J. Egypt. Acad. Soc. Environ. Develop., 24 (1):13-22 (2023) (D-Environmental Studies)
E. mail: easedjournal_egypt@yahoo.com ISSN 1110-8770
www.jades.journals.ekb.eg eISSN 2314-5471 (online)

Integrated fish culture with chickens under desert condition, North Sinai, Egypt

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Received: April 9, 2023
Accepted: May 11, 2023

ABSTRACT

An experiment in the integrated poultry and fish farming system was conducted during the year 2020. Nile tilapia fish was chosen because it is one of the most important freshwater fish and is widely farmed in many countries of the world. Three treatments were used: Artificial diet 27% crude protein (T_1) (the control treatment), 50% artificial feed (T_2) and chickens' droppings only (T_3). The survival rate of the fish under this system was 90.0%, 85.0% and 75.0% in treatments T1, T2 and T3, respectively. While, the respective average weight of individual fish was 116.5±4.5 g, 77.5±6.3g and 60.8±5.1g. The result of fish production per cubic meter was high, reaching 2.1 kg/m^3 for control; 1.5 kg/m^3 for T_2 and 0.77 kg/m^3 for T_3. Fish fed on a complete artificial diet (T_1) had better growth in terms of weight gain, followed by fish fed on 50% artificial feed and those fed on chicken droppings only. Length-weight relationship with respect to feed with different culture systems were estimated to be $W= 0.\ 0244*TL^{2.927}$, $W=0.0337*TL^{2.791}$ and $W=0.0396*TL^{2.7069}$ for fish of T_1, T_2 and T_3, respectively. The average Condition coefficient of fish under the single system of production was 2.04. The average Condition coefficient of fish under semi-integrated system and integrated system were 2.01 and 1.94, respectively.

Key words: Nile tilapia, integrated farming, chicks, feeding treatments, fish production, length-weight relationship, condition factor.

INTRODUCTION

FAO (2022) recorded 64.6% decrease in (2019) fishery stocks from previous years. Therefore, the trend towards alternative solutions, such as integrated farming in ponds or desert areas became necessary to supply people with their need of protein. The term ‘desert aquaculture’ refers to aquaculture production of fish, shellfish in arid areas or in areas where water supply is restricted (Kolkovski, 2013). Farrag *et al*. (2021) recommended drawing the attention towards the desert of Egypt, enhancing the aquaculture awareness in Upper Egypt to create new fields of industries and ensure new job opportunities for young people in those areas.

The integrated fish farming is a way of farming with fish as the main target along with other farm produces to create a mutually beneficial system that leads to maximize productivity through optimum use of resources (Onada and Ogunola, 2016). The integrated fish poultry culture offers good ways to manage environment safely through feeding fishes with poultry wastes which saves the costs expended on conventional meals, thereby enabling profit maximization (Gabriel *et al*., 2007). On the other hand, the integrated fish farming with poultry and vegetable was a good for sustainable production, income generating, empowering rural women and increase use of untapped resource (Alam *et al*. (2010). Moreover, the integrated fish–crop production systems have been shown to have both economic and environmental benefits greater than mono-production systems (Da *et al*., 2020).

The current study aims to investigate the importance of applying chickens -fish integrated farms in Ber El-Abed desert area at North Sinai to reduce costs feeds in fish culture and maximize benefits for women empowerment and poverty alleviation there.

MATERIALS AND METHODS

1. Study area :

The integrated Fish - chicken farming system was carried out at Ber El-Abed district of Sinai in a privet small farm. The underground water was used in fish pond. Its average salinity was 2.8 ppt, while its average pH was 8.1

2. Experimental design:

The Nile tilapia fish (*Oreochromis niloticus*) (Fig. 1) was chosen as it is one of the most important freshwater fish in Egypt and is widely cultivated in many tropical and subtropical countries in the world.

Fig. (1): Tilapia fish (*Oreochromis niloticus*)

The experiment was carried out from 1 April to 30 July 2020, in six ≈ $0.5m^3$ net cages (75*80*80 cm) mounted on a metal frame, those cages sunken in the concrete pond (Fig. 2) of underground water. Water level one meter. Stocking in the pond consisted of 20 tilapia fish fingerlings/I m^3. Above the cages, 2 chicks for one treatment and 4 chicks of another treatment, 5 weeks old, were placed in the poultry house. The nutrient-rich water from the fish ponds was then used to irrigate a variety crops.

