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BIO-ECONOMIC EVALUATION OF AFRICAN CATFISH (*CLARIAS GARIEPINUS*) INTERACTION WITH NILE TILAPIA (*OREOCHROMIS NILOTICUS*) IN LOW INPUT SYSTEM AND ITS EFFECT ON WATER QUALITY

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Abstract

The present experiment was conducted in twelve earthen ponds 2100-m^2 at WorldFish Center, Abbassa, Egypt, to assess the efficiency of African catfish (*Clarias gariepinus*) in controlling unwanted Nile tilapia (*Oreochrmis niloticus*) recruits and its effect on water quality, in addition to evaluate the economics of tilapia (T) and catfish (CF) biculture under low-input production system (fertilized only ponds). Mixed sex tilapia fry (0.15 g) were stocked at a rate of 2 fish m^{-2} and African catfish fingerlings (223 g) were stocked two months later at stocking rates of 0, 7 and 13% of tilapia (T. only, T.+7%CF and T.+13%CF, respectively). Ponds were fertilized using chicken litter at a rate of 500 kg ha^{-1} week^{-1} for 30 weeks. Water quality parameters were monitored weekly for measuring dissolved oxygen concentration, water temperature, Secchi disk depth, pH and total ammonia nitrogen (TAN), while nitrate-nitrogen, available phosphorus, chlorophyll "*a*", and total hardness were measured biweekly. Among mean water quality parameters only pH and available phosphorus were differed significantly (P<0.05) among treatments. The other water quality parameters were not significantly different (P>0.05), although non significance mean TAN concentration was 1.5 folds in T. only treatment than other polyculture treatments. At the end of the experimental period, catfish significantly (P<0.05) reduced the biomass of tilapia recruits to 14.9 and 8 % fry as percentage of the total fish yield in T.+7%CF and T.+13%CF treatments, respectively as compared to 26.6% obtained in T. only. Total fish production was also significantly (P<0.05) higher in T.+13%CF and T.+7%CF compared to T. only treatment. But marketable size tilapia production in T.+7%CF and T.+13%CF (1617.3, 1725.9 kg/ha, respectively) was significantly lower than tilapia monoculture "T. only" (1865.5 kg/ha). Partial economic analysis showed that there were no significant differences among the different treatments for both net profit and rate of return on operational costs. This study concluded that the presence of catfish with tilapia reduced

TAN concentrations to about two thirds of tilapia monoculture, while introduction of catfish at a rate of 13% of tilapia stocking number eliminated 70% of tilapia reproduction and enhanced total pond production of marketable size fish since it was 2804.2 kg/ha while it was 2427.3, 1887.5 kg/ha for T.+7%CF and T. only treatments, respectively. But profit generation rates didn’t show significant differences among the different treatments.

Keywords: African catfish; bio-economic; biological control; low input system and tilapia.

INTRODUCTION

Tilapia is the main cultured fish species in Egyptian farms; in 2006 tilapias contributed to 43.5 % of farmed fish production and 24% of total fisheries Production (GAFRD, 2007). The main problem facing tilapia producers is the early sexual maturity producing more fish recruits, which lead to overpopulation in production ponds and producing smaller fish at harvest (Guerrero, 1980).

The use of 17α-Methyltestosterone (MT) for producing all male tilapia was widely used in Egypt to overcome this problem Barry *et al*. (2007). But the Egyptian Government banned the use of MT hormone for mono-sex tilapia production. Therefore, there is a need for focusing on alternative methods for controlling tilapia recruits in production ponds.

Introducing of predator's fish to control tilapia recruitment was reported by Guerrero, (1980); De Graaf *et al*. (1996); El-Gamal *et al*. (1998) and Fagbenro (2004). Among predators which could be used for biological control of tilapia recruits is the African catfish (*Clarias gariepinus*). Lin (1996) mentioned that African catfish have been investigated as a potential aquaculture species. This species is known for its high growth rate, resistance to low dissolved oxygen (DO) level, poor water quality, handling stress and excellent meat quality (El-Naggar *et al*., 2006).

