

Clarias and Tilapia Interaction in Polyculture

C. Kwei Lin

Agricultural and Food Engineering Division, Asian Institute of Technology,
G.P.O. Box 2754
Bangkok, Thailand

Abstract

Experiments were conducted to assess the effects of polyculture on tilapia growth and to evaluate African catfish (*Clarias gariepinus*) as a predator control for unwanted tilapia offspring in a polyculture system. Three treatments were tested using nine 200 m² earthen ponds. Ponds were stocked with male tilapia in treatment 1 (T1), mixed sex tilapia in treatment 2 (T2), and mixed sex tilapia and catfish in treatment 3 (T3). Fish were fed a commercial diet ration of 1.5% of body weight per day twice a day at 0900 hr and 1500 hr. Feed inputs, adjusted biweekly, were based on Nile tilapia (*Oreochromis niloticus*) biomass. Gut contents of African catfish were analyzed two weeks prior to termination of the experiment. Water quality parameters were estimated biweekly. Diel analyses of dissolved oxygen (DO), temperature, and pH were performed at three depths and six time intervals, and net primary productivity (NPP) was estimated using DO concentrations. A t-test was used to compare final fry biomass, daily weight gain (DWG) of Nile tilapia, net fish yield (NFY), and the diel variability of gut content. DWG and NFY were significantly higher for treatment T1 in which male Nile tilapia were stocked. Mean fry biomass for each treatment showed large fluctuations. Statistical analyses of two of the three replicates of T1, T2, and all three replicates of T3 indicated that T2 production was significantly greater than T3 production. Forty-seven percent of the sampled African catfish contained one of the following in the stomach or intestines: whole fish, partially digested fish, fish flesh, fish scales, fins, or bones; twenty-six percent of the African catfish had freshly ingested fry in the stomach. Biweekly variation in mean values for water quality parameters were comparable for each treatment. Tilapia production in polyculture with African catfish was significantly lower than the culture systems with either all male tilapia or mixed sex tilapia. African catfish predation of tilapia fry was sufficiently effective to serve as a population control for tilapia; however, active predation occurred only in semi-intensive culture systems where fish were fed their natural diet.

Introduction

Overcrowding in pond culture caused by the prolific reproduction of tilapia (*Oreochromis niloticus*) results in competition for food and consequent yields composed mainly of small fish of low market value. One of the management strategies used to control pond overpopulation is tilapia-snake head (*Channa striatus*) polyculture (Kaewpaitoon, 1992). The carnivorous snake head not only functions as a biological control, but also increases economic gain due to its high market value.

African catfish (*Clarias gariepinus*), which often contaminate tilapia ponds in Egypt, have been recently investigated as a potential aquaculture species. Considerable effort has been made to investigate its reproductive biology (De Groot, 1987). Feeding habits were also described. It is omnivorous, feeding mainly on detritus, invertebrates, and small fish; the extent of its predatory ability is unknown (Pillay, 1990). This experiment was designed to: 1) determine the suitability of African catfish as a predator to control unwanted tilapia offspring in a polyculture system, and 2) to determine the effect of polyculture on tilapia growth.

Materials and Methods

Pond Preparation and Stocking

The experiment was to be conducted at the Central Laboratory for Aquaculture Research at Abbassa, Egypt. Due to a shortage of catfish fry in Egypt and logistical problems, the experiment was moved to the Asian Institute of Technology (AIT) in Thailand, another PD/ A CRSP site. This site, located approximately 40 km north of Bangkok, has a tropical climate.

The experiment was conducted from 4 June 1994 to 5 October 1994. Nine 200 m² earthen ponds were used for the experiment. Three replicates were performed for the following treatments:

Treatment	Total No.	Mean Wt. (g)	Total No.	Mean Wt. (g)	Total No.	Mean wt. (g)
T1						
Only Male	400	32.5	N/A		N/A	
Nile Tilapia	400	30.5				
T2						
Mixed Sex	200	34.5	200	30.5	N/A	
Nile Tilapia	200	35.0	200	28.0		
T3						
Mixed Sex	200	34.0	200	29.5	50	75.1
Nile Tilapia	200	35.5	200	30.5	50	67.7
and African Catfish	200	32.5	200	26.5	50	68.3

Table 1. Stocking treatments of mixed-sex Nile tilapia and African catfish.

Treatment 1 (T1): ponds stocked with male tilapia only

Treatment 2 (T2): ponds stocked with mixed sex tilapia

Treatment 3 (T3): ponds stocked with mixed sex tilapia and catfish.

Prior to commencing the experiment, ponds were drained, sun-dried, and filled up to a depth of 80-90 cm with water from the peripheral canal. Water levels were maintained weekly to compensate for evaporation and seepage losses. Each pond was fertilized with industrial grade urea (45% N) and triple

super phosphate (21% P) at 21 g and 7 kg/ha/week, respectively. Fertilizers were dissolved in water and then spread over the pond surface.

Juvenile Nile tilapia were obtained from the AIT hatchery. One week prior to stocking, the sex was visually determined and male and female fish were manually sorted into separate hapas. Due to large variations in individual weight, male tilapia were manually sorted into two size groups. Each treatment received large and small fish at a ratio of 2: 1, respectively. Tilapia were stocked at a density of 2 fish/m² (400 fish/pond) in all three treatments. The sex ratios of tilapia in treatments T2 and T3 were maintained at approximately a 1:1 ratio.

Swim-up African catfish fry were obtained from a local commercial hatchery and reared in AIT ponds until they reached at least 50 g. During this rearing period, the catfish fry were fed with small floating pellets to satiation twice per day at 0900 hr and 1500 hr. A larger pellet was used after the fish had grown. The proximate nutrient composition of both pellet sizes was the same—crude protein 30%, crude lipids 4%, ash 8%, and moisture 12%.