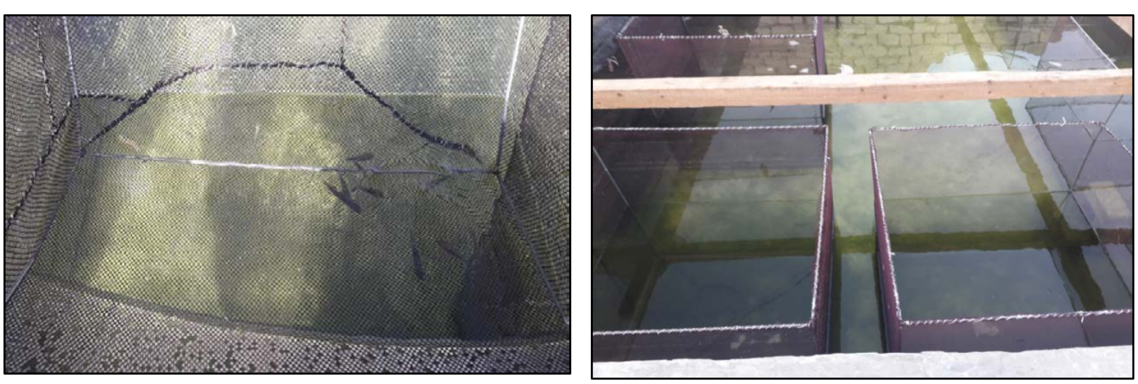

Fig. (2): Fish cages

Chickens in poultry houses built above the water in pond were raised for meat (broilers) and integrated with fish farming. Poultry house was raised over the ponds (vertical integration). The excreta from the birds serve as manure, which fertilizes the pond or the fish can feed on them directly. Each poultry cage; 0.45 m high, 0.6 m buried inside and 0.6 m protruding above, that lifts the cage above the fish pond (Fig. 3).

Fig. (3): Chickens cages

The chicks were purchased from the hatchery one day of age and were stocked in chick nursery operators till 5 weeks. Chicks were raised separately in a brooder (not on pond), as they need higher temperature of ≈ 30 ºC. To maintain the required temperature range, a plastic sheet was used to surround the chicks. An electric lamp was put above them). After that chicks were stocked to the experimental cages. Chicken wastes pass through a floor of the poultry house to the water below, and consider part of the food that the fish feed on.

To collect data on chicken manure production, 5 randomly selected chickens were kept individually for 5 days and fed normal ration. Fresh manure was collected every day and weighed. Chicken were fed on artificial feed. The chickens were harvested till reach the minimum live weight of 1.5 kg. Artificial Feed and poultry manure were analyzed in the laboratories of Aquaculture and Marine Fisheries, Arish University, and the protein level of the artificial Feed was determined at 27% protein and poultry manure at 22% protein. The poultry manure was determined as 12.2g per chicken per day.

3. Feeding treatments of fish

The commercial extruded floating diet (27% crude protein) was used in the control treatment with twice daily feeding at 9.00am and 2.00pm. Feed quantity was adjusted according to the average body weight of the sample. The amount of feed was changed to the new fish biomass. Chicken manure was used as a supplementary feed for fish in the pond with the other treatments as follow:

Control group (T_1): Conventional system. Fish in two cages fed on 100% artificial food (27% crude protein, 3% of body weight) without chicken manure inputs.

Group 2 (T_2): Semi- integrated system. Two fish cages received direct chicken dropping from 2 broiler chicken with 50% artificial food (27% crude protein, 1.5% of body weight).

Group 3 (T_3):Integrated system Two fish cages received direct chicken dropping feces from 4 broiler chicken without using artificial food.

The treatments were replicated twice on a completely randomized basis.

4. Sampling and growth measurements

4.1 Fish weight and growth

All fish were bimonthly weighed, the growth of fish recorded every 15 day and then fish were returned to culture pond. At the end of the experiment, tilapia of each treatment was weighed individually to determine the final average weight at harvest.