El-Gamal *et al*. (1998) contributed the less performance of African catfish as biological predator to control unwanted tilapia reproduction, to availability of fish feed in production ponds. The performance of African catfish in controlling tilapia recruits under low input system has not researched enough in Egypt. Therefore, this experiment was designed to determine the best stocking rate of African catfish (*Clarias gariepinus*) as a predator to control unwanted tilapia recruits in a bilyculture system and to assess the effects of that on fish growth, water quality, total fish production, and economic returns under low input production system in earthen ponds.

MATERIALS AND METHODS

The experiment was conducted in twelve earthen ponds 2100 m^2 each at the WorldFish Center, Abbassa, Egypt.

Experimental design:

Ponds were assigned into three treatments with four replicates each, as follows:

Treatment 1: Ponds stocked with tilapia only (T. only).

Treatment 2: Ponds stocked with tilapia and 7 % catfish (T.+7% CF).

Treatment 3: Ponds stocked with tilapia and 13 % catfish (T.+13% CF).

Pond preparation and management:

All ponds were dried for a week to eliminate wild fishes before starting of this experiment. Fine mesh screens were fixed over water inlet and outlet pipes. Ponds were fertilized with chicken litter at a rate of 500 kg/ha at the start of and water level was increased up to 50 cm. Two days prior to stocking tilapia fry, water was added to reach the average target level in ponds of 1-meter. Each pond was covered completely with bird netting supported by wood sticks to prevent entry of the birds. Water depth in all ponds was maintained at the same level throughout the experiment by adding water weekly to replace evaporation and seepage losses.

Experimental fish:

Mixed-sex Nile tilapia (*Oreochrmis niloticus*) fry were obtained from the Arabian Fisheries Company hatchery and kept in holding concrete tanks for two days before stocking for recovery from transportation stress, and reducing fish mortality. African catfish fingerlings (*Clarias gariepinus*) were obtained from previous year spawning done at the WorldFish Center facilities.

Nile tilapia fry (0.15 g) was stocked at a rate of 2 fish m^{-2} in all ponds. After two months of initial tilapia stocking catfish fingerlings (223 g) were introduced at a rate of 315 and 650 fish per pond representing 7% and 13% of tilapia number in the second and the third treatments, respectively. Catfish replaced Nile tilapia to keep stocking density at 2 fish m^{-2} in all treatments. All ponds were fertilized with chicken litter at a rate of 500 kg ha^{-1} $week^{-1}$ for 30 weeks.

Fish Sampling, data collection and final analysis:

During the experiment, fish samples were taken monthly where individual weight and length of 30 specimens of tilapia from each pond were recorded (120 fish per each treatment). Because of difficulty in getting catfish during fish sample from earthen ponds, no attempt was done to make growth curve. Mixed water samples (five samples from different five spots from each pond) were taken on biweekly basis during growing period. Pond water temperature, early morning dissolved oxygen (06.00 am), Sechi disk depth, pH and total ammonia nitrogen (TAN) were monitored weekly and nitrate-nitrogen, available phosphorus, chlorophyll “a”, total alkalinity and total hardness were monitored biweekly according to APHA (1998). Chemical analysis of fish was carried out according to (AOAC, 1990).

All fish were harvested after 215 days of growing period, fish were weighed and sorted into different size categories, and then number for each size group was counted to calculate fish survival rate. Fish yield (kg $pond^{-1}$), extrapolated yield (kg ha^{-1}), and daily weight gain (g $fish^{-1}$ d^{-1}), were calculated for each treatment.

Data were statistically analyzed using SPSS, 1998 (version 8.0) statistical software package (SPSS, Inc., Chicago, Illinois, USA). Analysis of variance (ANOVA) and Duncan’s Post Hoc Multiple Comparisons Test was performed to evaluate the differences among treatments means (Duncan 1955). Differences were considered significant at probability level of 0.05.

A partial budget analysis was conducted to determine economic returns of the different monoculture and polyculture systems tested (Shang, 1990). The analysis was based on farm-gate prices and current local market prices for all other items expressed in (LE) Egyptian pound /ha/year (US$1= LE 5.70).

