EFFECT OF INTEGRATED DUCK-FISH FARMING ON GROWTH PERFORMANCE AND ECONOMIC EFFICIENCY OF NILE TILAPIA (*Oreochromis niloticus* L.).

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ABSTRACT:

This trial was conducted for 200 days/year started on April to October, years 2004 and 2005 to evaluate the effect of two stocking densities of ducks along with a control (without ducks) on productive and economic efficiency of Nile tilapia in ponds.

Four earthen ponds were used in the non-integrated system (no ducks, T_1), two ponds/year, whereas four earthen ponds, two ponds/year were supplied with 1000 (T_2) and 1500 (T_3) Peking ducks per feddan (fdn)/cycle at years 2004 and 2005 (two cycles/year), were used for the integrated system. Each pond was stocked with Nile tilapia (*Oreochromis niloticus*) fry (9.0 ± 0.38 g) at a rate 15000/fdn.

Nile tilapia reared in the integrated ponds exhibited better body weight and food conversion than those of the non-integrated ponds. Fish yield per fdn produced from the integrated ponds was significantly higher than that obtained from non-integrated ones. Body mass of tilapia at harvesting and the net production per fdn were higher with T_3 than that of T_2 and T_1, respectively. The economical efficiency was in favor of T_3 and T_2 which were better than T_1 (regarding net returns/total costs %). Finally, the results showed that the integrated system was more profitable than the non-integrated system.

Key words: Integrated duck-fish culture - economic analysis - fish yield - growth parameters - water quality

INTRODUCTION

Semi-intensive systems are usually based on ponds fertilized with livestock manure and fed with low cost supplementary feeds. This type of integration can increase overall production intensity and economies on land, labour and water requirements for both poultry and fish. For example, one hectare of static water fish ponds can 'process' the wastes of up to 1500 birds, producing fish in quantities of up to 10000 kg/hectare without other feeds or fertilizers. Also, since effluents are few, environmental impacts are minimal (Little and Satapornvanit, 1996).

Duck-fish integration is very common in countries like China, Hungary, Germany, Poland, Russia and to some extent in India (Ayyappan *et al.* 1998). The integrated system was more profitable than non integrated (Delmendo, 1980; Prinsloo, *et al.*, 1999 and Soliman *et al.*, 2000). In Vietnam, raising 1000 to 2000 ducks/hectare on ponds increased the average fish yield to as much as 5 tons/ha/year, compared to 1 ton/ha/year without ducks (Delmendo, 1980). Wai-Ching-Sin (1980) reported that an optimum duck/water density appears to be 2,500 to 3,500 ducks per hectare.

Integrated fish farming systems work best in warm water fisheries, at temperatures of 25-32°C but can also be successful seasonally when summer temperatures approximate these levels (Little and Edwards, 2003).

The duck dropping was effective for better growth and development of fish (Islam *et al.,* 2004). Many kinds of fish-poultry integration have arisen to cater for local needs, but the practices are widespread. Duck-fish systems appear to be favored since ducks fit more easily into aquaculture facilities, performing both vegetation and pest management as well as fertilization roles, with minimum requirement of special facilities and expenditure in warm water systems (Little and Edwards 2005).

In the present study two stocking densities of ducks along with a control were used to evaluate the effects of different stocking densities of duck on fish production.

MATERIALS AND METHODS

This study was conducted in two private farms at Sinnuris, Fayoum governorate, Egypt for two years (2004 and 2005). Each farm consists of two ponds (2100 m^2 each) to evaluate two stocking densities of ducks along with a control on fish performance and economic efficiency. Duck pens were constructed beside the earthen ponds from brick and roofed with wood material. The floors of the duck sheds were covered with saw dust. Ducks were reared in two cycles. In the first they were housed for 10 days nursing in pens and continued for 66 days in ponds. In the second they were housed for 7 days nursing in pens and continued for 63 days in ponds. The time between cycle 1 and 2 was approximately 15 days where pond water was exchanged completely and gradually to be ready for cycle 2.

In the first year, Nile tilapia fingerlings with average body weight 9.0 ± 0.38 g where obtained from a private farm at Shakshouk region and were stocked at a rate of 7500/pond (15000/fdn) in farm No 1 ($T_{1,}$ control), farm 2 stocked with the same rate of Nile tilapia + 500 Peking duck/pond (1000 duck/fdn), T_2. Second year the same control and farm 2 stocked by the same rate of Nile tilapia (7500 fish/pond) + 750 Peking duck/pond (1500 duck/fdn), T_3. In each year, two cycles of Peking duck with the same stocking level (cycle 1 and two was 66 and 63 days) were conducted during the fish cycle (200 days).

