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AN ASSESSMENT STUDY OF TILAPIA POLYCULTURE IN FLOATING NET CAGES

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ABSTRACT

The present study was carried out from 15th May 2005 to 15th September 2005, in order to evaluate the polyculture of three tilapia species namely, *Oreochromis niloticus, Sarotherodon galilaeus* and *Tilapia zillii* in cages. This study was carried out at three sites in the project of fish cage culture of young farmers in El-Manzala Lake, El-Dakahlia Governorate, Egypt, under different three management conditions of tilapia polyculture as following: the 1st management site depending on the natural feeds only under low stocking density conditions (34.7 fish/ m^3, approximately) and initial weight of 36.7g; the 2nd management site depending on the natural feeds and the supplementary feeding (19.9% crude protein) under high stocking density conditions (49.2 fish /m^3) and initial weight of 25.9g and the 3rd management experimental site depending on a commercial fish pelleted diet (26.7% crude protein) and initial weight of 26.6g under high stocking density conditions (42.8 fish/ m^3). The tested parameters included the water quality, growth performance, carcass composition of fish, feed and nutrients utilization and the economic efficiency.

The obtained results showed that:

1- Water quality criteria were suitable for fish rearing such as water temperature ranged between 21 and 33°C, pH values 7.2 – 8.3 and dissolved oxygen 6.7 – 8.4 mg/l. other water biochemical parameters (ppm) of the three experimental cage's sites are also suitable for fish rearing except salinity, total hardness and bicarbonates were slightly differences.
2- Fish growth performance in 3rd cage's site one is better than other cage's sites (1st and 2nd).
3- There were superiority of *O. niloticus* in growth performance and carcass composition comparing with other tilapia species (*S. galilaeus* and *T. zillii*).
4- The 3rd cage's site was better than 2nd cage's site not only fish growth, but also in all feed and nutrients utilization parameters. There by the 3rd cage's site realized the best economic efficiency and relative economic efficiency comparing with other cage's sites, while the 2nd management site came second.

So, it could be concluded that it must be using the commercial complete diets for feeding fish especially under intensive fish culture such as cages in 3rd management site for higher fish production with economically efficiency. Yet, the obtained results in the present management study confirmed the superiority of Nile tilapia *(O. niloticus*) comparing with other tilapia species (*S. galilaeus* and *T. zillii*), in growth performance parameters and carcass composition in all experimental cage's sites and management. Also, from environmentally point of view, it could be concluded that the overcoming of different sources of water pollution in Lake El-Manzala are very important to get high quality and safety fish production

Keywords: Fish polyculture –*Tilapia* spp. - Cages - Water quality - Growth - Economic efficiency

INTRODUCTION

Cage aquaculture has grown rapidly during the past decades and is presently undergoing swift changes in response to pressures from globalization and an escalating worldwide global demand for aquatic products. There has been a move toward clustering existing cages as well as toward the development and use of more intensive cage farming systems. In particular, the need for suitable sites has resulted in cage aquaculture accessing and expanding into new untapped open-water culture areas such as lakes, reservoirs, rivers and coastal brackish and marine offshore waters (FAO, 2007).

In Egypt, Nile tilapia *Oreochromis niloticus*, *Sarotherodon galilaeus*, *O. aureaus* and *Tilapia zillii* are wide spreading in the Nile and its branches and most of the lakes of these species (Abo El-Wafa, 1996). In Egypt, most of the aquaculture production of tilapia is derived from semi-intensive fish farms in earthen ponds, intensive systems, integrated intensive fish farms and cages (GAFRD, 2006). Since, Egypt produces 12% of the world farmed tilapia (2121009 Mt) (FAO, 2007). Also, Egypt for tilapia production now takes the 2nd position after China in the world production and the 1st in Africa and Middle East. Local fish production is more than one million ton, from which the fish culture is about 63% (630 thousand tons) year 2007. About 43% of the culture production is tilapia (504 thousand tons) (GAFRD, 2008).

Tilapia cage culture has been practiced experimentally and commercially since the early 1970s (Bardach *et al*., 1972). Currently, commercial tilapia culture in cages is expanding at a very fast rate, especially in tropical and subtropical developing countries in Asia, Africa and Latin America (Lin and Kaewpaitoon, 2000; Guerrero, 2001 and Watanabe *et al*., 2002). The success of tilapia cage culture depends on a number of factors, including water quality, water level, tilapia species or strains, stocking density, stocking size, cage size and shape, feed quality and feeding frequency (El-Sayed, 2006; Essa *et al*., 2006; Nour *et al*., 2006 and Omar *et al*., 2006). Floating cages only produced 6.18% of the total Egyptian fish production since improving and outspreading of aquaculture among private sector led to developing and intensification the fish culture resulting in increased fish supply and reduced its price (Aldwaney, 2002; Ghanem, 2002 and Radwan, 2002 and GAFRD, 2008).

So, the present study was carried out to evaluate the polyculture system for three tilapia species namely, *Oreochromis niloticus, Sarotherodon galilaeus* and *Tilapia zillii* in floating net cages, at three management sites in the project of fish cages culture of young farmers in El-Manzala Lake, El-Dakahlia Governorate, Egypt. The tested parameters included the water quality, growth performance fish management, carcass composition, feed and nutrients utilization and the economic efficiency due to the cage culture system at the three experimental sites, for 123 days as an experimental period.

MATERIALS AND METHODS

The present study was carried out at three sites in the project of fish cages culture of young farmers in El-Manzala Lake, El-Dakahlia Governorate, Egypt from 15th May 2005 to 15th September 2005. The distance between these sites and other among 1000 m approximately.