RESULTS

Water Quality Parameters:

Among mean water quality parameters only pH and available phosphorus were differed significantly (P<0.05) among treatments (Table 1). The other water quality parameters such as water temperature, early morning dissolved oxygen (DO), total alkalinity, TAN, nitrate-nitrogen NO_3-N, chlorophyll "a" and Secchi disk visibility were not significantly different (P>0.05) among the different treatments. Although non significance mean TAN concentration was 1.5 folds in T. only treatment than other polyculture treatments (Table 1).

Monthly variation in mean values (±SE) for pH and available phosphorus throughout the experimental period is presented in Figures 1 and 2, respectively. The pH values recorded higher figure in T. only treatment than other treatments starting from June and remain significantly higher during July, August, and October. On contrary to pH, available phosphorus was significantly lower in T. only treatment from July up to September, then in October it was not significantly higher than T.+13% CF., while it was still the lowest.

Table 1. Water quality parameters (mean ± SE)[1] throughout the experimental period.

Parameter	T. only	T.+7%CF	T.+13%CF
Temperature range °C	17.7 – 28.4	17.9 – 28.6	17.6 – 28.7
pH	8.00[a] ± 0.08	8.52[b] ± 0.04	8.47[b] ± 0.05
Early morning DO (mg/l)	0.91[a] ± 0.10	0.92[a] ± 0.09	0.93[a] ± 0.03
Total alkalinity (mg/L as $CaCO_3$)	348.3[a] ± 18.36	371.9[a] ± 39.21	397.1[a] ± 28
TAN	0.15[a] ± 0.01	0.10[a] ± 0.02	0.10[a] ± 0.01
Nitrate-N (mg/L)	0.33[a] ± 0.09	0.27[a] ± 0.04	0.26[a] ± 0.08
Chlorophyll "*a*" (µg/L)	65.36[a] ± 11.47	70.38[a] ± 13.78	72.14[a] ± 7.16
Available phosphorus (mg/l)	0.75[b] ± 0.09	1.04[a] ± 0.07	0.98[ab] ± 0.06
Secchi Disk Visibility (cm)	23.5[a] ± 0.59	24.8[a] ± 0.38	23.3[a] ± 0.93

[1] Values with the same litter in the row are not significantly different.

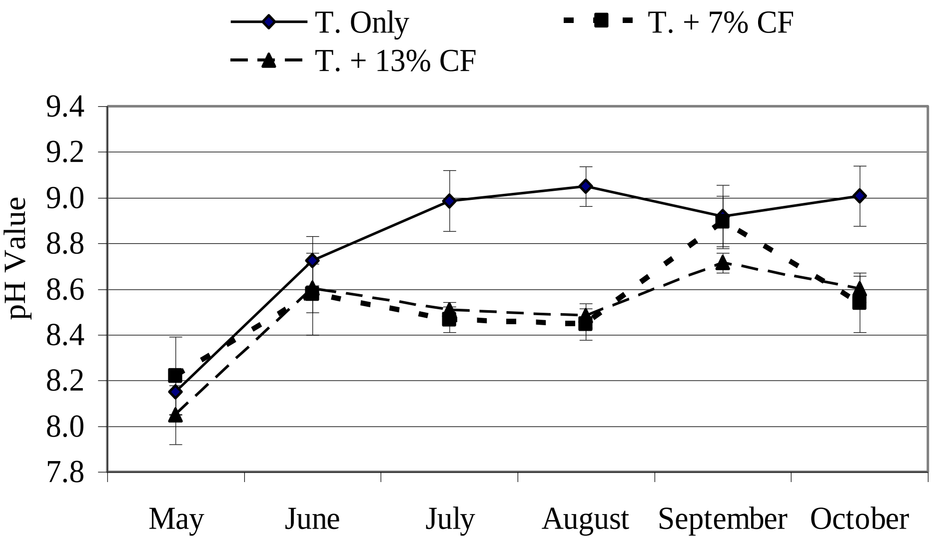

Figure 1. Fluctuation in mean values for the pH (± SE) during the culture period.