The following measurements were taken during stocking of each pond: individual lengths and weights of 15 large male tilapia (T1), 10 small male tilapia (T1, T2, and T3), 20 female tilapia (T2 and T3), 15 African catfish (T3), and total weight of the fish remaining to be stocked. African catfish were introduced into the culture system two weeks after stocking of the tilapia to ensure that Nile tilapia fry were abundant in the culture system at the time of the African catfish introduction. Details of the stocking for each treatment are presented in Table 1.

During the first six weeks of the study fish were fed a commercial diet ration of 1.5% of body weight per day (Table 2). Equal rations were offered twice a day at 0900 hr and 1500 hr. Feed input was adjusted biweekly based on Nile tilapia biomass. To monitor growth, Nile tilapia and African catfish were sampled for individual length and weight measurements—40 male tilapia (T1), 20 male and 20 female Nile tilapia (T2), and 20 male and 20 female Nile tilapia, and 15 African catfish (T3). Feeding was discontinued after six weeks because the catfish consumed feed instead of tilapia fry.

Gut Content Analysis of African Catfish

About two weeks prior to termination of the experiment, catfish were sampled for a gut contents analysis to determine if tilapia fry were an important component of catfish diet. Ponds were seined four times a day at 0600 hr, 1300 hr, 1600 hr, and 2300 hr to investigate gut content fluctuations over time. Two catfish were selected from each pond at each time interval. Fish were killed immediately by exposing them to a high concentration of Benzocaine (about 300 ppm). Sampling was repeated after ten days.

After total length and weight were determined, the fish were dissected. The alimentary canal was removed without rupture or content loss and weighed. Gut contents were preserved in 4% formalin. The weight of gut content was determined as the difference between the weight of the full alimentary canal and the weight of the empty alimentary canal. Gut content was expressed as percentage of total body weight [(content weight/total body weight) X 100]. The gut content was visually inspected for fry residue and microscopically inspected for fish scales and/or bones. Other components such as plant materials and plankton were also recorded if they were the dominant component of the gut

Treatment	Pond No.	Feed Amounts Applied (g/pond/day)		
		16 June to 28 June 1994	30 June to 11 July 1994	13 July to 25 July 1994
Treatment 1 (T1)	5	175.5	301.1	433.5
	7	195.0	329.3	474.5
	13	183.0	293.9	456.3
Treatment 2 (T2)	6	189.0	254.4	348.6
	9	198.0	297.6	361.4
	11	177.0	264.9	336.5
Treatment 3 (T3)	8	195.0	273.2	347.6
	10	189.0	304.4	398.1
	12	169.5	243.5	332.2

contents.

Table 2. Commercial ration feed amounts applied during the first six weeks of the study.

Water Quality Analysis

Standard methods (APHA, 1985) were used to estimate water quality parameters biweekly. One integrated water column sample was collected from each pond with a column water sampler and analyzed for total ammonia, nitrite, and nitrate, total Kjeldahl nitrogen, orthophosphate, total phosphorous, alkalinity, total suspended solids (TSS), and total volatile solids (TVS). Water temperature and dissolved oxygen (DO) were measured in situ with a digital meter (YSI model 57). Pond water pH was determined using a Suntex digital meter model SP-5A.

Diel analysis of DO, temperature, and pH was carried out at three depths at six time intervals (0600 hr, 0900 hr, 1200 hr, 1600 hr, 1800 hr, 2300 hr, and 0600 hr the following day) each month. Net primary productivity (NPP) was estimated using DO concentrations between 1600 hr and the preceding 0600 hr.

Statistical Analysis

Total crop weight was measured at the time of stocking and again at harvest. A t-test (STATGRAPHICS version 5) was used to compare final fry biomass, daily weight gain (DWG) of Nile tilapia, net fish yield (NFY), and the diel variability of gut content. Further investigated was the DWG of Nile tilapia and African catfish during feeding and after feeding was terminated ($\alpha = 0.05$). Collection schedule details for fish sampling, water quality analysis, pond fertilization, water level maintenance, and feed amount (kg/pond/day) for the first six weeks are presented in Table 3.

Results

Fish Survival, Growth, Production, and Fry Biomass

Nile tilapia mean population weight in all treatments ranged from 28.3-

32.9 g and African catfish mean population weight in T3 ranged from 67.7-75.1 g.

Activity and Description	Date and Day of Activity
Stocking	
Stocked Nile tilapia (recorded individual length and weight of 20 fish of each sex and total weight of population)	Tuesday, 14 June 1994
Stocked African catfish (recorded individual length and weight of 15 fish and total weight of population)	Thursday, 30 June 1994
Sampling	
Fish sampled (recorded individual length and weight of 20 fish of each sex)	Wednesday, 29 June 1994
Fish sampled (recorded individual length and weight of 20 Nile tilapia of each sex and 15 African catfish)	Wednesday, 13 July 1994
Fish sampled for Nile tilapia and African catfish	Wednesday, 10 August 1994 and Wednesday, 13 September 1994
Harvesting	
Fish harvested (recorded individual length and weight for 20 Nile tilapia for each sex and 15 African catfish, total weight of population, and total weight of fry biomass produced)	Wednesday, 5 October 1994
Water Quality Analysis	
Pre-stocking water quality survey	Monday, 13 June 1994
Biweekly and diel water chemistry	Monday, 20 June 1994 Monday, 19 July 1994 Monday, 15 August 1994 Monday, 12 September 1994 Monday, 3 October 1994
Biweekly water chemistry	Monday, 4 June 1994 Monday, 1 August 1994 Monday, 29 August 1994 Monday, 26 September 1994
Fertilization of Experimental Ponds	
Fertilization with urea and Triple Super Phosphate (TSP)	Thursday, 16 June 1994
Fertilization with urea and TSP	Beginning Thursday, 23 June 1994 and continuing once weekly through Thursday, 1 October 1994

Table 3. Collection schedule details for fish stocking, sampling, harvest, water quality analysis, and pond fertilization.

