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PRELIMINARY INVESTIGATIONS INTO THE INSHORE MARINE CAGE CULTURE IN EGYPT AND THEIR IMPACTS ON MARINE RESOURCES

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ABSTRACT

Although Egyptian aquaculture fish production from fresh and brackish water contributed 51 % of total Egyptian fish production (875990 tonnes), mariculture in the Mediterranean and Red Sea is a recent activity. Until now mariculture has been characterized by the introduction of foreign technology and knowhow and though there are no truly inshore marine fish cage culture at this stage. The limited availability of protected sites and the conflicts of other activities (tourism, recreational and commercial navigation as well as inshore fishermen) are all factors which may influence marine aquaculture development. The basic requirements for the development of inshore mariculture in Egypt are: finance, technology, expertise and government support.

Therefore, the pilot scale inshore marine cage culture have been established since 2000 along the West Northern Shore of the Mediterranean Sea, West Lagoon, Matrouh City, Matrouh Governorate. The pilot farm consisted of eight floating net cages (30 m^3 each). The Mediterranean Sea are especially convenient for sea bream (*Sparus aurata*), sea bass (*Dicentrarchus labrax*) and Florida red tilapia (*Oreochromis Sp.*). The fingerlings of these species were cultured in cages at a density 35.8 fish/m^3 (semi-intensive) and 50 fish/m^3 (intensive) for 323 days in case of sea bream and bass, but in case of red tilapia were 50 and 100 fish/m^3 for 159 days. The results demonstrated that: (1) at semi-intensive, sea bream cage culture possessed best survival rate (87.4%) and production (6.47 kg/m^3) comparing with those reared in intensive cage culture (73.1 % and 6.39 kg/m^3, respectively). The same trend was observed in case of sea bass (86.3% and 5.4 kg/m^3 vs 74.2% and 4.78 kg/m^3, respectively). At higher densities the stress caused by crowding may have increased the mortality rates due to cannibalism; and (2) For red tilapia, intensive red tilapia culture had higher fish production (10.24 kg/m^3) than those of semi-intensive group (6.43 kg/m^3) .The present results are encouraging because the bayback period from these successful systems varied between 0.56 (semi-intensive culture for sea bream) to 1.61 years (semi-intensive culture of red tilapia). While intensive sea bass culture shows a loss in economical profitability parameters and indicate that this system give low yield at high cost and requires effective management.

Moreover, analyses of nutrients within the sediments below the cages during study period revealed no noticeable accumulation of solid particulate wastes from the farm. This indicates that water current velocity (4-6 cm/sec.) in cage area was sufficient to distribute solid wastes.

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INTRODUCTION

Mariculture has great importance in national production and food supply, creating employment possibilities and high potential for export.

Cage farming could be considered the main system to determine the rapid growth of marine fish farming, especially in well protected coastal areas (sheltered bays and lagoons). Its advantages were: 1) lower investment need than intensive land based systems; 2) abundance of potential sites; 3) low energy cost; and 4) easier possibilities for expansion for existing projects. The development of inshore and off-shore sites is potentially one of the more promising avenues for marine aquaculture in the Mediterranean (Basurco, 2004). Its production had grown steadily over recent years, rising from 743, 516 mt in 1992 to 960, 013 mt in 1997. Greece and Turkey are particularly significant having both notable production levels and high growth rates.

Sea bass (*Dicentrarchus labrax*) ,sea bream (*Sparus aurata*) and Florida red tilapia (*Oreochromis* sp.) represent the most important marine fish in mariculture programs in Egypt due to the development of reliable seed production techniques. However, only started to culture in earth ponds recently due to lack of techniques for the rearing and formulation of specialized feeds as well as lack of policy advise and training (Essa, 2000; Gharabawy *et al.* 2002 and El-Kerdawy *et al.* 2004). Until now mariculture has been characterized by the introduction of foreign technology and know-how.

Recognizing the links between the environment and the sustainability of aquaculture, one of our main goals is to try to predict the occurrence of possible adverse environmental impacts of aquaculture development, so as to take measures to avoid, reduce or minimize them whene ever possible.

Therefore, the present work was carried out to study the effects of intensive and semi-intensive culture on growth and production performances as well as feed utilization parameters of cultivation sea bass, sea bream and Florida red tilapia in floating net cages in the Mediterranean inshore, west lagoon, Matrouh Governorate, Egypt. The interactions between a pilot cages farm and the environment were also employed during the present study.