The final weight and other calculated indices of fish growth were done.

4.2 Daily Growth rate (DGR)

DGR (g/day): (W1-W2)/ t2-t1

Where: W1 = initial weight (g)

W2 = final body weight (g)

t2-t1 = duration between W2 and W1 (days).

4.3 weight gain (WG)

$$\mathbf{WG\ (g) = FW - IW\ (g/fish)}$$

Where: IW = initial weight (g)

FW = final weight (g)

4.4. Specific growth rate (SGR)

$$\text{SGR (\%/day)} = \frac{100 \times [(\ln \text{final fish weight}) - (\ln \text{initial fish weight})]}{\text{experimental days}}$$

4.5. Survival rate and Mortalities

Mortalities for fishes were recorded every 15 days and the survival rate was calculated.

$$\text{Survival rate (\%)} = \frac{\text{fish stocked\_mortality}}{\text{fish stocked}} \times 100$$

4.6. Length-weight relationship:

It was computed as indicated by **Le Cren (1951)**.

$$\mathbf{W = a\ L^b}$$

Where: W= fish weight in grams.

L= fish standard length in centimeters.

a and b = Regression constants=

4.7 Coefficient of condition (K):

$$\mathbf{K = (Total\ fish\ weight\ /\ Fish\ length^3) \times 100}$$

5.Statistical analyses:

One way ANOVA analyses was used. Statistical significance was assessed using a probability level of P = 0.05. In addition, Different mean values were analysed using Minitab software version 17.0, Tukey's test was used to compare between samples at 0.05 levels.

RESULTS

Fish production

The findings on the various aspects of the integrated poultry-fish production during 16 weeks from the first of April to the end of July are summarized in Tables (1).

Table (1): Production of tilapia in one m³ fish cages receiving artificial feed and droppings from overhanging laying chicken batteries

Parameters	100% Artificial Feeding	Artificial Feeding 50% + droppings from chicken	Droppings from chicken
	T_1	T_2	T_3
Total cubic of the cage (m^3)	One	One	One
Stocking density (No)	20	20	20
Initial individual biomass (g)	4.45	4.55	4.45
Initial total biomass (g)	89	91	89
Total no. of fish harvested	18	17	15
% Survival	90.0a	85.0ab	75.0b
Final individual biomass (g)	116.5a	89.3b	60.8c
Final total biomass (Kg/m^3)	2.1a	1.5b	0.8c
Chicken yield (kg/m^2)		17.2	36.0

a,b,c…. etc: means within the same row with different superscripts are significantly different ($P<0.05$).

As illustrated in Table (1), the survival rate of the fish under this system was 90.0%, 85.0% and 75.0% in treatments T_1, T_2 and T_3, respectively. The survival rate was significantly variable between treatments ($p< 0.05$). It could be seen that the survival rates in T_1 was the highest, while that in T_3 was the lowest. However, there was insignificantly different in survival between T_2 and both T_1 and T_3.

The average weight of individual fish under full artificial nutrition at 16 weeks was 116.5±4.5 g. The average weight of individual under direct chicken feces from 2 broiler chicken with 50% artificial food at the same period was 77.5±6.3g, while that of fish under zero artificial diet with the use of poultry feces only feeding diet was 60.8±5.1g. The average weight of individual fish was significantly variable between the three treatments ($p< 0.05$) as shown in Table (1).

The results of fish production per cubic meter was high, reaching 2.1 kg/m^3 for control; 1.5 kg/m^3 for T_2 and 0.77 kg/m^3 for T_3 and there were significant differences ($P<0.05$) between the three treatments (Table 1).

5.6. Growth performance:

It was obvious from data in Table (2) that the daily weight gain and the specific growth rate (SGR, (%/day)) were high (0.93 g/day and 4.75% per day, respectively) in the control group. Fish in group (T_2) fed 50% artificial feed recorded 0.71 g/day as daily weight gain and 4.48 %/day of the specific growth rate. Fish in group (T_3) fed poultry feces only had the lowest values, 0.47g/day and 4.09 % per day of daily weight gain and specific growth rate, respectively. There were significant differences between treatments for these parameters ($P < 0.05$) in the three groups (Table 2).