Initial and final mean weight, daily weight gain (DWG), survival, net fish yield (NFY), and fry biomass of Nile tilapia are presented in Table 4. Fortnightly mean weight increases of Nile tilapia and African catfish are presented in Figures 1 and 2, respectively. Mean NFY of Nile tilapia for each treatment are presented in Figure 3.

DWG and NFY of the Nile tilapia populations were significantly higher for treatment T1 (stocked with male Nile tilapia) than treatments T2 and T3 ($p < 0.05$). However, there were no significant differences between Nile tilapia populations for DWG and NFY in T2 and T3. The well established fact that male Nile tilapia in a monosex population grow faster than individuals in a mixed-sex population may account for this finding.

The mean fry biomass for each treatment is presented in Figure 4. Large fluctuations among replicates of the treatments were observed. The t-test indicated that there were no significant differences in mean fry biomass for different treatments when all three replicates for each treatment were taken into account. It is important, however, to note that one of three replicates for treatments T1 and T2 showed much lower Nile tilapia fry biomass compared with the two remaining replicates. This may have been due to the unintentional presence of snake head that consumed fry in the ponds of the culture system. There were seven snakeheads in treatment T2 with a mean weight of 292.3 ± 37.4 g (SE) in one of the ponds (P#12), and three snakeheads in treatment T1 with a mean weight of 429.6 ± 145.9 g (SE) in another pond (P#5). Snakeheads are well known predators and most likely reduced the fry abundance in the replicates of T1 and T2, which had lower Nile tilapia fry biomass than treatments T1 and T2. Statistical analyses were therefore made using only two replicates from treatments T1 and T2 and three replicates from treatment T3. The fry production in treatment T2 was significantly greater than fry production in treatment T3 indicating that active catfish preyed on tilapia fry.

Gut Analysis of African Catfish

Gut content of African catfish, sampled four times per day, was calculated as a percent of the body weight of the fish (see Figure 5 and Table 5). Gut content generally decreased from 0600 hr to 1800 hr. but increased from 1800 hr to 2300 hr. Gut content at 2300 hr. however, generally was lower when compared with the preceding 0600 hr sample. This observation may be related to the nocturnal nature of the feeding cycle of African catfish. Greater feeding activity during the night and digestion during the day causes the reduction of the gut content after sunrise. The t-test indicated significantly lower gut content at 1800 hr compared with 0600 hr. No significant differences were found for gut contents at other times of the day.

Gut content analysis also revealed that, on average, 46.7 % ($\pm 8.2\%$ SD) of the sampled African catfish had one of the following in the intestine or stomach: whole fish, partially digested fish, fish flesh, fish scales, fins, or bones. Only 26.4% ($\pm 6.6\%$ SD) of the African catfish, however, had freshly ingested fry in the stomach. The percentage of captured African catfish having Nile tilapia fry in the stomach at various times of the day is shown in Figure 6 and Table 5. There was no significant difference in the percentage of African catfish having Nile tilapia

fry in the gut at different times of the day.

Water Quality During the Experiment

Biweekly variation in mean values (± 1 SE) for the water quality parameters—dissolved oxygen, pH, alkalinity, total Kjeldahl nitrogen, ammonia nitrogen, total phosphorous and total suspended solids—is presented for each treatment throughout the experimental period (Figures 7a-g). Overall, comparable values for different treatments were observed. Ranges of the maximum and minimum values for different water quality parameters of different treatments are summarized in Table 6.

Table 4. Initial and final mean weights, daily weight gain, survival, net fish yield,

Parameter	Experimental Treatments		
	Treatment 1 (T1)	Treatment 2 (T2)	Treatment 3 (T3)
Initial Mean Weight (g)	31.5 ± 0.7	32.0 ± 0.4	31.3 ± 0.8
Final Mean Weight (g)	128.9 ± 13.0	79.0 ± 0.4	71.9 ± 1.8
Survival (% of stocked fish)	87.4 a ± 2.1	92.4 a ± 3.6	87.8 a ± 1.4
Daily Weight Gain (g/fish/day)	0.87 b ± 0.11	0.42 ab ± 0.01	0.36 b ± 0.02
Net Fish Yield (kg/pond/112 days)	32.2 b ± 3.2	16.4 ab ± 1.4	12.7 a ± 0.6
Fry Biomass (kg/pond/112days)	9.6 b ± 1.4	24.7 a ± 1.5	3.87 b ± 2.1

and fry biomass of Nile tilapia (± 1 SE) for each treatment.

Fig.1. Fortnightly increase in Nile tilapia mean weight (± 1 SE) for each treatment.

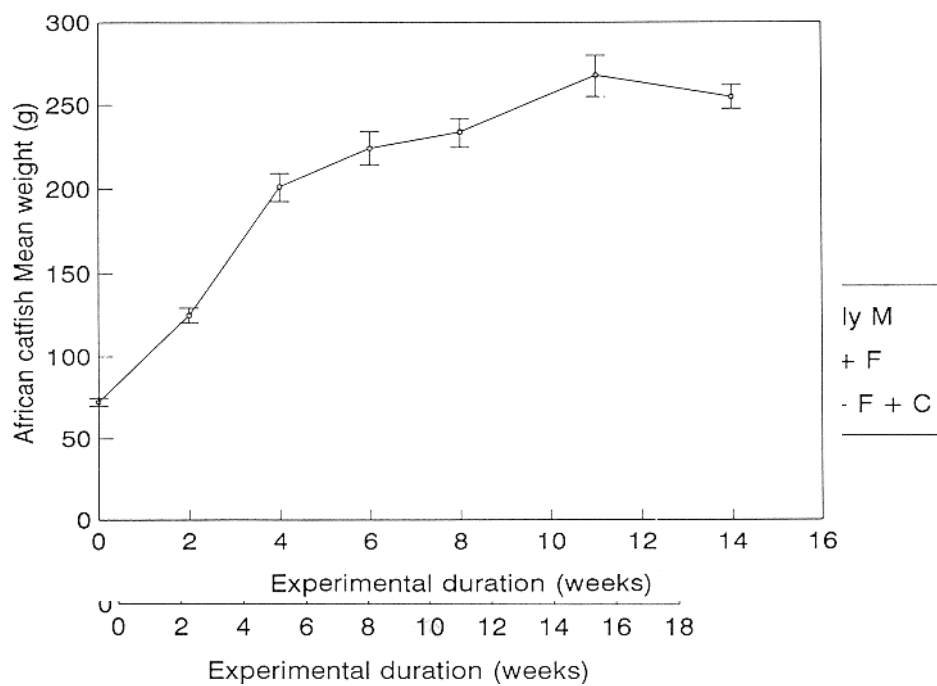


Fig. 2. Fortnightly increase in African catfish mean weight (± 1 SE) for each treatment.