The ponds were supplied with fresh water at a level of approximately 1.25 m from Nile river at canal endings, water turnover rate was every night by using irrigation machine (5/4 inch) for two hours changing approximately 1/3 from water volume/week/pond. One sample of water every week was obtained at mid day and analyzed. Water temperature, pH, dissolved oxygen and total ammonia-N were estimated through using centigrade thermometer, Orion digital pH meter model 201, Col Parmer oxygen meter model 5946 and Hanna instruments ammonia test kit (HI 4829), respectively. Mean values for each parameter, were determined and tabulated. Pellet sinking fish diet was obtained from a commercial factory (Zoocontrol), where it was fed manually twice daily at a rate of 3% (control) and 2% for duck fish pond. Chemical analysis of the used diet was conducted according to methods of AOAC (1984) and presented in Table 1. Gross energy of the used diet was calculated according to NRC (1993).

Table (1). Chemical analysis of fish diet, on DM basis.

Items	%
Crude protein, CP	25.12
Ether extract, EE	7.10
Ash	9.14
Crude fiber, CF	6.15
Nitrogen free extract, NFE	52.49
GE, kcal/g	4.497

NFE: Calculated by differences.
GE: Calculated according to NRC (1993) on the basis of 5.64, 4.11 and 9.44 Kcal GE/g CP, NFE and EE, respectively

Ducks and ducks feed used in this investigation were obtained from a commercial producer at Fayoum. The starter diet consisted of a 22% CP whilst the finisher ration had a 18% CP. Two thousands Peking ducks (500 per pond) at year 2004 and three thousands Peking ducks (750 per pond) at year 2005 were used in two growth cycles/year during the investigation lasting for 66 day (cycle 1) and 63 day (cycles 2). Ducklings were initially kept indoors for 10 and 7 days before being released onto the outdoor ponds in cycles 1 and 2, respectively.

Analysis of variance and LSD-range test were used to compare treatment means. Data were analyzed using Statgraphic Package Software (SPSS, 1997).

RESULTS AND DISCUSSIONS

Water quality

Water quality parameters of the Peking duck ponds before and during the experimental period are presented in Table 2.

Table (2). Water quality parameters as affected by duck-fish culture.

Item	Months						
	4	5	6	7	8	9	10
Pond without ducks							
Temperature, ^{o}C	21.0	25.5	27.0	28.5	29.5	27.5	27.0
Dissolved oxygen, mg/l	9.30	9.60	8.80	8.20	7.30	6.70	8.50
pH	7.92	8.12	7.98	7.68	7.85	8.31	7.74
Total ammonia, mg/l	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Pond with ducks							
Temperature, ^{o}C	20.5	25	27	28	29	27	26
Dissolved oxygen, mg/l	9.40	11.80	8.85	6.14	9.18	4.75	6.62
pH	8.10	7.44	6.90	7.12	7.56	6.32	7.45
Total ammonia, mg/l	Nil	0.25	0.40	0.15	0.35	0.40	0.25

Water samples were taken twice monthly before sun rise and afternoon. Initial variability in properties on duck ponds, which can be mainly ascribed to phytoplankton growths, the oxygen concentration remained fairly high during the first month after the introduction of ducks into ponds, this may be due to that ducks act as an aerator. These results were higher than that obtained in fish ponds without ducks. Thereafter, a significant decline in dissolved oxygen followed during the period from week 7 until marketing day. The effect of algal blooms on the water quality of the duck ponds also reflected by a high pH value which prevailed before the introduction of ducks. Ammonia values in duck ponds were considerably higher than the control and exceeded as wastes increased. All water parameters were within the acceptable limits for Nile tilapia as indicated by Miranda-Filho *et al.* (1995); Milstein and Svirsky (1996); El-Sayed *et al.* (1996), Durborow1 *et al.*, 1997 and Abd El-Maksoud *et al.* (1999 a,b), these may be due to decreased water polluted as a result of partial changed of water every night.

Fish growth performance

Fish growth performance parameters as affected by Peking duck-fish culture are shown in Table (3). It seems that there was a better performance of tilapia in duck-fish culture system than non integrated (control). T_3 showed higher final weight, weight gain and daily gain (273.52 g, 264.19 g, and 1.32 g, respectively) than other treatments. However, T_2 had higher SGR% of 1.73 than other treatments. Based on the results obtained in this study, it could be concluded that better performance of fish integrated with duck may due to increased plankton production from duck manure and spilled duck feed and adult duck feed on small Nile tilapia fry less than 5 g (strange fish comes from water or from spawning female) as indicated by Kumar and Ayyappan (1998), causing improved tilapia performance and graded as indicated by Delmendo, 1980 and Hopkins & Cruz 1982.

Table (3). Effect of integrated duck-fish on growth performance of Nile tilapia.