1- Place of study and its experimental scientific management:

1.1- The 1st management experimental site:

Figure 1a shows the 1st site of the experimental fish cages culture in El-Manzala Lake. The size of each cage in this site, 11m length X 10m Width X 2.5m depth . Cages were stocked with the three species from tilapia fish (*O. niloticus, S. galilaeus* and *T. zillii*), at a density 34.69 fish /m^3 (9541 fish/cage), with an average initial weight of 36.68 ± 0.5 g (or approximately, total fish biomass 350 kg/cage,). The feeding system in this site depending on the natural feeds only during the all experimental period.

1.2- The 2nd management experimental site:

The site of 2nd experimental fish cages culture was occurred at 1000 m far from the 1st site in El-Manzala Lake (Figure 1b). Cages were used for rearing fish in this experiment has the same size in the 1st site (11m X 10m X 2.5m). Cages were stocked with the same three tilapia species at a rate of 49.17 fish /m^3 (13523 fish/cage), with an average initial weight of 25.88 ± 0.5 g (approximately total fish biomass 350 kg/cage,).The feeding system in this site depending on the supplementary feeding with diet contains the mixture of shrimp and milled wheat in wet form. Chemical analysis of the experimental diet was showed in Table (1). Diet was presented to the fish once time a day at 9.00 am at a rate of 2.5% of total biomass.

Table (1): Chemical analysis (% on dry matter basis) of the experimental diet in the 2nd management site.

Nutrient Composition	%
Dry matter (DM%)	78.33
Crude protein (CP)	19.93
Ether extract (EE)	13.37
Ash	45.77
Total carbohydrates	20.93
*Gross energy (Kcal/100 g DM) (GE)	324.64
**Protein/energy (P/E) ratio (mg CP/Kcal GE)	61.39

***GE (Kcal/100 g DM) = CP x 5.64 + EE x 9.44 + Carbohydrates x 4.11 calculated according to (Macdonald *et al.,* 1973), **P/E ratio (mg protein/Kcal gross energy) = CP/GE x 1000.**

1.3- The 3rd management experimental site:

In this site fish cage culture was occurred at 1000 m far from the 2nd site in El-Manzala Lake (Figure 1c). Yet, cages were used for rearing fish in this experimental site has the same size of cages in both of the 1st and 2nd sites (11m X 10m X 2.5m). Cages were stocked with the same three tilapia species at a rate of 47.82 fish /m^3 (13151 fish/cage), with an average initial weight of 26.60 ± 0.5 g (approximately total fish biomass 350 kg/cage,). The feeding system in this management site depending on a commercial fish pelleted diet (25% crude protein), purchased from El-Morshedy Brothers Co., Meet Gammer, El-Dakahlia governorate, Egypt). Fish fed, at a feeding rate of 2.4% from the total biomass. The composition and chemical analysis of the experimental diet were showed in Table (2). Diet was presented to the experimental fish twice daily at 9.00 am and 14.00 pm.

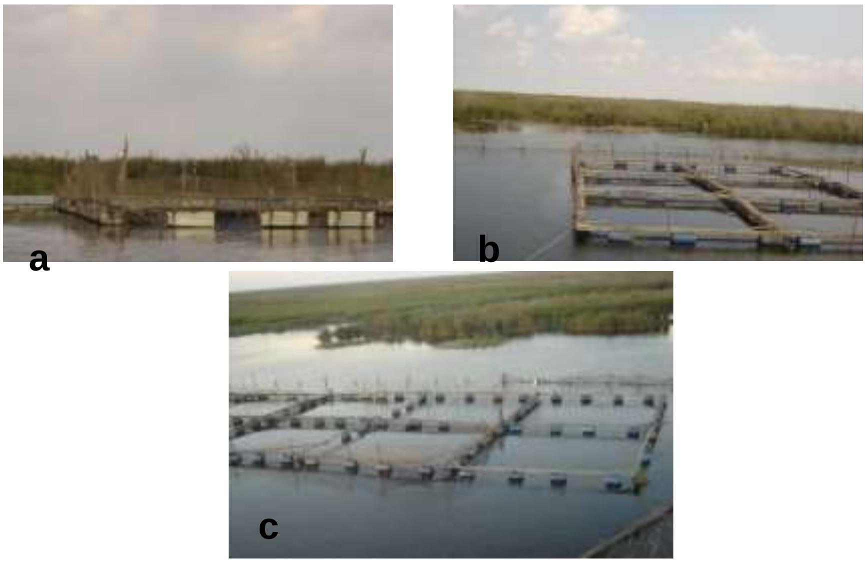

Fig. (1): Fish cages in the (a) 1st, (b) 2nd and (c) 3rd experimental sites in El-Manzala Lake.

2- Methods:

2.1- Chemical analysis of the experimental diet and fish carcass:

At the end of the experiment, the fish was sampled from each cage and kept frozen until chemical analysis. The chemical analysis of the experimental diets and the whole body fish (at the start and the end of the experimental period), was carried out according to the AOAC (2000).