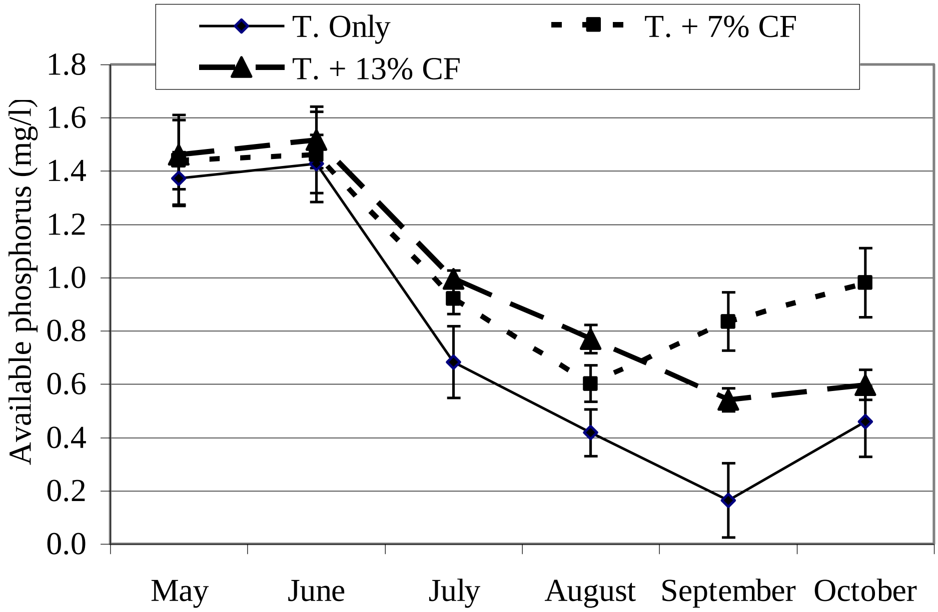

Fig. 2. Fluctuation in mean values for the available phosphorus (± SE) during culture period.

Fish Growth:

Table (2) showed that there were significant differences in all growth parameters, which are tilapia production, tilapia fry biomass with its percentage of fish yield, marketable sized tilapia yield, marketable sized catfish quantity and mean weight, among treatments ($P<0.05$). The introduction of catfish into tilapia ponds doesn't affect tilapia survival rate or growth rate ($P>0.05$).

Table 2. Fish yield, survival, growth, mean weight of tilapia marketable size, tilapia fry biomass for different treatments (Mean ± SE).

Parameters	T. only	T. +7% CF.	T. +13% CF.
Gross yield (kg/ha)	2540.1[b] ± 72.54	2855.6[a] ± 31.99	3048.6[a] ± 86.3
Net yield (kg/ha)	2527[a] ± 73.62	2521.8[a] ± 31.8	2373.9[a] ± 85.68
Tilapia survival (%)	90.2[a] ± 5.51	87.8[a] ± 4.56	89.0[a] ± 2.28
Tilapia growth (g/day)	0.99[a] ± 0.054	0.91[a] ± 0.045	0.89[a] ± 0.019
Tilapia production (kg/ha)	2528.8[a] ± 70.99	2099.67[b] ± 43.86	1970.27[b] ± 49.96
Market size fish (kg/ha)	1887.47[c] ± 75.7	2427.3[b] ± 58.36	2804.2[a] ± 88.73
Market size tilapia (kg/ha)	1865.0[a] ± 70.99	1671.3[b] ± 27.05	1725.9[ab] ± 55.45
Mean weight of market size tilapia (g)	208.8[a] ± 11.26	191.3[a] ± 9.49	187.3[a] ± 3.97
Market size catfish yield (kg/ha)	8.5[c] ± 4.9	755.93[b] ± 33.92	1078.36[a] ± 39.6
Mean weight of market size catfish (g)	599[a] ± 299.5	468[a] ± 47.8	353[b] ± 15.3
Tilapia fry biomass (kg/ha)	664.1[a] ± 12.74	428.4[b] ± 70.45	244.4[c] ± 13.76
Tilapia fry biomass as a % of total fish yield	26.6[a] ± 1.2	14.97[b] ± 2.37	8.00[c] ± 0.54

Values with the same litter in the same row are not significantly different.

Net fish yield was higher in T. only followed by T.+7%CF and T.+13%CF treatments respectively. On the other hand, marketable sized fish yield was lowest in T. only then T.+7%CF and it was the highest ($P<0.05$) at T.+13%CF (Table 2). The obtained tilapia fry biomass and its share as a percentage of the total fish yield significantly decreased ($P<0.05$) among the three treatments being geshighest for T. only followed by T.+7%CF then T.+13%CF. The total production of marketable sized tilapia was higher at T. only than that at T.+7%CF but not significantly different from T.+13%CF ($P\leq0.05$). Mean weight of marketable sized tilapia inversely correlated with increasing stocking rate of catfish, but the difference was not significant ($P>0.05$).