Table (2). Growth parameters and annual fish production of *O. niloticus* fed experimental diets.

Parameters	100% Artificial Feeding	Artificial Feeding 50% + droppings from chicken	droppings from chicken
	T_1	T_2	T_3
Initial body weight (g)	4.45	4.55	4.45
Final body weight (g)	116.5a	89.3b	60.8c
Daily growth rate (g/day)	0.93a	0.71b	0.47c
Specific growth rate (SGR,(%/day))	4.75a	4.48b	4.09c
Production (kg/m)	2.10a	1.52b	0.77c

a,b,c…. etc: means within the same row with different superscripts are significantly different ($P<0.05$).

It was clear from Figure (4) that fish fed on a complete artificial diet (the control treatment) had better growth in terms of weight gain than those fed on 50% artificial feed or chicken droppings only.

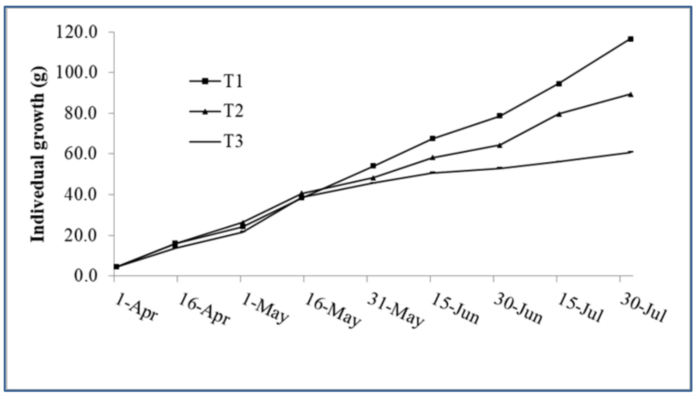

Fig (4): Individual fish growth performance under production without integrated system (T_1), semi-integrated system (T_2) and Fish-chicken integrated system (T_3) during the production period (from 1 April to 30 July, 2020).

5.7. Length-weight relationship and condition factor:

Length-weight relationship of fish in the three different culture systems were estimated to be $W= 0.\ 0244*TL^{2.927}$, $W=0.0337*TL^{2.791}$ and $W=0.0396*TL^{2.7069}$ for groups (T_1, T_2 and T_3, respectively). The average condition coefficient of fish under the single system of production (T_1) was 2.04, while that of fish under semi-integrated system (T_2) and integrated system (T_3) were 2.01 and 1.94 respectively.