Item	Treatment*			SED
	T_1	T_2	T_3	
Initial weight/fish, g.	9.17	8.50	9.33	0.33
Final weight/fish, g.	222.22[b]	270.80[a]	273.52[a]	3.29
Weight gain[1]/fish, g.	213.05[b]	262.30[a]	264.19[a]	2.96
Daily gain[2]/fish, g.	1.07[b]	1.31[a]	1.32[a]	0.015
SGR[3], %.	1.59[c]	1.73[a]	1.69[b]	0.012

* T_1, T_2 and T_3 were (15000 tilapia), (15000 tilapia + 1000 Peking duck) and (15000 tilapia + 1500 Peking duck)/fdn, respectively.
- Means within the same row having different superscripts are significantly different ($P \leq 0.01$).
- SED, standard error of differences.
[1], Final weight – initial weight
[2], weight gain/period, day (200) [3], $\{(\ln W_2 - \ln W_1) \times 100/\text{days}\}$

Fish Feed utilization

The effect of integrated duck-fish culture system on feed utilization of fish is presented in Table (4). Data showed that there are significant differences among treatments. Final weight of duck-fish ponds was higher than the control and the best values were found with T_3 followed by T_2. Regarding the FCR which improved significantly for duck ponds than the control (T_1), since feed intake in T_1 was higher significantly than in T_2 and T_3. These results may be due to growing of phytoplankton in duck-fish ponds since tilapia depend on it beside artificial diets, but the control ponds {non-integrated (control) Nile tilapia} depended on artificial feed mainly.

Table (4). Feed utilization of tilapia as affected by integrated duck-fish culture.

Item	Treatments *			SED
	T_1	T_2	T_3	
Initial weight, kg/pond	137.5	127.5	140.0	5.0
Final weight, kg/pond	3075^b	3700^a	3710^a	46.37
Feed intake, kg/pond	7275^a	6675^b	6712^b	65.35
FCR	2.48^a	1.87^b	1.88^b	.009

* T_1, T_2 and T_3 were (15000 tilapia), (15000 tilapia + 1000 Peking duck) and (15000 tilapia + 1500 Peking duck)/fdn, respectively.

Averages in the same row having different superscripts are significantly different ($P \leq 0.01$). SED, standard error of differences.

Duck production

The mean individual duck mass for the consecutive weeks are presented in Table 5. Insignificant differences between duck stocking rate concerning duck production were seen. However, duck production is considered a secondary production beside fish yield.

Production efficiency

Results presented in Table (6) showed the production efficiency of fish and Peking ducks as affected by integrated culture. Survival rates of

Nile tilapia ranged between 90.43 and 92.25%. These values are in the normal range as indicated by Hassouna *et al.* (1998) and Abd El-Maksoud *et al.* (1999 a and b), who reported values ranged between 87 and 95%.

Table (5). Effect of integrated duck-fish on growth performance of Peking ducks

Stocking rate of ducks/cycle							
1000 duck/fdn				1500 duck/fdn			
Date	Days	Number	Mean weight, kg	Date	Days	Number	Mean weight, kg
Cycle 1				***Cycle 1***			
1/5/2004	1	1000	0.059	20/4/2005	1	1500	0.060
11/5/2004	11	985	0.090	30/4/2005	11	1473	0.095
5/7/2004	66	963	2.596	24/6/2005	66	1433	2.565
Cycle 2				***Cycle 2***			
20/7/2004	1	1000	0.060	10/7/2005	1	1500	0.061
27/7/2004	8	988	0.080	17/7/2005	8	1475	0.090
20/9/2004	63	969	2.699	10/9/2005	63	1425	2.456

Body mass of Nile tilapia at harvesting was significantly higher with duck pond than the control (T_1). Tilapia graded was improved by culturing ducks with fish, the best 1st grade with T_3 which nearly similar with T_2 followed by T_1, oppositely 2nd grade was higher with T_1 followed by T_2 and T_3 but 3rd grade wasn't found in T_2 and T_3. These results showed that Peking ducks perhaps consumed small tilapia fries (so reduced survival rate in T_3 and T_2) and given good chance to improved tilapia growth performance and feed utilization in T_2 and T_3 ponds.

Economical evaluation

The economical analysis (Table 7) showed that either T_3 or T_2 had higher income than that of T_1 of about 364.73% and 297.45, respectively. On the other hand, the total costs of treatments as a percent of T_1 were

252.97 and 278.91 for T_2 and T_3, respectively. However, the net returns/fdn as a percent of T_1 was 471.4 and 700.4% for T_2 and T_3, respectively. Even though, the net returns/total costs (%) cleared that T3 was the best followed by T_2 and T_1, respectively.

Table (6). Production efficiency of fish and ducks as affected by duck-fish culture.