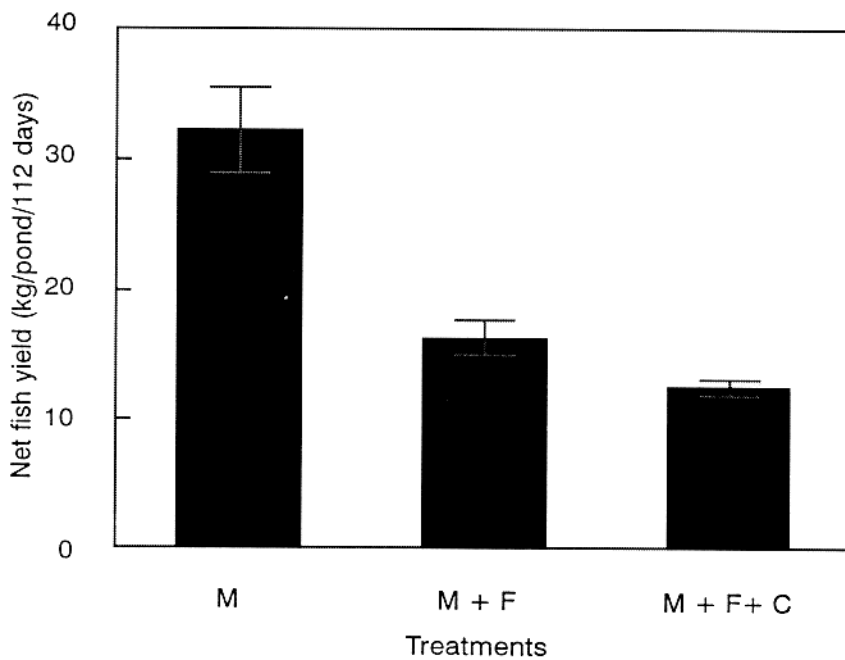


Fig. 3. Mean net fish yield (± 1 S.E.) for each treatment.

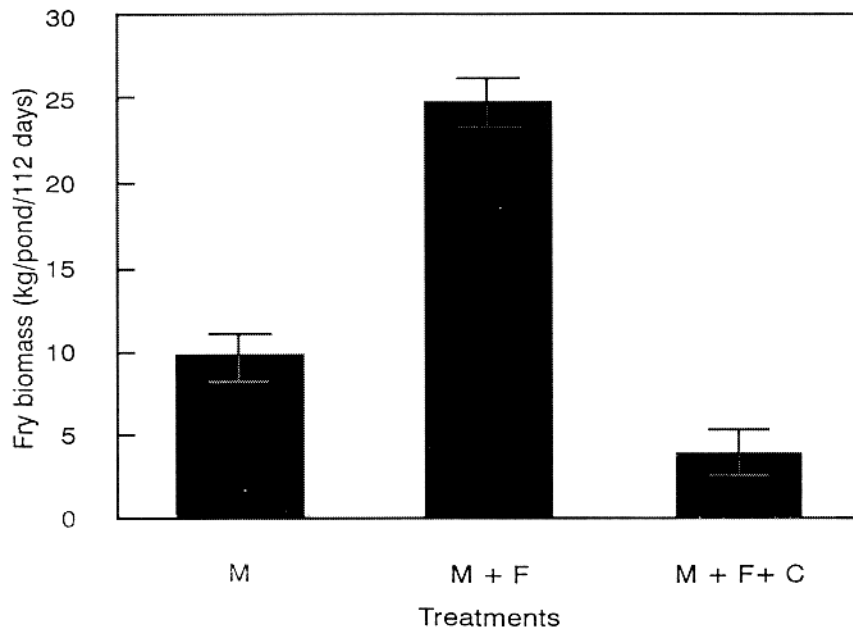


Fig. 4. Net fish yield of Nile tilapia (± 1 SE) for each treatment.

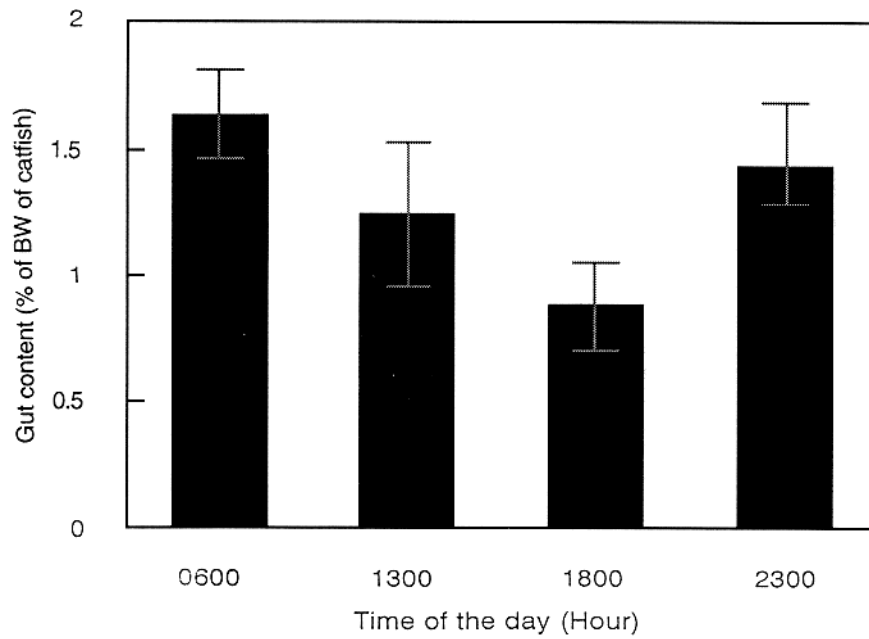


Fig. 5. Gut content expressed as % of body weight of African catfish at different times of the day.