2.2- Water quality parameters:

Some of water quality parameters were measured in all experimental management sites of cages at the start and the end of the experiment as following; water salinity, total hardness , bicarbonates, chlorides and sulfates were determined according to (Chapman and Pratt, 1982). However, total nitrogen content was determined by Kjeldahl method described by Black (1965). Total NH_3 and soluble No_3 were determined using the Devarda method according to Kemmer (1987). Minerals elements included macro elements such as sodium and potassium were determined photometrically using Perkin Elmer flame photometer (Jackson, 1958), meanwhile, calcium and magnesium were analysed by absorption spectrophotometry. Yet, micro elements such as zinc, iron, manganese and cupper were analysed by absorption spectrophotometry (West and Nurnberg, 1988). On the other side, water temperature, dissolved oxygen and pH values were measured monthly in the three cages sites. Whereas, water temperature in degree centigrade was recorded by using a thermometer, dissolved oxygen concentration was determined by using an oxygen meter model (D-5509) and pH values of water was measured by using an electric digital pH meter (using Jenway Ltd, model 350-pH meter).

Table (2): The composition and chemical analysis of the experimental diet in the 3rd management site

Ingredient	g
Fish meal	80
Soybean meal	300
Yellow corn	250
Rice bran	250
Wheat bran	100
Molasses	20
Total	1000
Dry matter (DM %)	87.40
Nutrient composition (% on dry matter basis)	
Crude protein (CP)	26.77
Ether extracts (EE)	15.63
Ash	28.17
Total carbohydrates	29.43
Gross energy (GE) (Kcal/100 g DM)	419.51
Protein/energy (P/E) ratio (mg CP/Kcal GE)	63.81

2.3- Growth performance and feed utilization measurements:

Body weight of individual fish of sample from each species were measured biweekly to point feed quantity and to calculate growth performance and feed utilization were calculated according to Abdelhamid (2003).

2.4- Economic efficiency:

At the end of the present study economic efficiency parameters (total outputs, total costs, net return and economic efficiency) of each experimental site were calculated as following equations:

1- Total feed costs per treatment (LE/Kg diet) = feed costs per one kg diet X feed intake

2- Total outputs per treatment (LE/Kg) = fish price X total fish production*

* Total fish production per treatment = final number of fish X fish weight gain

3- Net return per treatment (LE) = total outputs – total feed costs

4- Economic efficiency per treatment (%) = (net return/ total feed costs) X 100.

The price of 1 kg ingredient used according to locally marketing were 7.00 LE for fish meal, 2.50 LE for soybean meal, 1.50 LE for yellow corn, 1.50 LE for wheat bran, 1.25 LE for rice bran and 1.50 LE for molasses according to local market price at the time of study in Egypt (2005).

2.5- Statistical analysis:

The obtained data were statistically analyzed using SAS (2001) procedures for personal computer. When F-test was positive, least significant difference by Duncan (1955) was calculated for the comparisons among means for all experiments.

RESULTS

1. Water quality:

1.1- Dissolved oxygen, pH- values and Temperature:

Studying the characteristics of water in the experimental cages area is of a prime importance in evaluating and regulating their suitability for fish rearing. The water of cages area was greenish. It was very suitable for fish rearing. As shown in Table (3), all tested water quality criteria were suitable for rearing experimental tilapia species, since water temperature ranged between 21 and 33^{o}C, pH values 7.2 – 8.3 almost on the alkaline side and dissolved oxygen 6.7 – 8.4 mg/l. These values are suitable for fish growth and survival.

Table (3): Water quality parameters in cage's sites at different intervals of the experiment

Date	Dissolved oxygen, mg/l			pH- value			Temperature, °C		
	1st site	2nd site	3rd site	1st site	2nd site	3rd site	1st site	2nd site	3rd site
15/5/2005	7.22	6.92	6.75	7.25	7.66	7.77	32.10	32.40	32.70
15/6/2005	7.25	6.93	6.78	7.30	7.73	7.84	32.80	32.97	33.20
15/7/2005	7.20	6.88	6.72	7.47	7.60	7.45	31.20	31.40	31.50
15/8/2005	7.95	7.22	7.12	7.92	7.79	7.93	26.70	26.80	26.70
15/9/2005	8.40	7.85	7.76	8.30	7.90	7.90	21.10	21.30	21.40

1.2- Water biochemical parameters:

Table (4) shows that water biochemical parameters (ppm) of the three experimental cage's sites at the start and the end of the experiment. The results indicated that water quality were suitable for fish rearing in all fish cage's sites.

Table (4): Water biochemical parameters (ppm) in 1st, 2nd and 3rd cage's sites at the start and the end of the experiment

Item	1st site		2nd site		3rd site	
	At the start	At the end	At the start	At the end	At the start	At the end
Salinity	1894	2688	1888	2432	1600	2496
Total hardness	137.6	145.2	135.1	145.2	160.0	165.0
Bicarbonates	0.483	0.311	0.311	0.355	0.505	0.283
Chlorides	0.751	0.111	0.751	0.914	587.88	0.927
Sulphates	230.0	240.0	259.0	260.0	185.2	176.3
Total- Ammonia (NH_3)	0.04	0.02	0.02	0.01	0.04	0.01
Soluble-Nitrates No_3)	0.84	2.25	0.56	0.98	0.84	0.74
Ca	64.0	64.0	64.0	88.2	72.0	100.0
Mg	85.44	96.13	89.57	103.7	88.9	93.89
Na	86.41	106.22	96.32	115.1	91.03	115.16
K	10.0	13.0	9.0	7.0	28.0	13.44
Fe	0.25	0.05	0.46	0.04	0.45	0.02
Mn	0.06	0.01	0.04	0.02	0.06	0.01
Zn	0.05	0.01	0.02	0.01	0.04	0.01
Cu	0.01	0.01	0.01	0.01	0.02	0.01

2. Growth performance

2.1- 1st cage's site:

Table (5) illustrates that final weight, weight gain and average daily gain of fish in 1st management experimental cage's site increased significantly (P ≤ 0.01), but both of relative growth rate and specific growth rate were decreased significantly (P ≤ 0.01) at different intervals of the experiment. However, results in Table (6) shows that the growth performance parameters among tilapia species in 1st cage's site at the end of the experiment, where *O. niloticus* is the best among other tilapias species, where its final weight increased significantly (P ≤ 0.01) compared with *S. galilaeus* and *T. zillii*, but weight gain and average daily gain increased significantly (P ≤ 0.01) in *O. niloticus* and *S. galilaeus* compared with *T. zillii*. However, relative growth rate and specific growth rate of *S. galilaeus* and *T. zillii* increased significantly (P ≤ 0.01) compared with *O. niloticus*.

