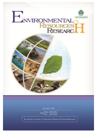

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Grey mullet (*Mugil cephalus*) rearing normative as a new species in Gomishan, Golestan Province

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Abstract

Grey Mullet (*Mugil cephalus*) is an important food fish species in the, Mugilidae which is able to adapt in a wide range of salinities and temperatures and is suitable for introduction of the species to freshwater, brackish, and brine waters for aquaculture. This study was implemented to determine appropriate normative of stocking density and initial weight of *Mugil cephalus* and also evaluate effects of these factors on the growth and feeding rates. Ten thousands of juveniles grey mullets (0.281±0.03 g 2.83±0.12 cm) were acquired from Mediterranean coastal waters of Egypt and were stocked in a quarter hectare of shrimp ponds in propagation and cultivation center of Gomishan, Golestan, for twenty- four months. Fish were stocked for first and second years at the density of 5000, 10000/ha and 2000, 2500/ha respectively. Mullets were fed by live foods and three concentrate diets in the first and second years of rearing, respectively. Recorded data showed that the weights and lengths were different at the end of the first year with different densities (113.7±5.21 g and 21.1±0.21 cm (5000/ha) and 86.6±2.54 g and 19.6±1.02 cm (density= 10000/ha)). The highest weight in the second year was 476.6±0.23 g (density: 2000, initial weight: 115) and the lowest was 327±0.98 (density: 2000, initial weight: 80). The FCR at density of 5000 and 10000/ha were 3.4±0.08 and 3.9±0.05 respectively, indicating that density can effect on FCR rate. In the second year, the lowest FCR belonged to treatment 5 (density of 2500 and initial weight of 115). There was no significant difference in the survival rate and SGR during the two years of rearing. Rearing information about mullet is rare so the aim of this research was to determine some standards and introduce a normative for Golestan climatic condition.

Keywords: Aquaculture, Mullet, Growth, FCR, Gomishan lagoon

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1. Introduction

Despite fluctuations in supply and demand caused by the changing state of fisheries resources, the economic, climatic and environmental conditions, fisheries and aquaculture remain very important as a vital source of food for people. Fish and fishery products represent a very valuable source of protein and essential micronutrients for balanced nutrition and good health. In order to supply this request, introducing new aquatic species is very important (Mirhashemi-Rostami, 2010). Sometime introducing an exotic species may have a wide range of risks for ecosystems' health and might affect biodiversity, agriculture, aquaculture, and related industries. In other hands, releasing new species may change an ecosystem's biodiversity through intra-species reproduction, predatory, competition for food, habitat, and also the habitat destruction (GESAMP, 1991). Therefore, the following actions are required to prevent and control the environmental damage (FAO, 1995); transfer and stocking must be carried out in quarantine condition and import fertilized eggs or larvae to have enough time to check their safety and health conditions. Treatments in open water should be implemented in small scale to examine the ecological effects and survey the aquaculture indices, also the propagation and farming center must be quarantined and sterile (FAO, 1995). After accepting the rearing of the new species in enclosed and controlled area, condition of the culture is very important, and one of the main factors will be density and initial weight of rearing in the ponds because the farmers may have a tendency for high density culture to earn the most profit. Nowadays, semi-intensive small scale aquaculture is completed in many countries especially in rural areas. Based on the pressure on catch and decline of the resources, it is a good measure to increase the density in the culture and produce fish protein in intensive conditions but this new condition may release wastes to the environment and affect oncological systems. On the other hand, survival, growth, and water physical and chemical parameters are affected by increasing density (Imanpour *et al.*, 2005), so changes in stocking density may lead to changes in survival and growth rate of the animals (Miao, 1992).

Mullets are extremely important fish which are cultured in many countries, particularly in the Mediterranean regions (Smith and Swart, 1998). Mullets are well suited for farming since they feed on algae, diatoms, small crustaceans, detritus organic matter, and mud; hence there is little need to concentrate feed (Swart *et al.*, 2001). Also, they are mainly detritivorous and can also shift to zooplankton (Blanco, 2003). For the first time in 1902, Russia attempted to transfer three species of mugil (*Liza saliens, Liza aurata*, and *Mugilcephalus*) to the Caspian Sea. Because of the importance of *Mugil cephalus* for culture purposes, despite the unsuccessful linkage of these species to the Caspian Sea, some attempts in terms of its culture have taken place in Iran due to its high quality meat, growth rate, large maximum size, and wide salinity and temperature tolerance (Smith and Swart, 1998).