MATERIALS AND METHODS

The pilot scale cage farming have been established since 2000 along the West Northern shore of the Mediterranean sea, West Lagoon, Matrouh Governorate by National Institute of Oceanography and Fisheries in cooperation with Academy of Scientific Research and Technology, Cairo, Egypt. Ten floating inshore cages were used (Fig. 1). Each cage had a frame made of 2 inch aluminium pipe with dimentions 4 x 3 meter, with nylon netting bag of 6 mm mesh size and block of styrofoam as floats (Fig. 2). The total water volume of each cage varied between 24 and 30m^3 (4 x 3 x 2 – 2.5 m depth). The pilot cages farm was anchored at an average depth of 6-8 meters above a sandy bottom.

Fingertings of sea bass (*Dicentrarchus labrax*), sea bream (*Sparus aurata*) and Florida red tilapia (*Oreochromis mossambicus* albino x *O. niloticus*) of about 1.11, 7.57 and 0.52 g, respectively were stocked in pilot cages at a density of 35.8 fish/m^3 (semi-intensive marine fish culture), 50 fish/m^3 (intensive marine fish culture), 50 fish /m^3 (semi-intensive tilapia culture)and 100 fish/m^3 (intensive tilapia culture).

Fish were acclimated in the cages for 2 weeks to adapt them to culture conditions and feeding regimes in captivity.

During the growing period (323 days for sea bass and bream and 159 days for red tilapia) the fish were hand fed on artificial diets (34.58% and 22.92% protein, for marine fish and red tilapia, respectively) at a rate of 5-10% of the live fish body weight, two times daily (9:00 A.M. and 15.00 P.M.) Formulations (%) and chemical analysis of fish diets are presented in Table (1). Sea bass and bream cages were fed also on fresh trash fish (mainly sardine, shrimp and rabbit fish) at a rate of 1% of the live fish body weight in 12:00 A.M. All diets were offered in wet form on plastic plates placed in the center of each cage.

A monthly sample of about 50 fish was netted from each cage and weighed, and the daily ration was readjusted accordingly.

Regular water samples were collected monthly from cages area (west lagoon) for water quality analysis (salinity, temperature, pH, dissolved oxygen, ammonia, nitrite, nitrate and phosphorus) according to APHA (1989). Sediment samples were collected and analysis according to AOAC (1985). The nutrient-budget balance were determined from fish biochemical analysis according to Molina *et al.* (1997), whereas nitrogen and phosphorus retention percentages for every cage were calculated using the protein productive value (ppv).

Formula:

$$\text{ppv} = \frac{\text{Mean final N - Mean initial N}}{\text{Ingested N}} \text{ x } 100$$

where values of nitrogen and phosphorus where employed respectively.

At the end of growing period, several measurements namely growth performance, feed utilization parameters and production were calculated as mentioned by Ballestrazzi *et al.* (1994) and Essa (2000).

Statistical analysis were performed by a computer software program Graph PAD instate (version 2.01) copy-right (c) 1990-1993 Steve Whetzel, Park-Davis 930762 A.

Table (1): Diets composition and chemical analysis of sea bass, bream and red tilapia reared in pilot cages in West Lagoon, Matrouh Governorate

Ingredients	**Sea bass and bream (%)**	**red tilapia (%)**
Fish meal	29	10
Soybean meal	41	20
Cotton seed cake	-	25
Wheat milling by-products	10	42
Corn	10	-
Oil	5	2
Vitamin premix	2	0.5
Mineral premix.	3	0.5
Chemical analysis (%)		
Dry matter (DM)	73.04	88.96
Crude protein	34.58	22.92
Crude fat	6.50	9.67
Crude fiber	6.66	8.49
Ash	7.92	9.34
Nitrogen free extract	44.34	49.58
Calculated gross energy (Kcal GE/100g DM)	443.03	429.12

Fig. (1): General view of pilot cages farm, West Lagoon, Matrouh Governorate.

Fig. (2): A unit of floating net cage

RESULTS AND DISCUSSION

1) Growth and survival performance:

