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COMPARISON BETWEEN MONOCULTURE AND POLYCULTURE OF TILAPIA AND MULLET REARED IN FLOATING NET CAGES.

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ABSTRACT

Oreochromis niloticus (5.3-5.5 g) and *Mugil cephalus* (5.8-5.9 g) fingerlings were reared either individually in monoculture or together in polyculture for 150 days in 12 wooden floating cages at Alexandria University Fish Farm. Each cage was made of 55 mesh size nets and the total water volume was one cubic meter per cage. The present study was carried out to investigate the effect of different rearing systems at two stocking densities on growth performance, survival rate, food and nutrients utilization as well as production of the fish. The fish were divided into two stocking densities (40 & 80 fish /m^3) in three rearing systems (monoculture of tilapia, mullet and polyculture of both fish species). Treatments were divided into six groups in duplicate floating net-cages. All fish groups were fed daily at 5% of their body weight on 30% crude protein unified diet. The results indicated that, polyculture of tilapia and mullet gave the highest growth performance and survival rate compared with monoculture of tilapia or mullet. On the other hand, protein and energy utilization (retention) were highest in tilapia reared in monoculture compared with tilapia reared with mullet in polyculture system or mullet alone in monoculture system, respectively. Decreasing stocking density from 80 fish / m^3 to 40 fish / m^3 led to realizing the highest growth performance, survival rate and the best protein and energy utilization. The results indicated also that the polyculture of tilapia and mullet at 30% crude protein containing diet and 40 fish / m^3 stocking density is a convenient system to achieve the best growth performance of each fish species.

Keywords*:* Tilapia, mullet, monoculture, polyculture, stocking density, cages.

INTRODUCTION

Aquaculture plays an increasingly important role in the world fishery production. It has been the world's fastest growing food production systems for the past decade. The total world fish production of aquaculture increased from about 35.5 million tones in 2000 to about 47.8 million tones in 2005 (FAO, 2006). The increase was a result of intensification of production from the existing farms and the expansion of areas under cultivation.

The cage culture system was more economically viable and practiced than other aquaculture intensification systems. Therefore, today cage culture is receiving more attention by both researchers and commercial producers. Beveridge (1996) reported, from the economics standpoint of view, that the efficiency of the cage culture consist 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.

Polyculture is the practice of culturing more than one species of aquatic organism in the same pond. The motivating principle is that fish production in ponds may be maximized by raising a combination of species having different food habits. The mixture of fish gives better utilization of available natural food produced in a pond. Different combinations of fish species in polyculture were used in different countries according to specific condition, as availability of fingerlings, adaptability of species to climatic conditions, market demand, types of food available and nature of the pond (Pruginin, 1975; Dimitrov, 1984; Rabanal, 1985; Falaya, 1986 and EL-Ebiary, 1998).

Owing to the good price and demand they have in the market as well as the availability of their fry and fingerlings, mullet and tilapia rated first among the species suited to fish culture in Egypt (Zaki and Essa, 1990 and Salama, 1994).

The present study was undertaken to know the suitable culture system (polyculture or monoculture) for tilapia and mullet reared in floating cages located in earthen pond at different stocking densities and their effects on growth performance and food and nutrients utilization for both species.

MATERIALS AND METHODS

Experimental cages:

Cages were suspended in a pond at Alexandria University Fish Farm. The pond was 350 m^2 in surface area with 1.2 m water depth. Twelve floating cages of wooden frames were used. Each cage was of one cubic meter capacity (1X1X1 m). Cage rafts were constructed from oil plastic drums and its body was made of 55 mesh size nets fixed to the frame and supported by small sand bags in the water column to maintain its shape.

Experimental fish:

Nile tilapia *Oreochromis niloticus* fingerlings, 5.3-5.5g were obtained from Alexandria University Fish Farm and mullet *Mugil cephalus* fingerlings (5.8-5.9 g) were obtained from Mariout Co. Fish Farm at Alexandria Governorate, Egypt. The fish were stocked from 25th May to 22nd October, 2007. Duration of experiment was150 days as follows:

Cage No.	Type of culture	Type of fish	Stocking density (fish/m^3)
1, 2	Monoculture	Tilapia	40
3, 4	Monoculture	Tilapia	80
5, 6	Monoculture	Mullet	40
7, 8	Monoculture	Mullet	80
9, 10	Polyculture	Tilapia and Mullet	40
11, 12	Polyculture	Tilapia and Mullet	80

Diet and feeding regime:

Fish were supplied with artificial pelleted diet containing 30.0% crude protein 450.74 kcal GE/100g. The diet was formulated from locally available ingredients, that were dried for 24h at 65°C, finally ground in domestic blender and thoroughly mixed in a plastic container. Vitamins and minerals mixtures were then added with continuous mixing. The oil was added (a few drops at a time) during mixing. Warm distilled water (45°C) was slowly added until the diets began clump. The diets were passed through a commercial meat grinder and dried for 24- 36 h at 65°C in oven. Dried diets were chopped into pellets in blender. The pellets were soft enough for fish to take and retain. Particle size was 0.6mm diameter, 2mm length. Fish were fed at 5 % of their live body weight, by hand feeding twice daily (9:00 am and 3.00 pm), and six days/week. Fish were weighed biweekly (random sample, at least 20 fish / cage.) and the allowances of feed were readjusted on the basis of the new weight. Food was placed into a wooden tray in the cage. Table (1) shows the food ingredients and its chemical analysis.

Table 1: Composition and chemical analysis of the experimental diet offered for Nile tilapia and mullet fingerlings.

Ingredients	% on dry matter basis
Fish meal	14.00
Soybean meal	70.00
Wheat bran	4.00
Sun flower oil	2.00
Whole liver oil	4.00
Vitamin mixture*	1.00
Mineral mixture**	1.00
Cellulose	4.00
<u>Chemical analysis</u>	<u>(% dry matter)</u>
Dry matter (DM %)	93.24
Crude protein (CP %)	30.13
Ether extract (EE %)	06.65
Ash (%)	06.85
Crude fiber (CF %)	03.28
NFE*** (%)	53.09
GE (kcal/100g)****	450.74

***<u>Vitamin mixture</u> (g/kg): vit. A (0.012). Tocopherol (0.40), Menadione (0.04), PABA (0.4), Biotin (0.006), L- ascorbic acid (3.0), D-calcium pantothenate (0.28), Choline chloride (8.0), Folic acid (0.015), Myo-inositol (4.0), Niacin (0.8), Pyridoxine HCL (0.04), Riboflavin (0.20), Thiamine HCL (0.06), BHT (0.30), Celufil (12.44).**

****<u>Mineral mixture</u> (g/kg): Ca $(H2PO_4)_2$-H_2O (0.40), Ca-lactate (1.0), Fe Citrate (0.10), MgSO4.7H2O (0.40), K_2HPO_4 (0.70), $NaH_2PO_4.H_2O$ (0.25), $AlCl_3$. $6H_2O$ (0.02), $ZnSO_4$. $7H_2O$ (0.126), $CuSO_4$. $5H_2O$ (0.03), $MnSO_4$. H_2O (0.015), KI (0.02), $CaCl_2$. $6H_2O$ (0.02).**

***** NFE: Nitrogen free extract.**

******GE: Gross energy (GE: Kcal /100 g diet), calculated according to NRC (1993) using the following calorific values: 5.64, 9.44 and 4.11 kcal/g dietary protein, fat and carbohydrate, respectively.**

Polyculture uses a combination of species that have different feeding niches to increase overall production without a corresponding increase in the quantity of supplemental feed. Polyculture can improve water quality by creating a better balance among the microbial communities of the pond, resulting in enhanced production. (Rakocy and Mc Ginty, 1989).

Feed and fish composition:

At the termination of the study, fish in each cage were removed, killed, weighed and frozen for chemical analysis. Initial fish analysis was performed on a sample of 30 fingerlings of monoculture treatments (tilapia and mullet) and polyculture treatments (tilapia and mullet), which were weighed and frozen prior to the study. Proximate chemical analysis (moisture, protein, lipid and ash) in both of the experimental diet and whole fish body was performed according to the official methods of AOAC (1990).

Water quality:

Water dissolved oxygen, chlorosity and alkalinity were determined daily at 8:00 am in the cages area according to the A.P.H.A (1985) methods. A Beckman pH meter was used to determine the pH values. Temperature of surface water was recorded also in the shade regularly.

Statistical analysis:

Collected data were analyzed by the method of analysis of variance (Snedecor and Cochran, 1974). Means were compared according to Duncan's multiple range test (Duncan, 1955).

RESULTS AND DISCUSSION

Water quality characteristics:

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. Bard *et al.* (1976) reported that, when ponds were well fed or fertilized, the color of the water turned into dark green, which was considered to be satisfactory development.