Due to the abundant resources of the brackish water in north and south coastal waters of Iran and its central Provinces, availability of non-productive and unsuitable lands for agriculture which are proper options for *M. cephalus* culture, and easy access to low cost nutrition , have encouraged fisheries organization decide to introduce grey mullet as a new rearing species (Ghanei-Tehrani, 2001). This study aimed to examine some standards of stocking density, initial weight, and their effects on growth and feeding factors of Grey mullet (*M. cephalus*) as a valuable marine species in Iran, regarding to environmental considerations and profitable aquaculture activities.

2. Materials and methods

2.1. Fish Larvae

Ten thousands grey mullet (*M. cephalus*) fries with an average weight of 0.281±0.03 g and length of 2.83± 0.12 cm were imported by air transportation from Mediterranean Sea coastal waters of Egypt around the Alexandria. Fish were transferred fully quarantined within the plastic bags containing 5 liters water (150-250 fry per bag, salinity: 22 ppt).

The study was implemented in shrimp propagation and cultivation center 11 km North of the Gomishan cityon the shore of Gomishan lagoon, Golestan Province (latitude: 37 degrees, 09 minutes, 10.97 seconds of North, longitude 54 degrees, 00 minutes,45.26 seconds of East) (Figure 1).

Figure 1. Gomishan, Golestan, Iran (red arrow)

2.2. Rearing Condition and Treatments

Water was provided through a 600-meter channel from Gomishan lagoon using a pumping station and its sub-channels into stocking ponds. Salinity was the same as the Gomishan lagoon and it usually ranged between 15- 25 ppt. In this study, four enclosed and protected ponds with the same area of 2500 m^2 and 1.5 m depth were used. In the first year of culture, two ponds contained densities of 5000/ha and 10000/ha. In the second year, there were two densities , 2000 and 2500/ha, and two initial weights 80 and 115 g. Treatments were as follows: first year, two treatments: T_1 (D[1]=5000, IW[2]=0.281 gr), T_2 (D=10000, IW=0.281 gr), and the second year, four treatments based on the last two treatments (T_1 and T_2): T_3 (D=2000, IW=115 gr), T_4 (D=2000, IW=80 gr), T_5 (D=2500, IW=115 gr), T_6 (D=2500, IW=80 gr).

2.3. Water physicochemical Parameters

For monitoring and evaluating the physicochemical parameters of water (APHA, 1985), water temperature was measured twice a day, early morning (before sunrise), and in the afternoon (4:00 pm) using a mercury thermometer (mean temperature ≈ 22-24˚C). To determine the salinity of water at entrance channels, an optic salinity refractometer (ATAGO-salinity Refractometer 0-100 ppt) was used (≈ 32-33 ppt). Pond water pH was controlled using a portable digital pH-meter (WTW 232) twice a day, early morning (before sunrise) and in the afternoon (4:00 pm). For water clarity, secchi disk was used daily. Dissolved Oxygen (ppm) was measured by an oxygen-meter (model: WTW 330i). Other factors, such as BOD (mg/l), total alkalinity (mg/l $CaCo_3$), and total hardness (mg/l $CaCo_3$) were controlled using a photometer 8000 of Palin Test Company. For aeration, air jet aerators in the same position were installed. Water exchange in the first week was about 10% per day, in the second week was about 20-30% per day and then stayed fixed on 40-50% per day.

2.4. Feeding

The larvae feeding was started on the second day after delivery in the first year, *Nannochloropsis oculata* (5×10^5 cell/ ml), *Brachionus plicatilis* (20 per ml), *Artemia nauplia* (density of 3-200 per liter), and also supplementary foods (100, 300 and 500 µm) were used. In the second year, fish were fed twice a day (8:00 and 16:00) based on 5-7% of ponds biomass using plastic food dish below the water. The used food (23±2% protein, 10±2% crude fat, ≈7% fiber, 15% ash,

1. Density
2. Initial weight

40±2% carbohydrates and the gross energy: 4000±200 kcal/kg) was provided from Denso[1] concentrate food.