Figure (3) illustrates the comparison of tilapia size grades production showed that the first grade of tilapia (≥ 200 g) was significantly higher in T. only compared to both of T.+7%CF and T.+13%CF treatments ($P<0.05$), while the second grade (120-200 g) tilapia production was significantly lower in T. only treatment compared to T.+7%CF and T.+13%CF treatments ($P<0.05$).

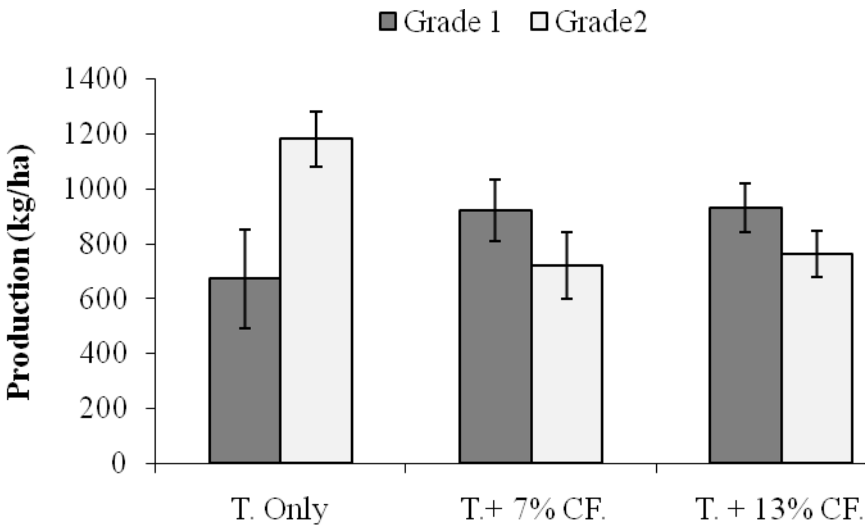

Figure 3. Tilapia production (Mean ±SE) as classified to size grades (grade 1 and grade 2) from various treatments.

The growth of tilapia in T. only started to show an increase over that for T.+7%CF and T.+13%CF starting from the third sample, which was one month after catfish stocking into the ponds (Fig 4). This divergence continued all through the experimental period to the end of study. The average weight of tilapia at harvest for the three treatments was similar to that obtained in the last fish sample.

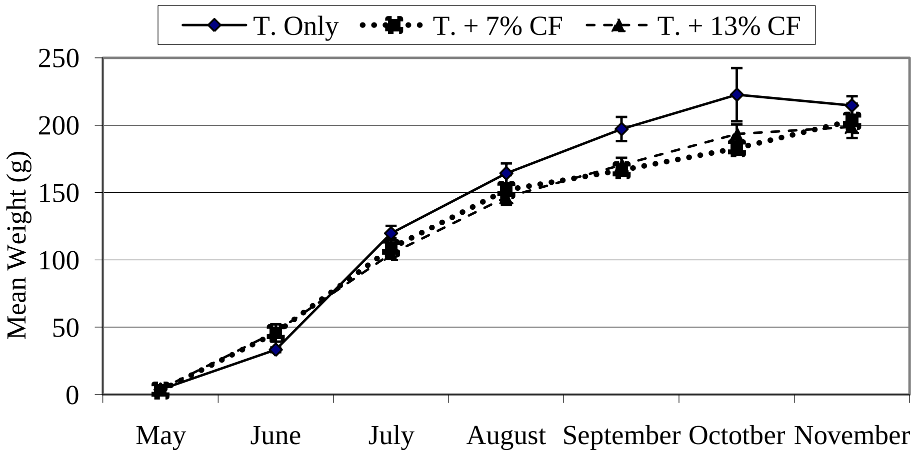

Figure 4. Average weight of Nile tilapia affected by catfish stocking ratio during the experimental period.