Table (5): Growth performance parameters in 1st cage's site at different intervals of the experiment regardless tilapia species (means ± standard errors)

Date	Final weight (g)	Weight gain (g)	Average daily gain (mg/fish/day)	Relative growth rate	Specific growth rate (%/day)
15/5/2005	31.84±0.99^{E}	4.39±0.31^{B}	146.55±10.43^{B}	16.49±1.67^{A}	0.506±0.05^{A}
15/6/2005	35.05±1.02^{D}	3.20±0.14^{C}	106.88±4.67^{C}	10.13±0.47^{B}	0.321±0.01^{B}
15/7/2005	39.017±1.17^{C}	3.97±0.22^{CB}	132.33±7.46^{CB}	11.315±0.47^{B}	0.356±0.01^{B}
15/8/2005	45.17±0.84^{B}	6.16±0.36^{A}	205.23±12.14^{A}	16.12±.29^{A}	0.498±.04^{A}
15/9/2005	49.16±0.76^{A}	3.99±0.25^{CB}	132.89±8.43^{CB}	8.89±0.68^{B}	0.283±0.02^{B}

Means in the same column having different capital letters differ significantly (P ≤ 0.01).

Table (6): Growth performance parameters among tilapia species in 1st cage's site at the end of the experiment (means ± standard errors)

Species	Final weight (g)	Weight gain (g)	Average daily gain (mg/fish/day)	Relative growth rate	Specific growth rate (%/day)
O. niloticus	67.22±0.54^{A}	24.89±0.80^{A}	165.92±5.36^{A}	59.46±3.26^{B}	0.309±0.013^{B}
S. galilaeus	47.05±1.31^{B}	23.77±0.472^{A}	158.48±3.17^{A}	106.84±9.067^{A}	0.479±0.03^{A}
T. zillii	33.21±0.58^{C}	16.49±0.37^{B}	109.92±2.45^{B}	102.22±7.80^{A}	0.466±0.02^{A}

Means in the same column having different capital letters differ significantly (P ≤ 0.01).

2.2- 2nd cage's site:

Final weight, weight gain and average daily gain of all tilapia species rearing in 2nd cage's site increased significantly (P ≤ 0.01). Meanwhile, relative growth rate and specific growth rate decreased significantly (P ≤ 0.01) at different intervals of the experiment (Table 7). However, results in Table (8) indicated that *O. niloticus* is the best among other tilapia species, where its final weight increased significantly (P ≤ 0.01) compared with *S. galilaeus* and *T. zillii*, but weight gain and average daily gain increased significantly (P ≤ 0.01) in *O. niloticus* and *S. galilaeus* compared with *T. zillii*.

However, relative growth rate and specific growth rate of *S. galilaeus* and *T. zillii* increased significantly (P ≤ 0.01) compared with *O. niloticus* in 2nd cage's site at the end of the experiment.

Table (7): Growth performance parameters in 2nd cage's site at different intervals of the experiment regardless tilapia species (means ± standard errors)

Date	Final weight (g)	Weight gain (g)	Average daily gain (mg/fish/day)	Relative growth rate	Specific growth rate (%/day)
15/5/2005	34.04±0.64^{E}	8.06±0.24^{B}	268.72±8.15^{B}	31.32±1.47^{A}	0.908±0.04^{A}
15/6/2005	42.07±0.65^{D}	8.02±0.08^{B}	267.49±2.64^{B}	23.65±0.53^{B}	0.708±0.01^{B}
15/7/2005	50.35±0.57^{C}	8.29±0.15^{B}	276.22±5.04^{B}	19.77±0.59^{C}	0.601±0.02^{C}
15/8/2005	55.69±0.44^{B}	5.34±0.17^{C}	178±5.77^{C}	10.65±0.46^{D}	0.336±0.01^{D}
15/9/2005	66.41±0.65^{A}	10.72±0.32^{A}	357.33±0.83^{A}	19.24±0.54^{C}	0.588±0.02^{C}

Means in the same column having different capital letters differ significantly (P ≤ 0.01).

Table (8): Growth performance parameters among tilapia species in 2nd cage's site at the end of the experiment (means ± standard errors)

Species	Final weight (g)	Weight gain (g)	Average daily gain (mg/fish/day)	Relative growth rate	Specific growth rate (%/day)
O. niloticus	94.35±1.37^{A}	50.23±1.19^{A}	334.87±7.978^{A}	113.8±2.45^{C}	0.51±0.01^{C}
S. galilaeus	56.55±0.36^{B}	35.27±0.51^{B}	235.13±3.37^{B}	168.99±9.08^{B}	0.66±0.02^{B}
T. zillii	48.34±0.57^{C}	35.8±0.75^{B}	238.67±4.98^{B}	306.33±29.68^{A}	0.92±0.05^{A}

Means in the same column having different capital letters differ significantly (P ≤ 0.01).