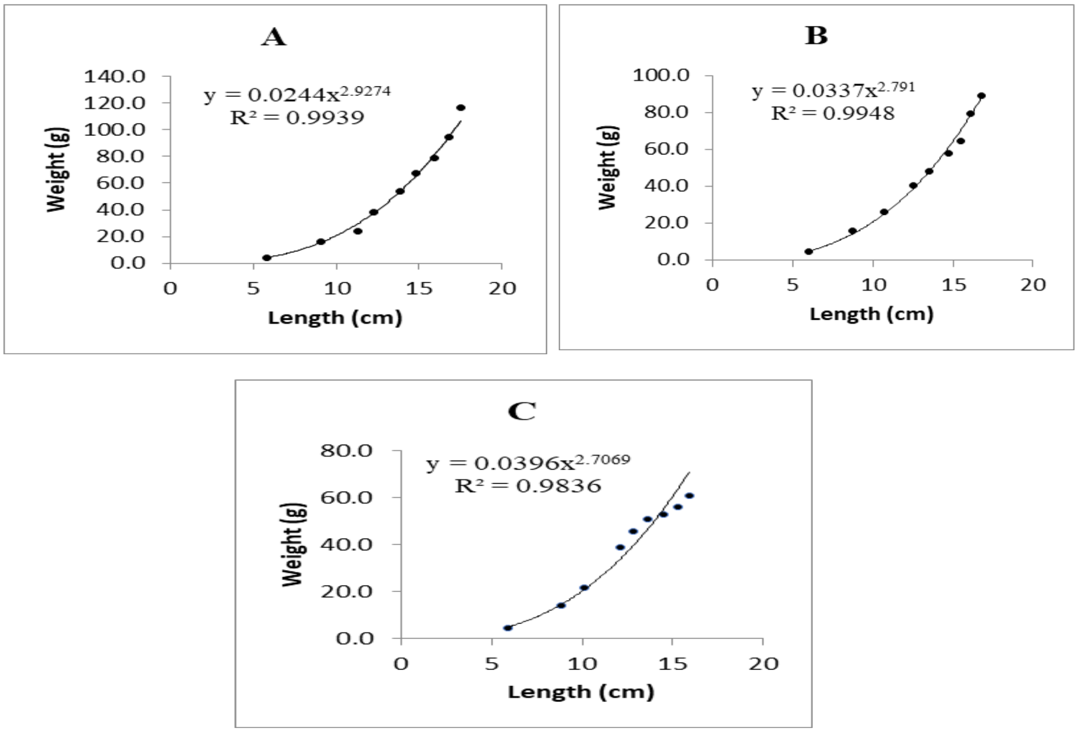

Fig. (5): Length-weight relationship of *O. niloticus* under production without integrated system (A), semi-integrated system (B) and Fish-chicken integrated system (C).

DISCUSSION

The practice of fish farming (Nile tilapia, *Oreochromis niloticus*) in ponds of limited size in small rural areas is an important economic and social alternative for the local population. Water is one of the components of the various production systems for fish farming and may harm the continuity of the product in this activity.

The result of production performance showed that the yield of fish was 1.52 kg/m^3 under semi-integrated system of chicken and fish and with using 50% artificial food (27% crude protein, 1.5% of body weight) for 16 weeks. The survival percentage of the fish under this system was 85%. The current results agree with other studies of Pratt (1975) and Tuleum (1992) who reported that using manure with considerable quantities of nutrients for fish production requires addition of 10-30% protein besides high levels of soluble vitamins. Fang *et al.* (1986) showed that 1 kg of common carp, silver carp and bighead carp can be produced by using 16.7 kg of chicken manure. In the present study 0.77 kg/m of *O. niloticus* can be produced by using 12.2g of chicken manure per day.

In the current experiment there was a reduction in the cost of purchase of artificial food in the semi-integrated and integrated fish systems in contrary to single operating system, this agrees with the result recorded by Ajani *et al*. (2020).

A length-weight relationship (LWR) provides information on growth patterns and growth of animals. During their development, fish are known to pass through stages in their life history which are defined by different length-weight relationships. Fish undergoing positive allometric growth is an indication of the stoutness of the body with increase in length. Growth is said to be positive allometric when the weight of an organism increases more than its length (b>3) and negative allometric when its length increases more than its weight (b<3) (Wootton, 1992). In the present study, there was variability between the exponent 'b' in length weight relationship for the control and other treatments. Results showed that the values of 'b' were less than 3 or nearly isometric (b=3) in control, while in semi-integrated system and integrated system values of 'b' were lower than "3". The present work revealed that *O. niloticus* followed the cube law completely in all the dietary treatments.

Statistical analysis of the length-weight relationship showed that *O. niloticus* fed both 50% artificial feed and chicken droppings only showed negative allometric growth. These values were less than the ideal isometric or positive allometric value of 3, which suggests that there was higher growth in length with respect to weight for all experimental groups. These differences may be due to differences in diet. Value of 'b' seems to be important as a key parameter in estimating population growth through the length-weight relationship (Safran, 1992; Kimmerer *et al.,* 2005).

Asmamaw *et al*. (2019) conducted a study in Koka Reservoir, Ethiopia, and they found the value of regression coefficient 'b' ranged from 2.868 to 3.210, with no fish population exhibiting an isomeric (b=3). In the present study the negative allometric growth of fishes in T_3 indicating that the environment is not suitable for isometric fish growth. This was also indicated from the low average condition coefficient of fish under integrated system (T_3) (1.94) in comparison with that of fish in the single system of production (T_1) (2.04) or that under semi-integrated system (T_2) (2.01). The condition factor indicates the changes in food reserves and therefore can be used as an indicator of the general fish condition (Sutton *et al.,* 2000). Generally, the K values of *O. niloticus* in all the dietary treatments in the present study were greater than 1 which suggests good fish health condition and indicates in fish farming. This suggests that all the fish diets used in this study will be suitable for commercial production of *O. niloticus*.