2.5. Biological Factors

Fish biometry was carried out monthly to survey growth factors. The growth parameters including body weight increase (BWI), condition factor (CF), specific growth rate (SGR), food conversion ratio (FCR), and survival rate (SR) were measured using the following formulas:

- BWI= (Final weight (gr) – Initial weight (gr) × 100
- CF= [Weight(gr) /Length^3(cm)] × 100
- SGR= [(Ln W_2 - Ln W_1) /t] × 100 (Larid and Needlham, 1988)
- FCR= Food intake (gr) /Weight gain (gr) (Hevroy *et al.,* 2005)
- SR = (Initial number-Casualties number) × 100

2.6. Statistical Analysis

Obtained data was normalized by launching K-S test and comparisons were implemented by one-way ANOVA test ($p \leq 0.05$). All analyses were performed using SPSS software (version 18; SPSS Inc., Chicago, IL, USA) and the results were shown as M±SD.

3. Results

3.1. The First Year of Culture

Growth rate of grey mullet in the first year of culture in the experimental ponds with a density of 5000 and 10000 / ha is shown in Table 1. There was no significant differences between the mean weight and length.

Table1. The growth factors of *M. cephalus* at the end of the first year with different stocking density

Treatment	Density	Initial weight(g)	Initial length(cm)	Final weight (g)	Final length(cm)	Survival rate(%)
1	5000	0.281±0.03	2.83±0.12	113.70±5.21	21.10±0.21	77.34
2	10000	0.281±0.03	2.83±0.12	86.60±2.54	19.60±1.02	77.05

Values are shown as Mean ±SD.

The mean weight and length of the first year fish in ponds with the density of 5000 fish per hectare were 113.70±5.21 g and 21.10±0.21 cm respectively and for the density of 10000 fish per hectare were 86.60±2.54 g and 19.60±1.02 cm respectively. No significant difference was seen between survival rate in treatments 1 and 2.

1. Mahdane Company, Karaj, Iran

3.2. The Second Year of Culture

The growth indices of *M. cephalus* at the end of the second year in different treatments (T_3-T_6) showed significantly the highest final weight for T3 and the lowest one in T_6 (Table 2). There were no significant differences in final length among the groups.

Table2. The growth factors of *M. cephalus* at the end of the second year with different stocking density and initial weight

Treatment	Density	Initial weight (g)	Initial length (cm)	Final weight (g)	Final length (cm)	BWI (%)
3	2000	115.00±6.24	22.00±0.12	476.60±0.23[a]	35.40±3.68[a]	75.87
4	2000	80.00±2.14	19.00±1.01	338.10±6.32[c]	31.60±2.52[a]	76.34
5	2500	115.00±6.24	22.00±0.12	440.00±5.28[b]	34.60±1.39[a]	73.86
6	2500	80.00±2.14	19.00±1.01	327.00±0.98[d]	30.70±2.92[a]	75.54

Values (Mean ±SD) with different superscript letters in the same column indicate significant differences among the experimental groups ($p<0.05$).

The weight and length of grey mullets in the second year of culture in an enclosed environment with the densities of 2000 and 2500 fish per hectare and initial weights of 80 and 115 g during six biological factors measurement (days 1st, 13th, 75th, 95th, 131th and 171th days) are displayed in Figures 2 and 3.

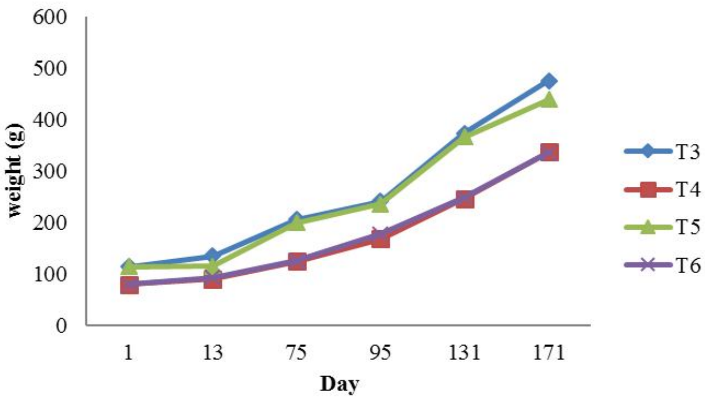

Figure 2. The weight of grey mullets in the second year, T_3 (D=2000/ha, IW=115gr), T_4 (D=2000/ha, IW=80 gr), T_5 (D=2500/ha, IW=115gr), T_6 (D=2500/ha, IW=80gr).