2.3- 3rd cage's site:

Results in Table (9) shows that growth parameters such as final weight, weight gain and average daily gain in 3rd cage's site, it were increased significantly (P ≤ 0.01). Meanwhile, relative growth rate and specific growth rate decreased significantly (P ≤ 0.01) at different intervals of the experiment. Yet, *O. niloticus* in 3rd cage's site realized the best final weight, weight gain and average daily gain among other tilapias species, where increased significantly (P ≤ 0.01) compared with *S. galilaeus* and *T. zillii*, However, relative growth rate and specific growth rate of *S. galilaeus* increased significantly (P ≤ 0.01) compared with *T. zillii* and *O. niloticus* at the end of the experiment (Table 10). From other side, Table (11) indicated that 3rd cage's site realized the best growth performance parameters among other sites 1st and 2nd, which increased significantly (P ≤ 0.01) compared with other sites.

Table (9): Growth performance parameters in 3rd cage's site at different intervals of the experiment regardless tilapia species (means ± standard errors)

Date	Final weight (g)	Weight gain (g)	Average daily gain (mg/fish/day)	Relative growth rate	Specific growth rate (%/day)
15/5/2005	41.13±0.88^E	14.53±0.19^C	484.46±6.23^C	55.16±1.91^A	1.46±0.04^A
15/6/2005	56.62±0.85^D	15.49±0.16^B	516.21±5.44^B	37.82±1.00^B	1.07±0.02^B
15/7/2005	69.88±0.48^C	13.26±0.38^D	442.1±12.65^D	23.56±1.03^C	0.71±0.03^C
15/8/2005	83.01±0.39^B	13.13±0.11^D	437.67±3.59^D	18.80±0.27^D	0.57±0.01^D
15/9/2005	102.37±0.21^A	19.35±0.26^A	645.1±8.87^A	23.33±0.42^C	0.69±0.01^C

Means in the same column having different capital letters differ significantly (P ≤ 0.01).

Table (10): Growth performance parameters among tilapia species in 3rd cage's site at the end of the experiment (means ± standard errors)

Species	Final weight (g)	Weight gain (g)	Average daily gain (mg/fish/day)	Relative growth rate	Specific growth rate (%/day)
O .niloticus	158.41±0.53^A	116.78±0.46^A	778.54±3.07^A	281.23±5.04^B	0.89±0.01^B
S. galilaeus	77.22±0.17^B	64.53±0.72^B	430.2±4.84^B	536.07±45.84^A	1.22±0.05^A
T. zillii	71.47±0.12^C	45.99±1.13^C	306.61±7.55^C	185.26±12.30^C	0.69±0.03^C

Means in the same column having different capital letters differ significantly (P ≤ 0.01).

Table (11): Growth performance parameters in 1st, 2nd and 3rd cage's sites at the end of the experiment regardless tilapia species (means ± standard errors)

Cage's site	Final weight (g)	Weight gain (g)	Average daily gain (mg/fish/day)	Relative growth rate	Specific growth rate (%/day)
1	49.16±0.76^C	21.72±0.48^C	144.79±3.21^C	80.89±5.09^C	0.393±0.01^C
2	66.41±0.65^B	40.43±0.28^B	269.56±1.89^B	156.74±4.64^B	0.628±0.01^B
3	102.37±0.21^A	75.76±0.71^A	505.11±4.77^A	288.35±11.98^A	0.900±0.02^A

Means in the same column having different capital letters differ significantly (P ≤ 0.01).

3. Carcass composition:

3.1- 1st cage's site:

Table (12) shows that carcass composition of tilapia species in 1st cage's site, where dry matter, crude protein, ether extract and energy content were significantly differ at (P ≤ 0.01) but there were no significant between *S. galilaeus* and *T. zillii*, while ash increased significantly in *O. niloticus* among other tilapia species.

Table (12): Carcass composition of tilapia species in 1st cage's site at the end of the experiment (means ± standard errors)

Species	Dry matter (%)	(% on dry matter basis)			Energy content (Kcal/100g)
		Crude Protein	Ether extract	Ash	
O. niloticus	24.73±0.09^{C}	47.47±0.17^{B}	25.5±0.2^{B}	27.03±0.37^{A}	508.43±2.83^{B}
S. galilaeus	25.13±0.03^{B}	50.9±0.8^{A}	26.8±0.3^{A}	22.3±1.1^{B}	540.07±7.33^{A}
T. zillii	25.87±0.12^{A}	49.53±0.37^{A}	26.17±0.13b^{A}	24.3±0.5^{B}	526.37±3.33^{A}

Means in the same column having different capital letters differ significantly (P ≤ 0.01).

3.2- 2nd cage's site:

Results in Table (13) notes that crude protein and energy content increased significantly (P ≤ 0.01) in *O. niloticus*, but ash decreased significantly (P ≤ 0.01) compared with other tilapia species in 2nd cage's site. However, no significant differences in ether extract content among all tilapia species, but dry matter in *O. niloticus* and *T. zillii* increased significantly (P ≤ 0.01) compared with *S. galilaeus*.

Table (13): Carcass composition of tilapia species in 2nd cage's site at the end of the experiment (means ± standard errors)

Species	Dry matter (%)	(% on dry matter basis)			Energy content (Kcal/100g)
		Crude protein	Ether extract	Ash	
O. niloticus	25.13±0.03^{A}	51.47±0.38^{A}	25.93±0.27	22.60±0.39^{C}	535.067±2.67^{A}
S. galilaeus	23.80±0.15^{B}	50.13±0.28^{B}	25.70±0.12	24.17±0.39^{B}	525.33±2.63^{B}
T. zillii	25.13±0.03^{A}	49.43±0.27^{B}	25.17±0.03	25.40±0.26^{A}	516.4±1.48^{C}

Means in the same column having different capital letters differ significantly (P ≤ 0.01).