The obtained results for growth and survival performance of sea bass (*D. labrax*), bream (*S. aurata*) and Florida red tilapia (*Oreohromis* spp.), reared in intensive and semi-intensive inshore cages, West lagoon, Matrouh Governorate, are shown in Table (2). Of particular note was that, by the end of the growing or fattening period, fish growth rates, condition factors and survival rates were inversely correlated with culture method (density). At semi-intensive culture the average final weights were: 172.29, 206.42 and 141.94 g for sea bass, bream and red tilapia, respectively, while in case of intensive culture reached only 128.91, 165.86 and 119.68 g, respectively. The same trend was observed for condition factor (2.13,2.71 and 2.94 VS 1.96, 2.59 and 2.86, respectively). In general, survival was excellent in all fish groups. However, fish reared in semi-intensive cages had a survival rates varied between 86.32-89.33% which although much better than reported by fish reared in intensive cages, 73.06-85.75% (Table 2). Decreased growth rate and condition factor (k) with increasing density can be explained by reduced feed efficiency (Cardenete *et al.* 1997; Essa, 1996 and Helal, 2003). The results of nutritional performance in Table (3) confirmed this finding also. The reported nutritional performance parameters (feed conversion ratio, protein efficiency ratio, protein productive value and energy utilization) were much better for semi-intensive fish groups than for intensive fish groups. Cannibalism was another important factor that may have effected the survival of intensive fish culture cages. Pillay (1990) reported, the stress caused by crowding may have increased mortality rates due to cannibalism. Similar observations have also been noticed by El-Sayed and El-Ghobashy (1997) for sea bass reared into 5120m^3 floating cages placed in shatta brackish water canal near Damietta.

It was also clear from the present results that, sea bream had higher growth performance, feed utilization and survival rates than those of sea bass either in intensive or semi-intensive cage culture. However, red tilapia had a promising growth and survival rates of 0.75-0.89 g/day and 85.75-89.33%, respectively in marine cage culture (Table 2). It used less feed (1.62-1.88 unit) to produce one unit of weight gain (Table 3).

2) Production performance:

The cited data in Table (4) clarifies that, sea bream (*S. aurata*) gave acceptable production under intensive or semi-intensive marine cage culture conditions in West Lagoon, Matrouh Governorate (6.47 and 6.39 kg/m^3/323 days, respectively). Sea bass (*D. labrax*) production was lower (4.78 and 5.40 kg/m^3/323, respectively). It may be of interest to note also from Table (4) that, intensive red tilapia cage culture had significantly ($P < 0.05$) highest fish production (10.24 kg/m^3/159 days) than those of red tilapia semi-intensive cage culture (6.43 kg/m^3/159 days) as well as sea bass and bream production. This might be due to Florida red tilapia could withstand conditions with high salinity and density, low content of dissolved oxygen and excess of organic matter (Dowidar and Essa, 1988; Bass and Rust, 1990).

The present results are encouraging for expanding inshore marine cage farming in the West-Northern Shore of the Mediterranean. Helal and Essa (2005) recommended this finding, and mentioned that these systems gave high yield at low cost with exemption of intensive sea bass cage culture, give moderate yield at high cost and require effective management.

Table (2): Growth and survival performance of sea bass, bream and Florida red tilapia, reared in intensive and semi-intensive inshore cages, West Lagoon, Matrouh Governorate*

Items	Intensive culture			Semi-intensive culture		
	Sea bass	Sea bream	Red tilapia	Sea bass	Sea bream	Red tilapia
• Duration period (day).	323	323	159	323	323	159
• No. of fish per m^3	50	50	100.0	35.8	35.8	50.0
• Total volume/cage (m^3)	30	30	24	30	30	24
• Av. intial body weight (g)	1.11±0.22	7.75±1.13	0.52±0.12	1.11±0.22	7.75±1.13	0.52±0.12
Harvesting data:						
• Av. final body weight (g)	128.91±14.48	165.86±11.38	119.68±5.89	172.29±19.00	206.42±14.52	141.94±6.66
• Survival rate (%)	74.20^{c}	73.06^{c}	85.75^{b}	86.32^{b}	87.44^{ab}	89.33^{a}
• Av. condition factor (k)	1.96±0.04	2.59±0.43	2.86±0.14	2.13±0.05	2.71±0.52	2.94±0.50
Growth parameters:						
Individ. total weight gain (g)	127.80^{e}	158.11^{c}	119.16^{f}	171.18^{b}	198.67^{a}	141.42^{d}
Individ. daily weight gain (g/fish/day)	0.40	0.49	0.75	0.53	0.62	0.89

* Figures In the same row with different superscript are significantly differences ($P < 0.05$).

Table (3): The nutritional performance of sea bass, bream and Florida red tilapia, reared in intensive and semi-intensive inshore cages.*

Items	Intensive culture			Semi-intensive culture		
	Sea bass	Sea bream	Red tilapia	Sea bass	Sea bream	Red tilapia
• Feed intake (kg/cage)	354^{c}	397^{b}	460^{a}	266^{e}	303^{d}	254^{e}
• Feed conversion ratio (FCR)	2.49^{a}	2.29^{a}	1.88^{b}	1.67^{c}	1.62^{c}	1.68^{bc}
• Protein efficiency ratio (PER, %)	1.16^{cd}	1.24^{c}	1.11^{d}	1.53^{b}	1.50^{b}	2.72^{a}
• Protein Productive value (PPV, %)	15.10^{d}	19.90^{c}	19.73^{c}	23.15^{b}	21.95^{bc}	47.98^{a}
• Energy utilization (EU, %)	10.88^{c}	14.12^{b}	10.57^{c}	15.48^{b}	15.48^{b}	26.00^{a}

* Figures in the same row with different superscript are significantly differences ($P < 0.05$).