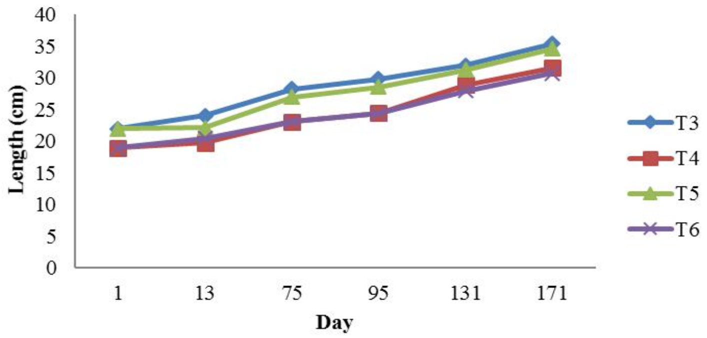

Figure 3. The length increase trend of grey mullets in the second year, T_3 (D=2000, IW=115 gr), T_4 (D=2000/ha, IW=80 gr), T_5 (D=2500/ha, IW=115/gr), T_6 (D=2500/ha, IW=80 gr).

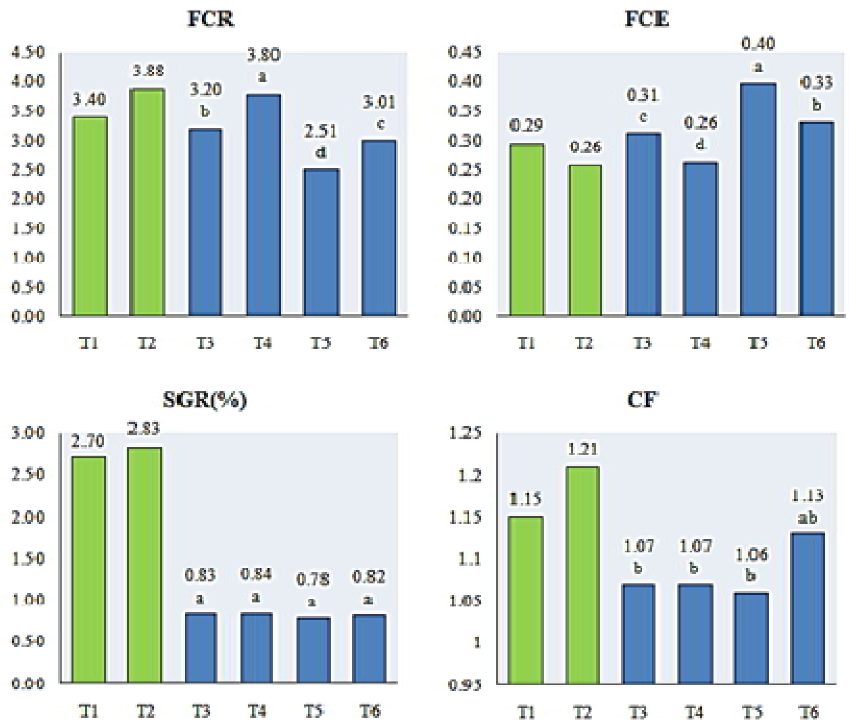

Figure 4. Feeding factors of grey mullets (*M. cephalus)* during 24 months. First year; T_1 (D=5000/ha, IW=0.281 gr), T_2 (D=10000/ha, IW=0.281/gr), and second year; T_3 (D=2000/ha, IW=115 gr), T_4 (D=2000/ha, IW=80 gr), T_5 (D=2500/ha, IW=115/gr), T_6 (D=2500/ha, IW=80 gr). Different superscript letters indicate significant differences among the experimental groups ($p<0.05$).

Feeding factors of grey mullets during 24 months of rearing with different densities (5000, 10000, 2000, and 2500/ha) and different initial weights (0.28, 80, and 115 g) are shown in Figure 4. FCR at the density of 5000 and 10000/ha were 3.4±0.08 and 3.9±0.05, respectively. In the second year, the lowest FCR belonged to treatment 5 (2500/ ha and WI: 115 gr). There was no significant difference in the survival rate and SGR during two years rearing.