The protein content of tilapia was found to be slightly higher in T.+7%CF and T.+13%CF compared to T. only (Table 3). On the other hand crude lipids and ash were slightly higher in T. only compared to T.+7%CF and T.+13%CF.

Table 3. Proximate composition of Nile tilapia (as % of dry matter bases) as affected by catfish stocking rations. (Mean ± SE).

Item	**T. only**	**T.+ 7% CF.**	**T. + 13% CF.**
Crude protein	58.9 ± 2.63	61.0 ± 0.16	61.6 ± 1.61
Crude lipid	23.2 ± 1.94	21.3 ± 0.34	21.1 ± 0.34
Ash	17.9 ± 0.29	17.7 ± 0.30	17.3 ± 0.55

Partial Economic Analysis:

Partial budget analysis showed that variable costs were increased significantly ($P<0.05$) with increasing stocking rate of catfish in tilapia ponds. Market size tilapia sales were higher in T. only compared to T.+7%CF and T.+13%CF. Also, both revenue of market size fish and recruited tilapia were higher in T. only compared to other treatments. Catfish sales increased significantly with increasing stocking rate of catfish to be highest in T.+13%CF, then T.+7%CF and the lowest in T. only, while gross revenue, net return and rate of return on variable cost were not significantly different ($P \geq 0.05$) among the treatments (Table 4).

Table 4. Partial budget analysis for various treatments (LE/ha) (Mean±SE)[1].

Parameter	T. only	T.+7%CF	T.+13%CF
Cost			
Tilapia Fry	500	500	500
Catfish Fingerlings	-	457	914
Chicken Manure	3689.6^{a} ±98.7	3778.3^{a} ±89.3	3837.8a ±14.6
Working Capital	5907.16^{a}	5907.16^{a}	5907.16^{a}
Operational cost	10097^{c} ±93.4	10642^{b} ±89.3	11186^{a} ±14.6
Revenue			
Adult Tilapia	10485.6^{a} ±594.2	9031^{b} ±250.4	9325.8^{b} ±276.3
Catfish	42.7^{c} ±24.6	3779.7^{b} ±169.6	5391.8^{a} ±198
Sum market size fish revenue	10528.3^{b} ±513	12810.7^{a} ±417.9	14717.7^{a} ±459.8
Recruited Tilapia	3873.1^{a} ±334.4	1344.78^{b} ±283.4	603.33^{b} ±54.2
Gross Revenue	14401.4^{a} ±846.3	14145.5^{a} ±134.5	15321^{a} ±460.8
Net Return	4304.8^{a} ±754	3503.3^{a} ±103.5	4162.4^{a} ±463.3
Rate of Return on operational cost (%)	42.3^{a} ± 7	32.67^{a} ±0. 9	37.25^{a} ± 4.3

[1] Values with the same litter in the row are not significantly different.

DISCUSSION

Water quality parameters measured during this trial indicated that addition of catfish into tilapia ponds improved the quality ($P<0.05$) of water in the grow-out ponds. It was noted that pH value decreased significantly in T.+7%CF and T.+13%CF treatments compared to T. only ponds (monoculture). On the other hand, available phosphorus was increased significantly (*P*>0.05) in the presence of catfish in tilapia ponds. Inverse relationship between pH and available phosphorus was explained by Boyd (1990), who stated that available phosphorus increases when pH values decline. The increased fish feces that came from the increased tilapia production in the tilapia monoculture (T. only) treatment (2528.8 kg/ha), than that in the two polyculture treatments (T.+7%CF and T.+13%CF) (2099.7 and 1970.3 kg/ha respectively) resulted in an increase in mean TAN concentrations to be 1.5 fold in T. only compared to the polyculture treatments (although the non significance). On the other hand the presence of catfish in polyculture treatments reduced these feces (i.e. TAN) according to the fact that catfish can feed on tilapia feces.

Despite the higher fish biomass in the two biculture treatments which concomitant to a higher grazing rate of algae, chlorophyll "a" concentrations were higher in the polyculture treatments than the monoculture (although the non significance), this may be due to the increased available phosphorus concentrations in both polyculture treatments. Ibrahim (1997) stated that phosphorus is the key nutrient that algae require to growth.