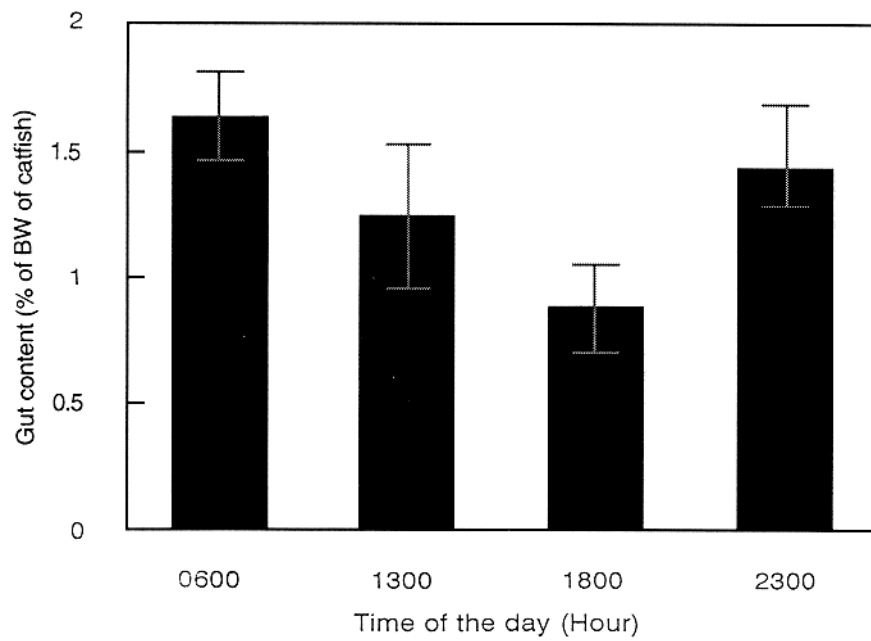


Fig. 6. Percentage of sampled African catfish having Nile tilapia fry in stomach.

Table 5. Details of gut content analysis of African catfish.

Pond No.	Sampling		Fish Wt. (g)	Gut Weight (g)		Content		Mean Gut Content		% Fish with Fry in Gut			
	Time	Date		TW	W/O cont.	Wt (g)	% of BW	1 day	Combined				
6	0600	19/9/94	343.4	10.7	5.9	4.8	1.4	1.49	1.64 a 0.17	33.3			
6			368.4	13.8	7.4	6.4	1.7						
6			329.2	10.4	6.8	3.6	1.1						
9			243.0	10.0	4.7	5.3	2.2						
9			265.5	9.1	5.2	4.0	1.5						
9			244.6	5.5	3.6	1.9	0.8						
11			351.7	12.0	7.7	4.3	1.2						
11			387.0	18.5	10.7	7.8	2.0						
6		28/9/94	287.7	12.3	6.5	5.8	2.0	1.88	33.3				
6			220.1	8.8	5.2	3.6	1.6						
9			309.6	7.6	5.0	2.6	0.8						
9			315.2	13.2	6.4	6.8	2.2						
11			345.2	20.3	10.9	9.4	2.7						
6	1300	19/9/94	278.7	13.9	6.0	7.9	2.8	1.49	1.25 ab 0.29	11.0			
6			168.4	8.7	4.2	4.5	2.6						
6			302.4	7.1	6.6	0.5	0.2						
9			278.5	7.4	5.3	2.1	0.7						
9			260.5	8.0	5.7	2.3	0.9						
9			160.0	10.3	4.5	5.8	3.6						
11			209.5	4.7	4.3	0.4	0.2						
11			185.9	4.7	3.7	1.0	0.5						
11			215.8	9.9	6.0	3.9	1.8						
6		28/9/94	329.2	8.9	7.8	1.2	0.3	0.89	0.0				
6			295.6	7.2	5.5	1.7	0.6						
9			237.2	4.9	4.0	0.9	0.4						
9			258.2	6.3	4.7	1.6	0.6						
11			303.9	10.1	5.4	4.7	1.5						
11			284.2	11.0	5.7	5.3	1.9						
6	1800	19/9/94	251.6	5.4	5.2	0.3	0.1	0.53	0.89 b 0.18	0.0			
6			218.4	6.2	4.2	2.0	0.9						
9			305.9	7.5	6.3	1.2	0.4						
9			309.7	8.8	6.6	2.2	0.7						
11			221.6	6.7	5.1	1.6	0.7						
11			216.2	5.6	4.7	0.9	0.4						
6		28/9/94	321.8	13.5	6.3	7.2	2.2	1.25	33.3				
6			224.9	7.4	4.5	2.9	1.3						
9			296.3	8.9	6.2	2.7	0.9						
9			374.8	15.3	9.7	5.6	1.5						
11			204.5	6.6	4.1	2.5	1.2						
11			212.8	5.0	4.3	0.7	0.3						
6	2230	19/9/94	235.8	13.7	6.1	7.6	3.2	1.63	1.44 ab 0.25	50.0			
6			198.0	7.8	4.2	3.6	1.8						
9			300.5	7.6	5.5	2.1	0.7						
9			233.3	9.8	6.9	2.9	1.2						
11			356.1	12.1	8.5	3.6	1.0						
11			244.0	9.1	4.7	4.4	1.8						
6		28/9/94	205.3	5.1	3.4	1.7	0.8	1.25	50.0				
6			215.9	9.7	4.9	4.8	2.2						
9			337.0	13.3	7.0	6.3	1.9						
9			186.4	4.5	3.9	0.6	0.3						
11			177.3	4.2	3.1	1.1	0.6						
11			270.1	10.2	5.7	4.5	1.7						
Grand Means			267.2	9.2	5.7	3.5	1.3				26.4		
SE			8.2	0.5	0.2	0.3	0.1				6.6		