3.3- 3rd cage's site:

Data in Table (14) shows that crude protein and energy content increased significantly (P ≤ 0.01) in *O. niloticus*, but ash decreased significantly (P ≤ 0.01) among other tilapia species in 3rd cage's site. Meanwhile, dry matter decreased significantly (P ≤ 0.01), but ether extract increased significantly (P ≤ 0.01) in *O. niloticus* and *S. galilaeus* compared with *T. zillii*.

Table (14): Carcass composition of tilapia species in 3rd cage's site at the end of the experiment (means ± standard errors)

Species	Dry matter (%)	(% on dry matter basis)			Energy content (Kcal/100g)
		Crude Protein	Ether extract	Ash	
O. niloticus	25.43±0.34^{B}	53.17±0.35^{A}	27.53±0.18^{A}	19.30±0.49^{C}	559.77±3.37^{A}
S. galilaeus	24.97±0.09^{B}	51.37±0.38^{B}	27.17±0.07^{A}	21.47±0.43^{B}	546.17±2.59^{B}
T. zillii	27.90±0.12^{A}	49.13±0.28^{C}	25.17±0.03^{B}	25.7±0.25^{A}	514.70±1.31^{C}

Means in the same column having different capital letters differ significantly (P ≤ 0.01).

4- Feed and nutrients utilization:

Feed intake, protein efficiency ratio, protein productive value and energy utilization were increased significantly (P ≤ 0.01), also feed conversion ratio improved significantly in 3rd cage's site compared with 2nd cage's site (Figure 2).

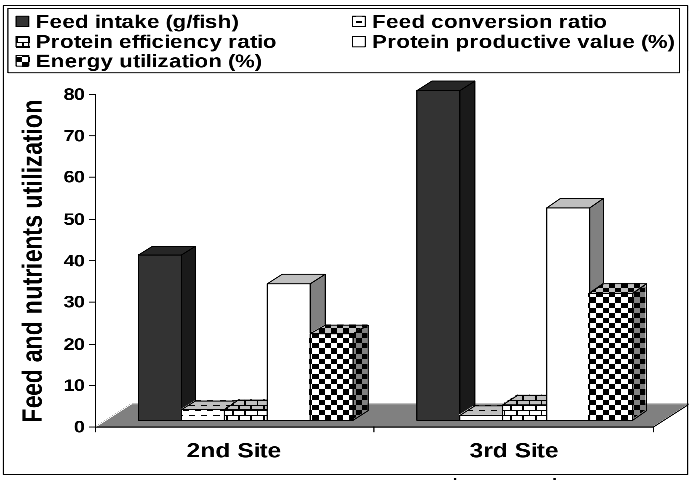

Fig. (2): Feed and nutrients utilization of 2nd and 3rd cage's sites at the end of the experiment

5- Economic efficiency:

Economic efficiency of the scientific management at the 1st, 2nd and 3rd cage's sites shows in Figure (3) where, 3rd cage's site realized the best economic efficiency and relative economic efficiency comparing with other cage's sites followed by 2nd and 1st cage's sites, respectively.

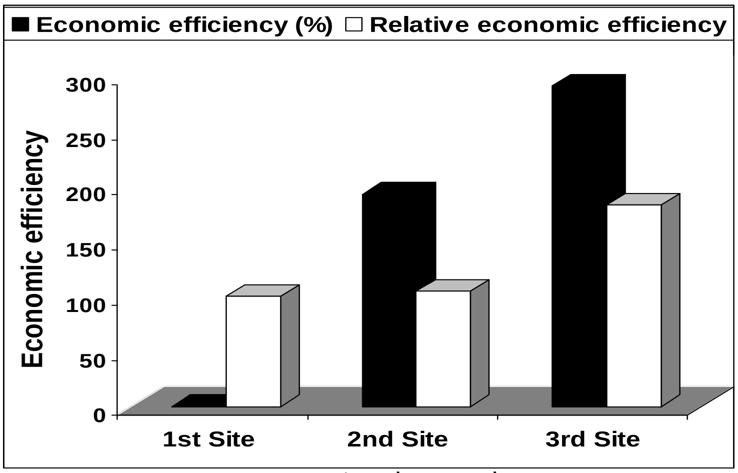

Fig. (3): Economic efficiency of 1st, 2nd and 3rd cage's sites at the end of the experiment.

DISCUSSION

Studying the characteristics of water in the experimental cages area is of a prime importance in evaluating and regulating their suitability for fish rearing. In the present study all tested water quality criteria were suitable for rearing experimental tilapia species (Table 3), since water temperature ranged between 21 and 33^{o}C, pH values 7.2 – 8.3 and dissolved oxygen 6.7 – 8.4 mg/l. In this respect, Abdelhamid *et al.* (2007) tested water quality criteria and reported similar values which were suitable for rearing tilapia fish. Thus, Abd El-Hakeim *et al*. (2002) cited the suitable values of water quality parameters for pisciculture as > 5 mg / L DO, and pH 6.7 – 8.6. Also, Abdelhamid (2003) cited the water quality criteria which are suitable for aquaculture in fresh water as pH 6.5 – 9.0 and DO > 5 mg / L. From other side, Water biochemical parameters (ppm) of the three experimental cage's sites indicated that water parameters are approximately suitable conditions for fish rearing in all fish cage's sites. These water parameters reversed that water sources of El-Manzala Lake are marine water (Mediterranean Sea) and fresh water drainages. Both sources are increasingly contaminated, where sea water contains about 3.5% total soluble solids, mostly (99%) as chlorides and sulphates of sodium, potassium, calcium and magnesium (Abel, 1989). In this manner, Higgins *et al.* (2001) reported that El-Manzala Lake exposed to high levels of pollutants from industrial, domestic, and agricultural sources, where five major drains carry irrigation return flows to the lake. The Bahr El-Baqar Drain drains approximately 270,000 hectares, including Cairo. The average flow is approximately three million cubic meters per day, carrying large amounts of particulate matter, nutrients, bacteria, heavy metals, and toxic organics. So, the condition of the lake is clearly deteriorating and concern is widespread.