4. Discussion

Mazandaran and Golestan Provinces are located in the southern part of the Caspian Sea and there are thousands of hectares of salty and useless land (such as Gomishan area) which has the potential to be changed and improved for marine aquaculture. Grey mullet is able to adapt to a wide range of salinity (0-100 ppt) and temperature range (0-40˚C) which makes it one of the most important culture species in the world.

This study was carried out with successful results obtained from imported grey mullet fingerlings in an enclosed area in north of Iran (Ghanei-Tehrani, 2001). The aim was to examine the impact of different densities and initial weights on cultivation success. The ability of the grey mullet to adapt to a wide range of temperature and salinity, suitable FCR, SGR, marketing, and poly-culture possibility (with shrimp, milk fish (*Chanos chanos*), and Cyprinidae) makes it known as one of the best rearing marine fish all over the world. Several countries including India, Pakistan, Japan, Hong-Kong, Taiwan, Vietnam, Indonesia, the coastal area of the South Pacific and Hawaii, and also countries in Europe and North Africa rear this commercial species. Grey mullet are usually fed daily about 3-5% of their body mass weight containing 20-25% protein (Oren, 1981; Tamaru *et al.*, 1993) while in this study the fish were fed twice a day (8:00 and 16:00) based on 5-7% of biomass.

In spite of its increasing sale, its optimal growth is inhibited when rearing in high density conditions (Rowland *et al.*, 2006). Research showed the main reasons are low food intake and high energy demands (Ramadan *et al.*, 2008: 2010; Ramadan and Verdegem, 2010). Hence, to obtain sufficient growth and appropriate size, fish stocking density should be considered with higher care (Feldite and Milstein, 2000). Similar to these findings, in the end of first year, the densities of 5000 and 10000/ha showed an obvious difference in final body weight and length, (113.7±5.21g and 21.1±19.6 cm against 86.6±2.54g and 19.6±1.02 cm) which shows a 50-percent improvement in efficiency when the density was half, whereas Eid, (2006) found that the optimum stocking density of grey mullet (*M. cephalus*) is about 10000 fish /ha (0.42 ha.) in fertilized brackish water ponds with artificial feeding. However, Bakeer (2006) reported that the best stocking rate of grey mullet (*M.cephalus*) fingerlings during 32-weeks of rearing in brackish water ponds was 2 fish / m^3 under fertilization and artificial feeding.

Rearing in intensive conditions with the maximum use of water is preferred, but as our results demonstrated, increasing the density of storage might have negative effects on survival and growth rate of aquatics species (Imanpoor *et al.*, 2005). In the second year of rearing in the shrimp ponds, the mean weights of T_3, T_4, T_5, and T_6 were 476.6±0.23, 338.1±6.32, 440±5.28, and 327±0.98 g, respectively from which T_3 (D=2000/ ha, IW=115 gr) significantly showed the highest final weight while the lowest one belonged to T_6 (D=2500/ha, IW=80 gr) ($p \leq 0.05$). The reason could be the reverse correlation between the stocking density and growth indices which are caused by competition for food and space which results in a kind of chronic stress affecting animal growth rate (Ebrahimi *et al.*, 2010). Unlike our results, Hssan Nataj Niazie *et al.* (2013) showed no significant differences in the survival rates of gold fish in different densities both in the first and the second year of rearing.

In the case of feeding factors, there was an obvious difference in FCR values in the first year with 5000 (3.4±0.08) and 10000/ha (3.9±0.05) densities. In the second year, significantly different FCR values were observed in T_3, T_4, T_5, and T_6 (3.20±0.04, 3.80±0.06, 2.51±0.01, and 3.01±0.03, respectively). These FCR differences could be due to stocking density per hectare and decreased feeding rate for different initial weights. These factors can affect and increase the feeding activity among fishes and finally cause weight and feeding performance (Mohseni *et al.*, 2007). Also, no significant difference was observed in SGR ($p > 0.05$). Bakeer (2006) reported that in grey mullet (*M. cephalus)* mono-culture system with supplementary feeding showed the highest profitability for weight gain and growth rate. The obtained data showed the densities of 5000 and 10000/ha in the first year of larval culture, whereas in the second year introducing juveniles with the initial weight of 115 g (either the density of 2000 or 2500/ha) is profitable and suggested this to be a normative for rearing of mullet in shrimp ponds. Nonetheless, for introducing new species, environmental and ecological conditions have to consider as well.

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