The temperature of water must fit with the biological requirement of fish, whereas the influence of temperature is significant on fish feeding and growth (Boyd, 1979). The minimum value was reached in May (22.6± 0.45°C) and the maximum was in October (32.4±0.46°C). Nagel (1979) reported that, water temperature over 18°C was best for warm water fish survival and growth.

Dissolved oxygen (DO) values in the cage's area seemed to be suitable and ranged from 5.8 to 8.4 ppm. The lowest tolerance limits of (DO) for tilapia have been reported to range from 0.1 to 3.0 ppm (Ross and Ross, 1983). Mullet are sensitive to low oxygen concentration, less than 4 ppm (El-Ebiary, 1982 and Salama, 1994). This condition has not been recorded during this study.

Cage's surrounded water was slightly alkaline (pH 7.6-8.4). This may be due to the phytoplankton activity and the utilization of CO_2 and HCO_3. Alabaster and Lioyd (1984) reported that, water ranging in pH from 6.50 to 9.00 is regarded as most suitable for fish production.

Chlorosity (Cl %) of the water ranged between 1.1 g/l and 1.8 g/l. However, tilapia and mullet osmoregulate in a wide range of salinity (Hickling, 1962; El-Ebiary, 1982 and Essa and Salama, 1994).

Effect of culture system:

Plankton is normally the most plentiful food in pond, so it is very important to include a plankton feeding fish in a polyculture system. Tilapia is frequently cultured with other species as planktonic feeder to take advantage of many natural foods available in ponds and to produce a secondary crop, or to control tilapia recruitment. On the other side, grey mullet, bottom feeder fish, have a detrimental effect on large zooplankton and chironomid midges (Cardona *et al*., 1996).

Polyculture uses a combination of species that have different feeding niches to increase overall production without a corresponding increase in the quantity of supplemental feed. Polyculture can improve water quality by creating a better balance among the microbial communities of the pond, resulting in enhanced production. (Rakocy and Mc Ginty, 1989).

Table (2) summarizes the effect of different culture methods (mono or polyculture) on growth performance and survival rate of experimental species, *O. niloticus* and *M. cephalus*, during 150 days of rearing in floating net cages. The results show that, polyculture of tilapia and mullet reared together realized a higher growth and survival rates than the monoculture of tilapia or mullet, respectively. There were no significant differences ($P > 0.05$) between polyculture of both species and monoculture of tilapia. Monoculture of mullet obtained the lowest growth parameters and survival rate, which may be attributed to jailing the fish into suspended cage, which keep mullet away from consuming a variety of decaying organic matter, aquatic organisms such as clams, insects, worms, snails, and bacteria living in or on the sediments. In similar study, Wassef *et al*. (2003) obtained opposite results, where *M.cephalus* grown better than *O.niloticus* in caged monoculture system in brackish water. On the other hand, results showed that, growth performance and survival rate of tilapia in monoculture system was better than mullet and the differences between species were significant ($P< 0.05$), this may be attributed to tilapia characteristics such as tolerance to environmental bad conditions, while mullet are very sensitive fish (Bard *et al*., 1976 and EL-Ebiary, 1982). Hassan *et al*. (1997) recorded that polyculture has many advantages, such as high efficiency in utilizing natural feed and culturing space, and more variety in harvesting, but optimal stocking density ratios of various species combinations must be used in order to achieve stable ecosystems. Liao (1981) recommended intensive culture of mullet with some other species as secondary fishes, which will not cause inter- specific competition. Bishara (1967) reported that low gain and survival rate of mullet fingerlings may be attributed to low natural food levels in the pond and so mullet fingerlings need at least 50% of its feeding as natural food.

Table (3) showed the results of food and nutrient utilization of *O. niloticus* and *M. cephalus* reared either together in polyculture or in monoculture systems. The results show that, the feed efficiency ratio (FER), protein efficiency ratio (PER), protein productive value (PPV %) and energy utilization (EU %) of tilapia which were reared in monoculture system were better than polyculture system of tilapia and mullet followed by mullet which were reared in monoculture system respectively. This indicates that tilapia fish is very suitable fish for cage culture. On the other side, there were a lowest utilization of supplementary feed and nutrient by fingerlings of mullet. It may be due to fry of mullet and fingerlings prefer feeding on natural food at the early life (Bishara, 1967), then feeding on bottom fauna (Sarig, 1981).

Effect of stocking density:

The results in Table (2) show that, there were significant differences ($P < 0.05$) in growth rates performance between different stocking densities (40 and 80 fish / m^3).

Table 2:Effect of type of culture (monoculture and polyculture) and different stocking density on growth performance, and survival rate (%) of *O. niloticus* and *M. cephalus* reared in floating cages.