N.B. Column with same letter (a,b) are not significantly different at $p=0.05$

Table 6. Range values of water quality parameters for each treatment during

Parameters	Unit	Treatment 1	Treatment 2	Treatment 3
Dissolved Oxygen	mg/L	0.7-21.0	0.3-26.1	1.0-22.6
Temperature	C	27.5-35.2	27.2-35.3	27.4-34.9
pH		7.5-10.0	7.2-10.0	6.7-9.9
Alkalinity	mg/L	48-116	54-108	54-102
Total Kjeldahl Nitrogen	mg/L	2.04-5.86	1.67-6.62	1.88-10.66
Ammonia-nitrogen	mg/L	0.00-2.24	0.00-2.39	0.00-2.44
Nitrite-nitrogen	mg/L	0.00-0.52	0.00-1.10	0.00-0.57
Nitrate-nitrogen	mg/L	0.00-1.23	0.00-1.58	0.00-0.85
Total phosphorous	mg/L	0.17-0.48	0.13-0.69	0.01-0.42
Soluble reactive phosphorous	mg/L	0.00-0.14	0.00-0.14	0.00-0.16
Total suspended solids	mg/L	22-276	17-265	19-252
Total volatile solids	mg/L	17-65	13-55.4	8-70

culture period.

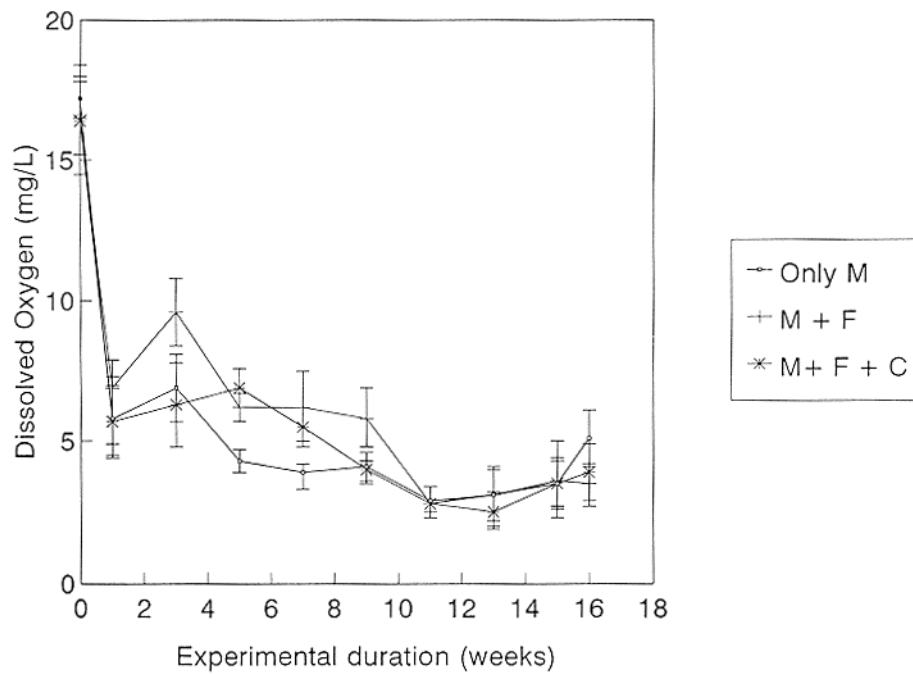


Fig. 7a. Biweekly variation in mean value for the dissolved oxygen water quality parameter.

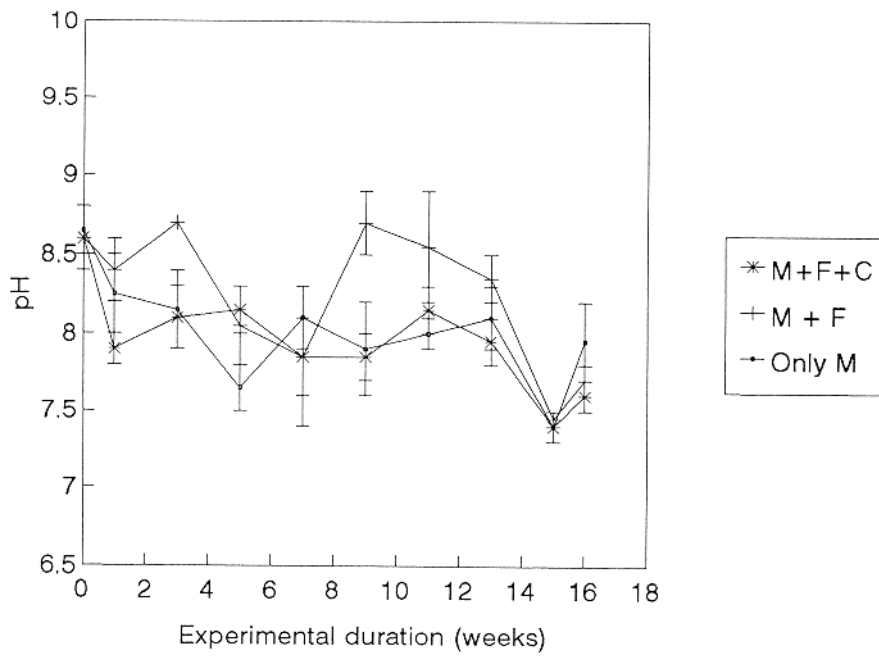


Fig. 7b. Biweekly variation in mean value for the pH water quality parameter.