Item	Treatments *			SED
	T_1	T_2	T_3	
Nile tilapia				
Fish No/fdn				
At start	15000	15000	15000	---
At harvesting	13838	13663	13565	112.5
Survival rate[1] %	92.25	91.09	90.43	0.75
Fish biomass, kg/fdn				
At start	137.0	127.0	140.0	5.0
At harvesting	3075	3700	3710	46.37
1st grade[2]	1815	3338	3375	89.10
2nd grade[3]	1037	362	335	38.19
3rd grade[4]	223	0.0	0.0	14.28
Net production[5]	2938	3573	3570	43.11
Relative % of net production	100	121.61	121.51	----
Peking duck				
Number of ducks/fdn (two cycle)				
At start	0.00	2000	3000	
At marketing	0.00	1932	2858	
Survival rate[1] %	0.00	96.60	95.27	
Duck biomass, kg/fdn				
At start	0.00	119	181	
At markting;	0.00	5115	7175	
Net production	0.00	4996	6994	

* T_1, T_2 and T_3 were (15000 tilapia), (15000 tilapia + 1000 Peking duck) and (15000 tilapia + 1500 Peking duck)/fdn, respectively.

SED, standard error of differences. 1, Survival rate = (fish No at harvesting/fish No at start) ×100
2, 3-4 fish/kg 3, 5-6 fish/kg 4, 7-10 fish/kg
5, body mass of fish at harvesting, kg – body mass of fish at start, kg

Table (7). Economical efficiency of integrated duck-fish system.

Item	Treatments *		
	T_1	T_2	T_3
Income, L.E/fdn			
Nile tilapia	24709	32576	32720
Peking duck	0.00	40920	57400
Total income	24709	73496	90120
Relative % of total income	100.0	297.45	364.73
Costs, L.E/fdn			
Nile tilapia	19675	22375	22375
Peking duck	0.00	27400	32500
Total costs	19675	49775	54875
Relative % of total costs	100.0	252.97	278.91
Net returns, L.E/fdn	5032	23721	35245
Relative % of net returns	100	471.4	700.4
Net returns/total costs, %	25.58	47.66	64.23

* T_1, T_2 and T_3 were (15000 tilapia), (15000 tilapia + 1000 Peking duck) and (15000 tilapia + 1500 Peking duck)/fdn, respectively.

- The average price of 1 kg fish × the fish yield, kg/ fdn
- Selling price of one kg of tilapia was 9, 7 and 5 L.E. for 1st grade, 2nd grade and 3rd grade, respectively and for Peking duck 8 L.E. and the price of kg fish feed was 2.160 L.E.

Under these experimental conditions, results concluded that the integrated duck-fish culture was more efficient than the non-integrated as indicated by Wetcharagarun (1980) and T_3 was more efficient than T_2. Moreover, the economical efficiency was in favor of T_3 regarding net returns and net returns/total costs, %. Therefore, it could recommend the rearing of ducks with Nile tilapia together in integrated system in earthen ponds at a density of 1500 Peking duck and 15000 fry of fish /fdn for the best net income.

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ARABIC SUMMARY

تأثير تكامل استزراع البط والأسماك على مظاهر النمو والكفاءة الاقتصادية لأسماك البلطى النيلى

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أجريت هذه الدراسة لمدة ٢٠٠ يوما/سنة بدأت في أبريل حتى أكتوبر عامي ٢٠٠٤ و ٢٠٠٥ لتقييم تسكين كثافتين من البط البكينى بالإضافة إلى الكنترول (بدون بط) المربى في أحـواض الأسماك على الكفاءة الإنتاجية والاقتصادية للبلطى النيلى.

استخدمت أربعة أحواض ترابية، ٢ حوض/ معاملة/سنة وكانت المعاملات كالتالى المعاملـة الأولى (كنترول)، المعاملة الثانية ١٠٠٠ بطة بكينى/فدان/دورة (٢٠٠٤) و المعاملة الثالثـة ١٥٠٠ بطة بكينى/فدان/دورة (٢٠٠٥) تم عمل دورتين بط/دورة سمك/سنة وخزن السمك فى الأحواض بكثافة ١٥٠٠٠ سمكة بلطى متوسط وزنها ٩ ± ٠,٣٨ جم لكل فدان. وقد أوضحت النتائج تحسن وزن الجسم وكفاءة تحويل الغذاء للبلطى النيلى المحمـل عليـه بـط وكـذلك محصول الأسماك للفدان عنه في أحواض الكنترول كذلك وزن الأسماك عند الحصاد والإنتاج الصافى كان أعلى مع المعاملة الثالثة عنه في الثانية والأولى على الترتيب. تحسنت الكفـاءة الاقتصادية للمعاملات الثالثة والثانية عن المعاملة الأولى (الكنترول) وذلك بـالنظر لصـافى الإنتاج بالنسبة للتكاليف. لذلك فان نظام تحميل البط مع الأسماك أكثر كفاءة من نظـام عـدم التحميل.