Results of growth performance parameters of fish in 1st and 2nd cage's sites at different intervals of the experiment (Tables 5 and 7) have some disturbance, which may be related to the water pollution (Table 4), random management, less awareness with fish cage culture system from the young farmers during the time of the experiment and feeding system in these sites, which depended only in natural food or random feed ingredients. In this respect, Landau (1992) reported that nutrition is the most important factor for the culture process; it is often represent the major operating cost of aquaculture. So, under intensive culture system, fish totally depend on complete balanced diets during their life stages. Fish can not grow well without feeds and they should not be underfed. Yet, supplemental feeds providing additional quantities of nutrients are needed when the productivity of a water body cannot provide sufficient nutrients to achieve the desired fish growth. However, to improve and expand fish production for aquaculture, growers require faster-growing fish strains, optimum culture environment, high quality feeds, and more efficient feeding protocols. Therefore, to save time and money, there is a need to develop these methods for rapid and direct assessment of growth over relatively short periods of exposure to experimental conditions (Brown *et al*., 2000). On the other hand, results of growth performance parameters of fish in 3rd cage's site realized the best growth performance parameters among other sites 1st and 2nd, which increased significantly ($P \leq 0.01$) compared with other sites (Table 11). From this point of view, it could be noted that improving the growth performance parameters in the 3rd management site, which may be related to the enhancement of management conditions of fish culture and good feeding system, fed fish on commercial diet (26.7% crude protein) comparing with the fish management in other sites (1st and 2nd). Although, there were water pollutants in El-Manzala Lake affected on water quality parameters (Table 4) and fish growth performance and production. In this manner, Yones (2005) found that caged Nile tilapia fed on natural feeds showed the least growth performance parameters (final body weight, daily weight gain and specific growth rate) compared with those fed to apparent satiation (equivalent 2.76% of fish body weight/day) recorded the highest values in all above growth performance parameters. These values are in agreement with the results reported by Eid and El-Gamal (1996) on tilapia reared in cages.

Generally, growth performance parameters in the present study, decreased in the fish fed on natural feeds only (T_1, 1st cage's site) or supplementary feeds ingredients (T_2, 2nd cage's site) compared with T_3 (3rd cage's site). Although its (T_1) received the lowest stocking density (34.69 fish/m^3) and highest initial weight (36.68 ± 0.5 g) compared with other cage's sites, which received the highest stocking density 49.17 fish /m^3 and 47.82 fish /m^3 and lowest initial weight 25.88 ± 0.5 g and 26.60 ± 0.5 g, respectively. This finding may be due to insufficiently available natural food in the water column. Also, in cages, where the stocking densities high, it is difficult to control the production of natural feeds (Azim *et al*., 2001). From the other hand, the less performance in T_2 (2nd cage's site) compared with T_3 (3rd cage's site) may be due to in fish T_3 received the pelleted balanced diet contains 26.7% crude protein compared with supplementary diet used in T_2, which contains only 19.9% crude protein. These results are in agreement with those reported by (Abdelhamid *et al*., 2001 and El-Sayed, 2002). From other side, growth performance parameters among tilapia species in all cage's sites at the end of the experiment indicated that *O. niloticus* is the best ($P \leq 0.01$) (Tables 6, 8 and 10).These superiority of *O. niloticus* among other tilapia spp. may be due to genetically factor and its feeding habits, where Nile tilapia has been a periphyton grazer (Beveridge and Baird, 2000). Periphyton is mainly composed of diatoms, an important component of wild Nile tilapia diet (Getachew, 1993), and also due to *O. niloticus* has the best feed utilization parameters as reported in the present study.

In the present study, carcass composition of three tilapia species in all experimental cage's sites indicated that *O. niloticus* is better than other tilapia species. This superiority of *O. niloticus* may be related with the species and/or it's realized the best growth performance parameters among other tilapia species in all experimental cages' sites (Tables 6, 8 and 10). In addition, high production of *O. niloticus* juvenile in cages could be attributed to high crude protein content of the feed, the favorable physicochemical conditions of the reservoir and the design of the cage whereby it was internally lined allowed for the maximum utilization of the feed (Osofero *et al*., 2009).

The present results indicated also that 3rd cage's site was better than 2nd cage's site in all feed and nutrients utilization parameters. This result may be related to the good management and feeding system, which depend mainly on pelleted diet and better growth performance (Table 11) in 3rd cage's site comparing with cage's sites. In addition, El-Sayed (2006) reported that tilapia nutrition under intensive and super intensive farming systems which, it deals with the requirements of farmed tilapia for the five classes of dietary nutrients, namely proteins, lipids, carbohydrates, vitamins and minerals. Consideration is also given to feeding regimes (feeding levels and frequency) and diet form. Also, Siddiqui and Al-Harbi (1999) found that feed consumption rate was highest at the lowest stocking density (1 kg $/m^3$) and decreased significantly (P < 0.05) with increasing density (5, 10 and 15 kg $/m^3$), indicating that feed intake was influenced by stocking rate. However, FCRs were not significantly different within this range of stocking density.