The coefficient of determination R^2 values varied between 0.99 (control treatment) and 0.98 (other treatments). This high value of coefficient of determination means a good quality of the prediction of power regression constants for this species, and suggested that, culture of *O. niloticus* can be done in ponds integrated with broiler production in desert area. Macartan (2012) indicated that integration of broiler and fish production is proposed, where broiler litter from broiler production has value as nutrient input to fish, and the water in the ponds in turn causes evaporative cooling of the broilers.

The values of final body weight (FBW), specific growth rate (SGR), daily growth rate (DGR) were relatively higher in the control tank than in the experimental ones due to the presence of high protein content in fish food provided to fish in control group. In fish nutrition, most attention is given to protein products, due to the importance of protein as a major constituent of assists in the synthesis of body tissue, for that renovation and growth of the body.

Conclusion

It is concluded that Nile tilapia *Oreochromis niloticus* examined were in good growth and healthy when feed on 50% artificial feed and chicken droppings. Hence, the cultured *O. niloticus* using integrated system were in good condition and healthy, and will be suitable for the desert production of this species.

The total cost of fish production was highest for fish produced without integrated systems followed by the semi-integrated system with chicken manure, and lowest for integrated systems.

Therefore, it became clear that integrating two systems actually reduces the costs of artificial fed and led to a significant increase in the net income.

Recommendation:

In desert area, it is recommended to apply the integrated aquaculture system so that one can produce poultry and fish and can use the water of the pond to irrigate crops.

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دراسات بيولوجية للاستزراع التكاملي بين (الأسماك والدجاج) في البيئة الصحراوية ، شمال سيناء ، مصر

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المستخلص

تم إجراء تجربة في نظام تربية الدواجن والأسماك المتكاملة خلال عام ٢٠٢٠. تم اختيار أسماك البلطي النيلي لأنها من أهم أسماك المياه العذبة فى مصر ويتم استزراعها على نطاق واسع في العديد من دول العالم. تم استخدام ثلاث معالجات: علف صناعي ٢٧٪ بروتين خام ((T1) (معاملة التحكم) ، ٥٠٪ علف صناعي (T2) وفضلات الدجاج فقط (T3). كان معدل بقاء الأسماك تحت هذا النظام ٩٠.٠٪ و ٨٥.٠٪ و ٧٥.٠٪ في المعاملات T1 و T2 و T3 على التوالي. بينما بلغ متوسط وزن الأسماك الفردية في هذا النظام ١١٦.٥ ± ٤.٥ جم و ٧٧.٥ ± ٦.٣ جم و ٦٠.٨ ± ٥.١ جم في المعاملات T1 و T2 و T3على التوالي. كانت نتيجة إنتاج الأسماك لكل متر مكعب عالية ، حيث وصلت إلى ٢.١ كجم / م ٣ للمعاملة الاولي. ١.٥ كجم / م ٣ للمعاملة الثانية (T2) و ٠.٧٧ كجم / م ٣ للمعاملة الثالثة (T3). كان للأسماك التي تتغذى على نظام غذائي صناعي كامل (معاملة التحكم) نموًا أفضل من حيث زيادة الوزن من تلك التي تتغذى على ٥٠ ٪ من العلف الصناعي وتلك التي كانت تتغذى على فضلات الدجاج فقط. تم تقدير علاقة الطول والوزن فيما يتعلق بالتغذية بأنظمة الاستزراع المختلفة لتكون $W = 0.0244 * TL^{2.927}$ ، $W = 0.0337 * TL^{2.791}$ ، $W = 0.0396 * TL^{2.7069}$ على التوالي. كان متوسط معامل الحالة للأسماك في نظام الإنتاج الواحد ٢.٠٤. بلغ متوسط معامل الحالة للأسماك في ظل النظام شبه المتكامل والنظام المتكامل ٢.٠١ و ١.٩٤ على التوالي.