Table (4): Effect of culture method on production performance of sea bass, bream and red tilapia.

Items	Total weight gain (Kg fish/m^3)	Total fish production (Kg fish/cage)
*** Intensive culture of:**		
Sea bass	4.78	143.48
Sea bream	6.39	191.66
Red tilapia	10.24	245.74
*** Semi-intensive culture of :**		
Sea bass	5.40	162.00
Sea bream	6.47	194.03
Red tilapia	6.43	154.30

3) Ecological effects of pilot cage farm in the West Lagoon:

The origin of any environmental impact derived from intensive cage aquaculture lies mainly in organic matter dumping , as a result of fish metabolism (excretion, faeces, mucus, etc) and the food supply (uneaten feed). These cause changes in the physical, chemical and biological characteristics of the receiving environment and are more evident on the seabed (Preston and Rothlisberg, 2000; Dosdats 2001; and MAPA, 2002).

The seabed in West Lagoon, Mersi Matrouh City, has a very low slop and the depth ranges from 6-8 m in cages area. The average current speed was 5.10 cm/sec.(maximum 6.80 cm/sec.)

Water quality criteria of cages area were showed in Table (5). The temperature varied between 15°C in January and 28°C in August. For salinity, the values were found to in the range of 32.18 to 36.11 ppt. pH values were almost in the alkaline side.

The cited results in Table (5) revealed also that, dissolved oxygen values in cages area not less than 6.88 and unionized ammonia not more than 0.123 mg/l. These values were found to be in the desirable range of sea bass, bream and Florida red tilapia culture (Emst *et al.,* 1989; Alvardo, 1997 and Helal, 2003). Nitrate and nitrite values were not toxic to fish (Wu, 1995 and Alvardo, 1997). Phosphate values were very low in cages area. Phosphorus is not important in promoting algal growth in the marine environment (Handy and Poxton, 1993), therefore, unlikely to have a significant effect. Nitrogen is considered to be the limiting nutrient for primary production in coastal areas (Gundersen, 1981).

Table (6) and Fig. (3) shows the results concerning nutrient feed content, nutrient fish retention and nutrient loading for the total ten cages (Pilot farm). When compared with data reported for the same fish species, the mean percentage of nitrogen and phosphorus retention during the present study (20.15 and 26.20%, respectively) were closer to the values obtained by Ewos (1996) as well as Aquado and Garcia (2004), although slightly higher than those reported by Molina *et al.,* (1997). The differences may be due to presence of red tilapia (herbivorus fish) as well as calculating methods.

with respect to the sediment analysis, the results of the present study revealed also that no significant differences were found for nitrogen, phosphorus and organic matter content between the different influence zones studied (underneath the cages, 50 and 100 meters from the cages), may suggest that no noticeable accumulation from the cages farm had taken place over the time period of this study (323 days). The nitrogen and phosphorus content of initial samples 7.35 and 21.40 mg/g were only slightly lower than the average values for zone 1 (8.03 and 22.03 mg/g), zone 2 (7.85 and 21.90 mg/g) and zone 3 (7.68 and 21.45 mg/g). With respect to the organic matter content of the sediments, the values oscillated between 1.5 and 2%, with no significant differences observed between the different zones.

It is possible that the water current velocity (4.50-6.80 cm/sec) in cages area was sufficient to distribute solid wastes, thus avoiding the undesirable effects of organic sediment accumulation both under the cages and on the environment. Also, increasing feeding frequency (number of meals per day) and feeding time during the present study improved fish feed utilization. Fish used less feed (1.62-2.49) to produce one unit of weight gain. The physical, chemical and operating cages area characteristics including depth, low biomass production and the short life of the fish farm may have influenced this finding also. Probably, if the farm continues to operate or if it increases its biomass production, sediment changes in its vicinity will be became more patent.

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Table (5): Water quality criteria in floating net cages area at the West Lagoon, Mersi Matrouh City, Matrouh Governorate.