Economic efficiency of 1st, 2nd and 3rd cage's sites indicated that 3rd cage's site realized the best economic efficiency and relative economic efficiency comparing with other cage's management sites followed by 2nd cage's site. This result was not surprised because its associated with better fish culture management, feeding system, growth performance (Table 11) feed and nutrients utilization (Figure 2) of 3rd cage's site comparing with other cage's sites. In this respect, Beveridge (1996) reported that from the economics standpoint of view, the efficiency of the cage culture consists of producing fish of good market value with an acceptable food conversion rate during a given period of time and in a quantity that is economically beneficial. Yet, the same author added that cage culture system was more economically viable and practiced than other aquaculture intensification systems.

From obtained results, it could be concluded that it must be using the balanced pelleted complete diets for feeding fish especially under intensive fish culture such as cages in 3rd management site for higher fish production with economically efficiency. The obtained results in the present study also confirmed the superiority of Nile tilapia *O. niloticus* than other tilapia species (*S. galilaeus* and *T. zillii*), in growth performance parameters and carcass composition in all experimental cage's management sites. Also, from environmentally point of view, it could be concluded that the controlling on different sources of water pollution in Lake El-Manzala are very important to get high quality and safety fish production.

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دراسة تقيميه للاستزراع المتعدد للبلطي في الأقفاص الشبكية العائمة

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أجريت الدراسة الحالية فى الفترة من 15 مايو إلى 15 سبتمبر 2005م ، لتقييم الاستزراع المختلط فى الأقفاص لثلاث من أنواع أسماك البلطى تسمى البلطى النيلى ، البلطى الجاليلي والبلطى الأخضر. هذه الدراسة أجريت فى ثلاث مواقع للأقفاص بمشروع شباب الخريجين في بحيرة المنزلة – محافظة الدقهلية – جمهورية مصر العربية من أجل تقييم ثلاث ظروف للتربية المتعددة للبلطى كالتالى: الموقع الأول: الاعتماد على التغذية الطبيعية فقط تحت ظروف كثافة منخفضة نسبيا(34.7 سمكة/م^3) ووزن ابتدائي قدرة 36.7 جرام ، الموقع الثانى: الاعتماد على التغذية الطبيعية بالإضافة إلى علف تكميلى19.9% بروتين تحت ظروف كثافة عددية عالية(49.2 سمكة/م^3) ووزن ابتدائي للأسماك 25.9جرام والموقع الثالث: الاعتماد على عليقة كاملة ذو محتوى بروتينى26.7% ووزن ابتدائي للأسماك 26.6 جرام تحت ظروف كثافة عددية عالية (47.8 سمكة/م^3). القياسات المختبرة اشتملت على خواص جودة المياه ، كفاءة نمو الأسماك ، التحليل الكيماوي لجسم الأسماك ، الاستفادة من الغذاء والعناصر الغذائية والكفاءة الاقتصادية بين الأقفاص السمكية فى هذه المواقع لمدة 123 يوم كفترة تجريبية.

أوضحت النتائج المتحصل عليها:

1- بعض خواص جودة المياه كانت مناسبة لرعاية الأسماك مثل درجة الحرارة، درجة الحموضة والقلوية والأكسجين الذائب. بينما كانت قياسات الخواص البيوكيميائية للمياه (جزء فى المليون) فى مواقع الأقفاص التجريبية الثلاثة متباينة قليلاً ما عدا الملوحة ، العسر الكلى والبيكربونات والتى كانت مناسبة للأسماك.

2- كانت كفاءة نمو الأسماك فى موقع الأقفاص الثالث أفضل من الموقعيين الأخريين (الأول والثاني).

3- يوجد تفوق لأسماك البلطي النيلي فى كفاءة النمو والتحليل الكيماوى بين نوعى أسماك البلطى الأخريين.

4- كان موقع الأقفاص الثالث أفضل من موقع الأقفاص الثانى فى كفاءة الاستفادة من الغذاء والعناصر الغذائية ، حيث إن ذلك مرتبطاً بجودة إدارة الحوض والنظام الغذائي فى موقع الأقفاص الثالث مقارنة بالموقعيين الأخريين. حقق موقع الأقفاص الثالث أفضلية من حيث الكفاءة الاقتصادية والكفاءة الاقتصادية النسبية مقارنة بالموقعيين الأخريين يليه موقع الأقفاص الثاني.

من النتائج السابقة يمكن التوصية بضرورة استخدام العلائق المتزنة لتغذية الأسماك تحت نظم الاستزراع المكثف كما حدث فى موقع الأقفاص الثالث وذلك للحصول على أعلى إنتاجية بكفاءة اقتصادية. أيضاً النتائج المتحصل عليها فى الدراسة الحالية أكدت تفوق أسماك البلطي النيلي على النوعيين الأخريين من أسماك البلطي (الجاليلي والأخضر) فى كفاءة النمو والتحليل الكيماوي للأسماك في كل مواقع الأقفاص التجريبية. كذلك من وجهة النظر البيئية يمكن التوصية بالأهمية البالغة للسيطرة على المصادر المختلفة لتلوث المياه فى بحيرة المنزلة للحصول على أعلى إنتاجية للأسماك بجودة وأمان عاليين.

قام بتحكيم البحث

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