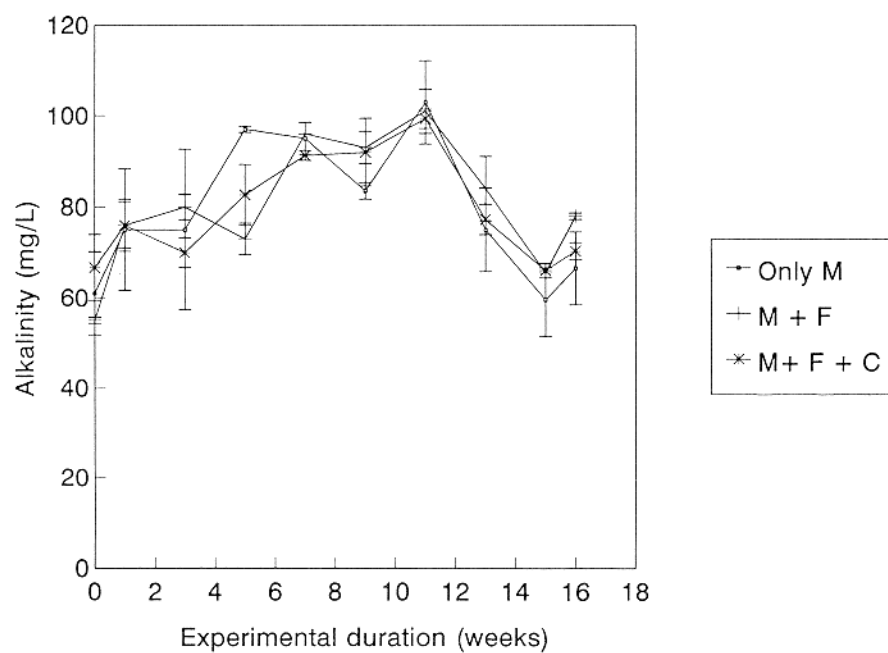


Fig. 7c. Biweekly variation in mean value for the alkalinity water quality parameter

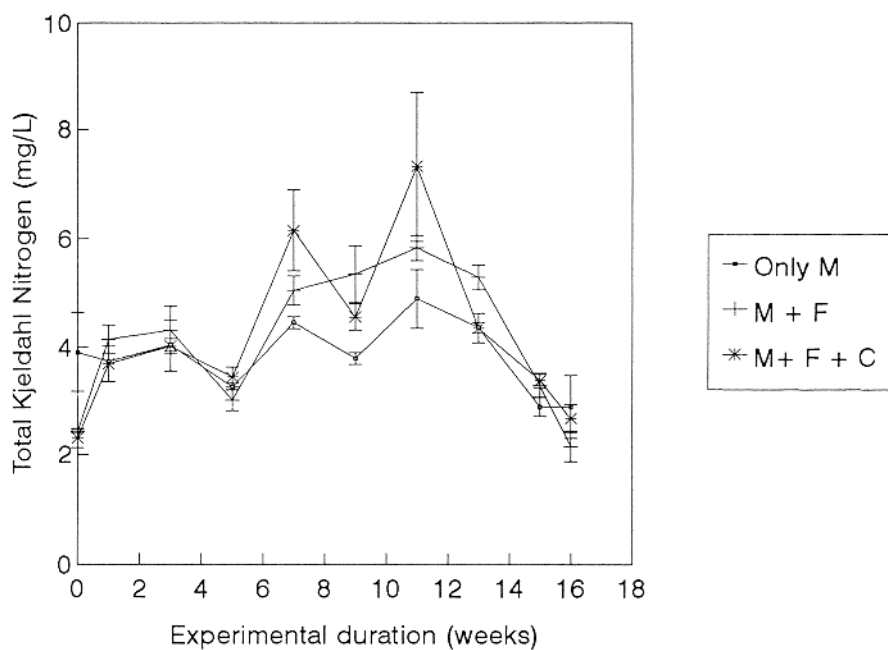


Fig. 7d. Biweekly variation in mean value for the total kjeldhal nitrogen water quality parameter.

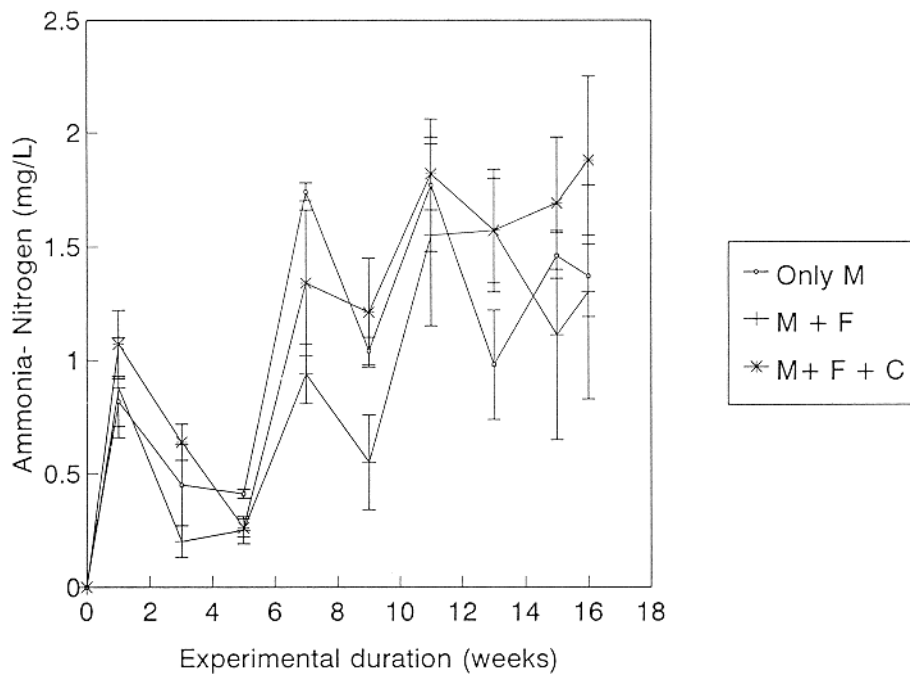


Fig. 7e. Biweekly variation in mean value for the ammonia nitrogen water quality parameter.