Other water quality parameters such as dissolved oxygen, total alkalinity, nitrate and chlorophyll "a" were not significantly different among treatments (*P*>0.05).

The present study showed that bi-culture of catfish with mixed-sex tilapia in earthen ponds under low input system (fertilization only), would reduce tilapia reproduction that significantly (*P*<0.05) reduced tilapia fry biomass. At harvest, presence of tilapia fry decreased significantly with increasing stocking rate of catfish in tilapia grow-out ponds (0 %, 7% and 13% catfish), represented 8, 14.9 and 26.6% of fish yield, respectively. De Graaf (1996) reported that catfish at ratio of 1:2.7 and snakehead at ratio 1:30 were able to control tilapia reproduction to less than 0.15% of total harvest biomass against 25% fingerlings found in mixed sex tilapia culture.

The efficiency of catfish and Nile perch in controlling tilapia reproduction was investigated by El-Gamal *et al*. (1998), who reported that in earthen ponds when artificial feed was offered to fish, catfish were observed consuming artificial feed and attributed the less predator performance of catfish in such environment to the availability of the feed. They also reported that stomach analysis of catfish and Nile perch showed that predator activity started at an average weight of 13.0 g and 5.5 g, respectively.

Gross fish yield was increased with increasing stocking density of catfish, but net fish yield was slightly decreased with catfish introduced into tilapia ponds, with no significance difference among treatments ($P \geq 0.05$). Tilapia production was significantly ($P<0.05$) affected by introduction of catfish into tilapia ponds either at 7 or 13%, (T.+7%CF or T.+13%CF, respectively) with no significant difference between them. Lin (1996) reported similar result and concluded that polyculture of tilapia with African catfish would reduce tilapia yield than in monoculture of tilapia. The result of this experiment disagree with result obtained by Ngugi *et al*. (2006), who found that final weight and yield of market size tilapia was higher in ponds stocked with tilapia: catfish at 2:1 than those ponds stocked at 6:1 and 19:1.

Mean weight of tilapia marketable size decreased with increasing stocking density of catfish, but the difference was not significant ($P>0.05$). Tilapia grade 1 was significantly higher in T. only compared to other treatments ($P<0.05$), while second grade tilapia was significantly lower ($P<0.05$) in T. only compared to T.+7%CF and T.+13%CF. Tilapia survival was not affected with introduction of catfish to grow out ponds and ranged from 87.8 to 90.2%. Also daily weight gain of tilapia was not significantly differed ($P>0.05$) and ranged between 0.89 to 0.97 g/day/fish. Under high input production system higher daily weight gain of tilapia, was reported by Long and Yi (2004) to be 1.25 to 2.5 g/fish/day when artificial feed (30% protein) was offered to fish.

The partial economic analysis showed that there were significant increases in variable cost related to increasing stocking rate of catfish (Table 4). The high price of catfish fingerlings contributed to the increase of production cost in T.+7%CF and T.+13%CF treatments, respectively. Also, increasing density of catfish in T.+7%CF and T.+13%CF contribute to increasing its biomass at harvest and consequently lead to increases in catfish revenue significantly (P<0.05).

On the other hand, revenue from marketable size fish and tilapia recruits were significantly higher in T. only compared to T.+7%CF and T.+13%CF treatments. That result is supported by Lin (1996) findings, who reported that tilapia production in polycutlrue with catfish was significantly lower than monoculture of tilapia.

Net return and rate of return on variable cost showed no significant difference among treatments. That may be explained by increasing production biomass from catfish and consequently increasing fish sales revenue to compensate increasing production cost of T.+7%CF and T.+13%CF that led to the insignificant differences among treatments in net revenue and rate of return on operational cost.

In conclusion, the results of this study have demonstrated that the presence of catfish with tilapia reduced TAN concentrations to about two thirds of tilapia monoculture. Also, introduction of catfish at the rate of 13% of total tilapia stocking rate in earthen ponds as biological predator to eliminate unwanted tilapia reproduction led to eliminate 70% of total tilapia reproduction under low input system and enhanced total pond production of marketable size fish. Biculture of tilapia and catfish under such low input system didn`t improve neither net return nor rate of return on operational costs. Further research may be needed to improve the economic viability of tilapia and catfish polyculture under low input system to improve farmer income in rural areas where high input resources are not available.