Stocking density (fish/m^3)	Culture type	Body weight		ADG[2] (g/fish/day)	SGR[3] (%)	Survival rate[4] (%)
		Final (g/fish)	Gain[1] (g/fish)			
	Nile tilapia (*O. niloticus*)					
40	Mono	138.0^b	132.46^b	0.88^b	2.14^b	96.0^b
	Poly	168.0^a	162.38^a	1.08^a	2.27^a	100.0^a
	Mean	153.0	147.42	0.98	2.21	98.0
	±SE	10.92	14.96	0.1	0.07	2.0
80	Mono	115.5^b	110.14^b	0.73^b	2.05^b	94.0^b
	Poly	132.0^a	126.58^a	0.84^a	2.13^a	98.0^a
	Mean	123.75	118.36	0.79	2.09	96.0
	±SE	8.25	8.22	0.06	0.04	4.0
	Gray mullet (*M. cephalus*)					
40	Mono	100.5^b	94.64^b	0.63^b	1.89^b	90.0^b
	Poly	126.0^a	120.26^a	0.80^a	2.06^a	96.0^a
	Mean	113.25	107.45	0.72	1.98	93.0
	±SE	12.75	12.81	0.09	0.09	3.0
80	Mono	82.5^b	76.68^b	0.51^b	1.77^b	86.0^b
	Poly	94.0^a	88.44^a	0.59^a	1.89^a	94.0^a
	Mean	88.25	82.56	0.55	1.83	90.0
	±SE	5.75	5.88	0.04	0.06	4.0

1 Body Weight Gain = Final weight (g) – Initial Weight (g).
2 Average Daily Gain = Final Weight –Initial Weight / duration (day).
3 Specific Growth Rate (%)=100* ln Final Weight – ln Initial Weight / duration (day).
4 Survival Rate (%) = 100* No. fish at the end / No. fish at the start
Mean in the same column having different superscripts letters are significantly different (P<0.05)

Final body weight, gain, average daily gain (ADG), and specific growth rate (SGR %) were affected negatively with increasing stocking density, particularly for fish reared in polyculture than those reared in monoculture. The effect of stocking density on survival rate was not significant ($P > 0.05$). Carro-Anzalotta and Mc-Ginty (1986) found that growth of *O. niloticus* in cages held in freshwater was negatively correlated with stocking density, suggesting that inhibitory effects of high stocking densities emerged as biomass densities reached high levels. Nour *et al.* (1993) in their studies on grey mullet *M. cephalus* fingerlings (body weight 4g) to study the effect of different stocking densities (40 and 60 fish /m^3) on growth performance and feed utilization at floating net cages, showed that growth performance was decreased with increasing of the stocking density. Also, feed utilization site from 40 to 60 fish /m^3 significantly reduced the growth performance, net fish production and feed utilization. Tidwell and Webster (1993) on their studies about the effect of stocking density on green sunfish *Lepomis cyanellus* X bluegill *L. macrochirus hybrids* in ponds, found that final mean weights were higher for fish stocked at 12 350 fish/ ha. than those stocked at 24 700 fish/ ha. Table (3) shows the effect of different stocking density on feed and nutrient utilization of the two species. Increasing stocking density from 40 to 80 fish / m ^{3} reduce significantly ($P < 0.05$) feed efficiency ratio (FER), protein efficiency ratio (PER), protein productive value (PPV) and energy utilization (EU). This may indicate that feeds are not being well utilized or that utilization was varied. At the low stocking density (40 fish / m^3), feed was well utilized or less important due to availability of natural foods. In cages stocked with 80 fish/m^3, it appears that the prepared diet was more important, but feed acceptance or feed utilization was more variable. This is corborated by the observation that in some high stocking rate cages, fish were observed to accept feed while in others, they were not. EL-Sayed *et al.* (1993) in their studies about the effects of stocking density (30, 45 and 60 fish/ m^3) on growth rate and feed utilization of rabbit fish *Siganus canaliculatus*, the results revealed significant effect of stocking density levels on fish performance. Excellent growth rates and feed efficiency were noted at all stocking densities.

Table 3: Effect of type of culture (monoculture and polyculture) and different stocking on feed and nutrient utilization of *O. niloticus* and *M. cephalus* reared in floating cage.