Months	Water temperatures (C°)	pH	Dissolved oxygen (mg/l)	Salinity ‰	Ammonia NH_3 (mg/l)	Nitrite NO_2 (mg/l)	Nitrate NO_3 (mg/l)	Phosphate PO_4 (mg/l)
April, 2000	20.70	8.07	7.98	32.18	0.07	0.03	0.03	0.00
May	23.17	8.10	7.92	32.36	0.08	0.03	0.04	0.00
June	26.10	8.09	7.79	32.96	0.09	0.04	0.05	0.01
July	26.90	7.79	7.72	34.20	0.09	0.04	0.09	0.02
August	28.00	7.76	6.88	34.90	0.09	0.04	0.10	0.01
September	27.50	7.75	6.92	34.81	0.10	0.04	0.08	0.02
October	23.05	7.70	7.26	36.05	0.10	0.04	0.07	0.01
November	19.40	7.68	7.75	36.07	0.09	0.04	0.07	0.01
December	16.80	7.68	7.77	36.11	0.09	0.05	0.04	0.01
January,2001	15.00	7.66	7.97	36.08	0.11	0.05	0.02	0.01
February	16.10	7.54	7.95	36.25	0.11	0.05	0.02	0.02
March	17.90	7.35	7.83	33.89	0.12	0.05	0.03	0.02

Table (6): Results on nutrient feed content (NFC), nutrient fish retention (NFR) and nutrient loading (NL) from this study compared with the reported results from other authors for the same species with exemption of tilapia, under cages conditions.

Fish species	NFC (%)	NFR (%)	NL (%)	References
Sea bass, bream	6.89N	20.15N	79.85N	Present study
and red tilapia	1.06P	26.20P	73.80P	
Gilthead sea bream,	7.50N	22.20N	77.80N	Ewos, 1996
Sparus aurata	1.0P	27.80P	72.20P	
Sea bream and	7.90N	18.80N	81.20N	Molina *et al.*,1997
bass	1.08P	31.40P	68.60P	
Sea bass and	7.52N	22.63N	77.37N	Aquado-Gimenez *et al.,* 2004
bream	1.07P	27.50P	72.50P	

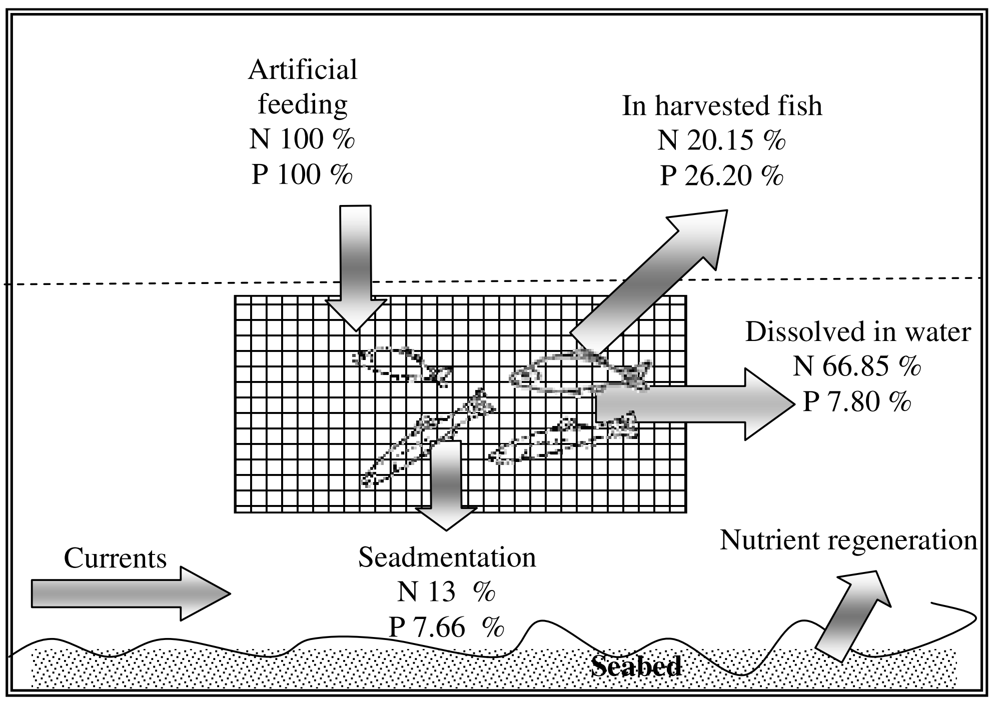

Fig.(3): Diagram showing main nutrients budget in a fish cages farm West Lagoon, Matrouh Governorate (Sedimentation rate was modified from Folke and Kautsky,1989).

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