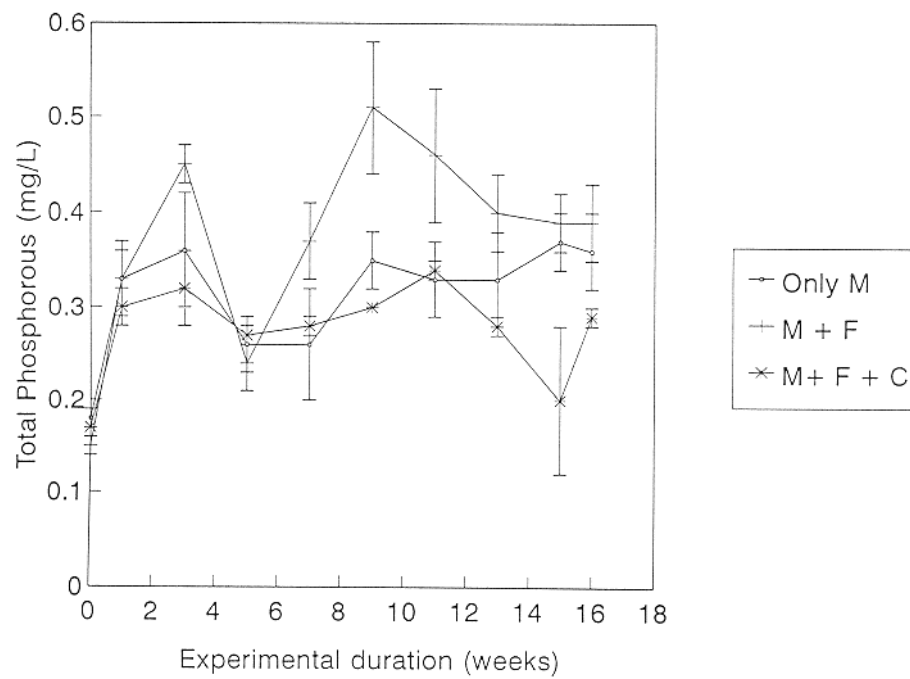


Fig. 7f. Biweekly variation in mean value for the total phosphorous water quality

parameter.

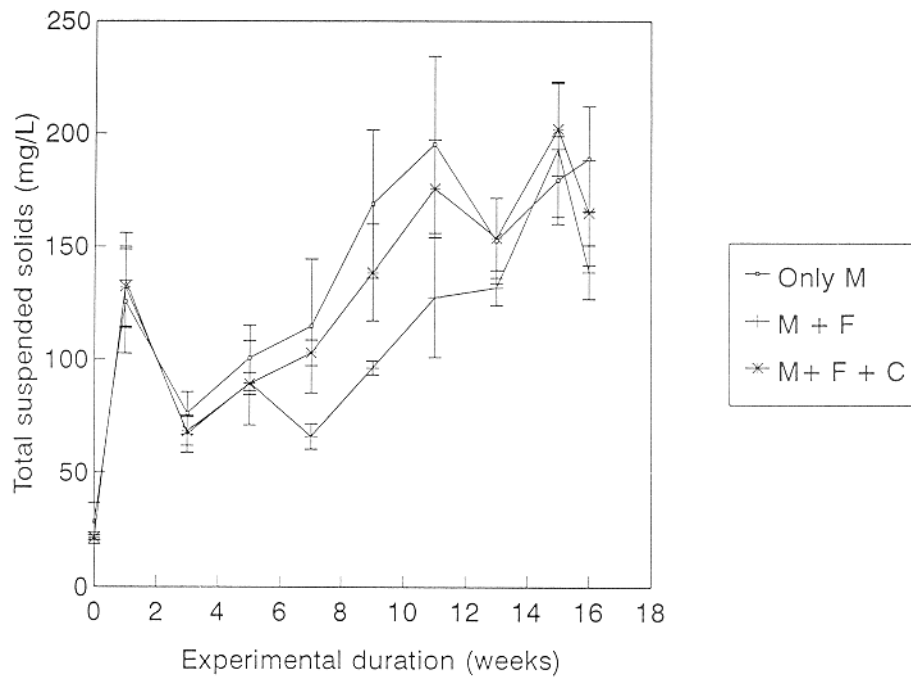


Fig. 7g. Biweekly variation in mean value for the total suspended solids water quality parameter.

Conclusions

1. The reliability of manually sexing tilapia is low and results in serious contamination of all male treatments with female fish. Reproduction undermined the all male treatment experiment.
2. Production of large adult tilapia is significantly lower in ponds with mixed sexes; however, the total biomass including reproduction does not differ greatly.
3. Tilapia production in polyculture with African catfish is significantly lower than the culture systems with either all male tilapia or mixed sex tilapia.
fi
4. African catfish predation of tilapia fry is sufficiently effective to serve as population control for tilapia. The active predation, however, occurred only in semi-intensive culture systems where fish are fed their natural diet.
5. Gut content analysis of catfish can provide a reliable method for estimating predation.

6. Further research should be focused on the following areas: 1) the assessment of the effects of increased variation in tilapia and catfish stocking ratios, and 2) the bioeconomics of the polyculture versus the monoculture of catfish and tilapia.

Literature Cited

- APHA (American Public Health Association), 1989. American Water Works Association and Water Pollution Control Federation: Standard methods for the examination of water and wastewater, 17th edition. APHA, Washington, D. C.
- De Groot, S.J., 1987. Culture of *Clarias* species. Elsevier Science Publishers, Amsterdam, 366 pp.
- Kaewpaitoon, K., 1992. Utilization of septage-raised tilapia (*Oreochromis niloticus*) as feed for snakehead (*Channa striates*). PhD Dissertation. Asian Institute of Technology, Bangkok, Thailand, 212 pp.
- Pillay, T.V.R., 1990. Aquaculture: Principles and Practices. Fishing News Books, London, 575 pp.