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التقييم الاقتصادى الحيوى لاستزراع أسماك القرموط الأفريقى مع البلطى النيلى فى نظام الاستزراع منخفض المدخلات وتأثير ذلك على خواص جودة المياه

جمال عثمان النجار ، أحمد محمد نصر الله ، نبيل أحمد إبراهيم

المركز الدولى للأسماك – المركز الإقليمى لأفريقيا وغرب أسيا – العباسة أبو حماد – شرقية

الملخص العربى

أجريت هذه الدراسة فى أحد عشر حوضاً ترابياً مساحة كل منها ٢١٠٠ متر مربع بالمركز الدولى للأسماك. وذلك بهدف معرفة تأثير أسماك القراميط فى التحكم فى الأعداد غير المرغوبة من زريعة أسماك البلطى وتأثير ذلك على صفات جودة المياه ومن ثم تقيمها اقتصادياً وذلك تحت نظام الاستزراع المختلط منخفض المدخلات (الذى يعتمد على التسميد فقط دون التغذية). استخدمت لهذا الغرض أسماك البلطى النيلى خليطة الجنس بوزن ابتدائى ٠.١٥ جم وبكثافة تخزين ٢ سمكة/المتر المربع مع اصبعيات أسماك القراميط بوزن ابتدائى ٢٢٣ جم والتى تم استزراعها بعد شهرين من استزراع البلطى بمعدلات تخزين ٠ و ٧ و ١٣% من كثافة البلطى وذلك فى المعاملات التالية T. only، T.+7%CF and T.+13%CF على الترتيب. تم تسميد الأحواض اسبوعياً بفرشة الدواجن بمعدل ٥٠٠ كجم/هكتار.

تم مراقبة خواص جودة المياه وذلك بقياس تركيز الاكسجين الذائب، درجة حرارة المياه، عمق قرص الشفافية، درجة الحموضة، نيتروجين الأمونيا الكلى اسبوعياً. وكذلك نيتروجين النترات، الفوسفور الذائب، الكلوروفيل "أ" والعسر الكلى وذلك مرة كل أسبوعين.

دلت نتائج التحليل الاحصائى أن وجود أسماك القراميط قلل بشكل معنوى من كثافة زريعة أسماك البلطى إلى ١٤.٩% و ٨% من محصول الأسماك الكلى فى معاملتى T.+7%CF و T.+13%CF على الترتيب مقارنة بـ ٢٦.٦% فى معاملة T. only. كما ارتفع الإنتاج الكلى للأسماك فى معاملتى T.+7%CF و T.+13%CF عنه فى معاملة T. only. وعلى العكس من ذلك كان الحجم التسويقى لأسماك البلطى أعلى فى معاملة T. only (١٨٦٥.٥ كجم/هكتار) عنه فى معاملتى T.+7%CF و T.+13%CF (١٦١٧.٣، ١٧٢٥.٩ كجم/هكتار على الترتيب). ولكن نتائج التحليل الاقتصادى الجزئى أشارت إلى أنه لا يوجد فروق معنوية بين المعاملات الثلاث لا فى صافى الربح ولا فى معدل العائد على تكاليف التشغيل.

خلصت نتائج هذه الدراسة إلى أن استزراع أسماك القراميط مع أسماك البلطى قلل من تركيز نيتروجين الأمونيا الكلى إلى ثلثى تركيزه فى أحواض البلطى فقط (معاملة T. only). كما أشارت

النتائج أيضاً إلى أن استزراع القراميط بنسبة ١٣% مع البلطى ساهم فى التخلص من ٧٠% من زريعة أسماك البلطى غير المرغوبة، فأدى ذلك إلى رفع إنتاجية الأحواض الكلية من الأحجام التسويقة للأسماك المستزرعة حيث كانت ٢٨٠٤.٢ كجم/هكتار فى معاملة T.+13%CF بينما كانت ٢٤٢٧.٣ ، ١٨٨٧.٥ كجم/هكتار فى معاملتى T.+7%CF و T. only على الترتيب. ولكن من وجهة النظر الاقتصادية لم يكن هناك فروق معنوية فى معدلات الربح بين المعاملات الثلاث.