Stocking density (fish/m^3)	**Culture type**	**FER[1]**	**Protein utilization**		**EU%[4]**
			PER[2]	**PPV%[3]**	
	Nile tilapia (*O. niloticus*)				
40	Mono	0.54^a	1.81^a	29.30^a	17.44^a
	Poly	0.50^b	1.33^b	26.17^b	16.17^b
	Mean	0.52	1.57	27.74	16.81
	±SE	0.02	0.24	1.57	0.64
80	Mono	0.49^a	1.63^a	25.52^a	15.11^a
	Poly	0.31^b	1.04^b	17.47^b	9.85^b
	Mean	0.40	1.34	21.50	12.48
	±SE	0.09	0.30	4.03	2.63
	Gray mullet (*M. cephalus)*				
40	Mono	0.27^b	0.90^b	14.57^b	10.20^b
	Poly	0.40^a	1.44^a	21.15^a	17.33^a
	Mean	0.34	1.17	17.86	13.77
	±SE	0.07	0.27	3.29	3.57
80	Mono	0.23^b	0.77^b	13.14^b	8.44^b
	Poly	0.38^a	1. 41^a	18.47^a	10.18^a
	Mean	0.31	2.18	15.81	9.31
	±SE	0.08	0.77	2.67	0.87

5 FER : Feed efficiency ratio = g wet weight gain / g dry feed intake.
6 PER : Protein efficiency ratio = g wet weight gain /g dry protein intake.
7 PPV %: Protein productive value % = 100 (g carcass protein gain / g dry protein intake.
8 EU% : Energy utilization (retention) % = 100 (Kcal carcass gross energy gain / Kcal gross energy of feed intake.
Mean in the same column having different superscripts letters are significantly different (P<0.05)

However, fish growth performance was superior at low stocking density (30 fish/ m^3). At moderate density (45 fish/ m^3), growth rates were slightly reduced, while a sharp reduction in growth performance was evident at high density (60 fish/ m^3). Mabrouk and Nour (1993), in their study on *Mugil cephalus* in net enclosures, concluded that 40 fish/m^3 is the best stocking density for better growth performance and feed utilization. Sharma and Chakrabarti (1999) in their studies on larvae rearing of common carp *Cyprinus carpio* under three stocking densities (25, 50 and 100 larvae / 15-l aquarium), they obtained maximum survival (91%) and final growth (401 mg), at the lowest density, followed by the medium density (86% and 330 mg), and then high density (80% and 205 mg, respectively). Similarly, the average weight of larvae was greatest at the low density (85.2 mg) followed by average weights from the medium (77.07 mg) and the high (67.70 mg) densities. The results of the present study are in agreement with the results of the above researchers.

In conclusion, the results of this study indicate that the survival rate, growth and feed utilization of tilapia and mullet fingerlings reared in floating cages are influenced by both culture methods (monoculture or polyculture) and stocking density.

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مقارنة لرعاية أسماك البلطي والبوري بنظام وحيد أو متعدد في الأقفاص الشبكية العائمة

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٢- المعهد القومي لعلوم البحار والمصائد ، قلعة قيتباي ، الإسكندرية ، مصر.

تم تربية إصبعيات أسماك البلطي النيلي (٥,٣- ٥.٥ جم) واسماك البوري (٥,٨-٩.٥ جم) بصورة وحيدة (مفردة) أو متعددة لمدة ١٥٠ يوما في أقفاص خشبية شبكية عائمة، بحجم حوالي واحد متر مكعب لكل منها، في المزرعة السمكية التابعة لكلية الزراعة جامعة الإسكندرية. وأجريت هذه الدراسة بغرض دراسة تأثير نظام التربية عند استخدام كثافتي التخزين (٤٠ & ٨٠ سمكة /م٣) على كفاءة الأداء والنمو ومعدل الإعاشة، وكفاءة الاستفادة من الغذاء والمكونات الغذائية (البروتين والطاقة)، حيث غذيت الأسماك بمعدل ٥ ٪ من وزن الجسم يومياً وعلى عليقة تحتوي ٣٠ ٪ بروتين خام .

أشارت النتائج إلى:

أن تربية أسماك البلطي والبوري بنظام متعدد أعطى أعلى كفاءة أداء ونمو وإعاشة مقارنة بتلك الأسماك التي ربيت مفردة (بلطي او بوري). وجد أن أفضل كثافة تخزين للأسماك كانت ٤٠ سمكة / م٣ وعندها تحقق أعلى معدل كفاءة أداء ونمو، ومعدل إعاشة وكذلك أفضل استخدام للبروتين والطاقة.

لذا فان هذا البحث يوصي باستخدام نظام التربية المتعدد للبلطي مع البوري وبكثافة ٤٠ سمكة/م^{٣}.