 15 L of fresh pond water. After 24 h, tank contents were stirred and a 50 ml water sample was removed from each tank. The algae were concentrated and counted following the methods of Boyd (1979). Multicellular phytoplankton were counted as individual colonies or filaments. Taxa were identified using Desikachary (1959), Prescott (1962, 1978), and Cocke (1967). Algae other than the blue-greens were identified to the genus level. Comparisons of arcsine transformed means of the percentage of phytoplankton numbers remaining after 24 h relative to the control levels between small and medium tilapia tanks were made by Student's *t*-test ($P \leq 0.05$). ANOVA was used to compare differences in percentages filtered of algal species within a test by each fish size group.

Results and Discussion

Significant differences in the levels of phytoplankters remaining after 24 h between the tanks containing the two tilapia size groups were found for two species of algae. Less *Oscillatoria agardhii* and more *Scenedesmus* were removed by filtering by the medium-sized fish than by the small fish in Trial 1 (Table 1). *Oscillatoria agardhii* numbers in the controls were at a low concentration in this trial and thus sampling and counting variation could have accounted for the difference in filtering between the fish observed in this group. The lower filtering rate of *Scenedesmus* by small fish may reflect a less efficient filtering mechanism for that size fish. Less *Coelastrum* was also con-

sumed by the small fish compared to the medium fish, although not significantly so (Table 1). Gophen et al. (1983) found that the closely-related blue tilapia *Oreochromis aureus* at sizes less than 76 mm SL employed both filter-feeding and vision-based particulate feeding modes.

Small fish removed 9.6–12.3 × 10^3 plankters from whole pond samples in 24 h and medium fish 9.8–43.7 × 10^3. Rates of filtration averaged 3.5 × 10^6 individuals/h for each small fish and 12.4 × 10^6 individuals/h for each medium fish. The rate based on fish weights was similar for both sizes (0.4 × 10^6 individuals/g/h). This accords with the finding that development of the filter-feeding apparatus occurs at 40 mm SL in Nile tilapia (Northcott and Beveridge 1988).

Within a trial and fish size, no significant differences in percentages remaining after 24 h were found by algal species. The lack of apparent selectivity may reflect the nonselectivity of mucous entrapment feeding for algae of these sizes, as discussed by Northcott et al. (1991), as well as variability in the data set.

Percentages of *O. agardhii* removed in Trial 2 were low, although at densities of 278,000 individuals/ml the numbers of *O. agardhii* filtered in 24 h was the highest of the study by the medium fish (44,000) and equalled the highest filtration level by the small fish (11,000). *Raphidiopsis mediterranea* filaments apparently were not filtered in Trial 2, in contrast to the high percentages removed in Trials 1 and 4, indicating possible cessation of filtering after ingestion of a given quantity of *O. agardhii* filaments (Table 1). Satiation was suggested as the cause of reduced filter-feeding observed in laboratory tests of filtering rates in Nile tilapia (Northcott et al. 1991). Assuming nonselective filtering, only 40 and 150 *R. mediterranea* filaments would be filtered with the *O. agardhii* by small and medium tilapia, respectively. These numbers would not have been detected within the error involved in sampling and counting.

Water samples in Trials 1 and 4 exhibited MIB off-flavor odors and analysis of water samples for MIB confirmed the presence of that compound. On 11 and 18 September MIB levels were 0.3 and 0.9 μg/L in the water of the Trial 1 pond. On 18 September MIB levels were 1.5 μg/L in the water of the Trial 4 pond. The species suspected of producing the MIB were the *Oscillatoria chalybea*-like species in Trial 1 and *Anabaena sphaerica* in Trial 4 (unpublished data). These species were effectively removed in the trials by the tilapia. The *O. chalybea*-like species was 92–94% filtered by the two fish groups after 24 h and *A. sphaerica* 90–94% filtered (Table 1).

In polyculture with channel catfish, blue tilapia have improved water quality problems related to the presence of algae. Torrans and Lowell (1987) found channel catfish in polyculture with blue tilapia experienced off-flavor 8.3% of the times sampled compared to 62.5% for catfish reared in monoculture. Stocking levels of blue tilapia were either 5,000 fingerlings/ha or 60–120 adults/ha. In catfish ponds with blue tilapia stocked at 625 fingerlings/ha and with a final biomass of 1,000–1,500 kg/ha including reproduction, larger green and blue-green algae numbers were much reduced compared to ponds without tilapia (Perschbacher 1975). Additions of monosex blue tilapia at 2,000 fish/ha did not change algae composition compared to catfish-only controls (Dunseth 1977).

Small and medium Nile tilapia at 12,000 kg/ha and 20,000 kg/ha respectively, removed approximately 90% of suspected off-flavor-causing algae in 24 h in laboratory tests. At 8,300 fish/ha they reduced larger algae in outdoor mesocosms after 20 d (Drenner et al. 1984). Nile and blue tilapia at densities above 5,000 fish/ha and 1,000 kg/ha may prove to be effective biological controls of problem algae in field testing.

Acknowledgments

Drs. David Millie, William Shelton, Les Torrans and Mr. William Troeger reviewed

the manuscript. Their helpful comments are appreciated.

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