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All correspondence should be addressed to:

Abbassa International Journal for Aquaculture, Abbassa – Abou Hammad – Sharkia – Egypt. Tel.: 0020553401028 – Fax: 0020553400498

GENERAL INFORMATION

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EFFECT OF STOCKING DENSITY ON GROWTH AND PRODUCTIVE PERFORMANCE OF STRIPED MULLET, *MUGIL CEPHALUS* (L.) REARED IN FERTILIZED EARTHEN PONDS WITH SUPPLEMENTARY FEEDING

Mohammed N. Bakeer; Amal S. Hassan and Ahmed F. Fath-El-Bab

Department of Fish Production and Aquaculture Systems, Central Laboratory for Aquaculture Research, Abbassa, Abo-Hammad, Sharkia, Egypt.

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Abstract

This study was conducted to evaluate the effect of different stocking densities on the growth and productive performance of striped mullet, *Mugil cephalus*, reared in fertilized earthen ponds and supplemented with artificial diet for 6 months. Fish densities were 8000, 10000, and 12000 fish/feddan (D_1, D_2, and D_3, respectively). Each pond was fertilized with 100 kg chicken manure, 25 kg super phosphates, and 10 kg urea per feddan every two weeks. Fish diet (30% crude protein) was offered to each pond for satiation twice daily. Results indicated that individual growth decreased significantly with increasing fish density; however, final fish weight was 183.4, 154.3, and 123.6 g for D_1, D_2, and D_3, respectively. Similarly, weight gain, daily weight gain, and specific growth rate showed the same trend. No significant difference was observed in fish survival and its range was 96.3 – 98.4%. Feed intake decreased significantly with increasing fish density and it was 295.4, 276.7, and 258.7 g feed/fish for D_1, D_2, and D_3, respectively. Contritely, feed conversion ratio increased significantly with increasing fish density and it was 1.64, 1.83, and 2.15 for D_1, D_2, and D_3, respectively. Total fish production at the end of experiment (6 month) was 1439.3, 1518.3, and 1428.3 kg/feddan for D_1, D_2, and D_3, respectively. Similarly, net fish production was 1411.3, 1483.3, and 1386.3 kg /feddan for D_1, D_2, and D_3, respectively. It is noticed that the highest total and net production was obtained at D2 indicating that the optimum stocking density of striped mullet was 10000 fish/feddan whenever fish reared in fertilized earthen pond and supplemented with 30%-CP artificial diet.

Key words: Monoculture, striped mullet, *Mugil cephalus*, fertilized earthen ponds, growth, and fish production.

INTRODUCTION

Striped mullet, *Mugil cephalus* is one of the best-known members of Mugilidae that has significant commercial value in many countries (Oren, 1981). It is a euryhaline marine teleost that inhabits coastal waters but enters estuaries and rivers as well (Harrison and Senou, 1997). Striped mullet is an extremely important fish which are cultured in many countries due to its high growth rate, flesh quality, and its tolerance to wide range of salinity and temperature (Smith and Swart, 1998). In Egypt and worldwide, striped mullet is one of the most important components of fish farming and it is widely cultured in both brackish and freshwater semi-intensive fishponds (Lupatsch *et al*., 2003). Striped mullet is well suited for farming since they feed on algae, diatoms, small crustaceans, decayed organic mutter and mud (Odum, 1970; Brusle, 1981; Cardona *et al*., 1996). Jana *et al*. (2004) found that striped mullet could efficiently use periphyton colonized the bamboo substrates in inland saline groundwater. Moreover, Abd-El-Tawab and Yones (2001) and Abdel-Tawwab *et al*. (2005) reported that striped mullet could use the supplementary diet as well as the natural food.

Stocking density is a key factor in determining the productivity and profitability of commercial fish farms. Many studies have demonstrated an effect of stocking density on various aspects of the farmed fish (Wedemeyer, 1997), though the results depend on the species concerned. In this regard, Arctic charr (*Salvelinus alpinus*) suffer less physical damage and grow more rapidly at high density, whereas sea bass *Dicentrarchus labrax* (Vazzana *et al*., 2002) and gilthead sea bream *Sparus aurata* (Montero *et al*., 1999 and 2001) showed evidence of reduced growth and health at high densities. Studies of the relationship between health and stocking density are further complicated by the interaction with other variables such as food availability and water quality etc (Robel and Fisher, 1999; Ellis *et al.*, 2002). Therefore, this study was conducted to investigate the effect of different stocking densities of striped mullet, *M. cephalus* reared in fertilized earthen ponds with supplementary feeding on water quality, growth and productive performance.

MATERIALS AND METHODS

Experimental design and culture system:

This work was conducted in private fish farm, Sahl El-Tinah, Port Said, Egypt. Eight earthen ponds (1 feddan each) with one meter water depth were used. Ponds were supplied with freshwater from El-Salam canal. The experiment was started on 8 May 2007 and continued for 6 months. Each pond was fertilized with 100 kg chicken manure, 25 kg mono-super phosphate (15.5% P_2O_5), and 10 kg urea (46.5 % N) per feddan every two weeks to accelerate primary standing crop. The fertilization was started one week before fish stocking and stopped two weeks before fish harvesting. Ponds were stocked in monoculture with striped mullet fingerlings (3.1 – 4.5 g) at three densities of 8000, 10000, and 12000 fish per feddan for treatments D_1, D_2, and D_3 respectively. Fish diet (30% crude protein) was offered to each pond for satiation twice daily. Each treatment was represented by two ponds. Every month, 50 fish from each pond were sampled and individual length and weight were measured. Fish were returned to pond after sampling. The offered fish diet was readjusted accordingly.

Water quality measurements:

Water samples were collected every two weeks between 09:30 and 10:30 at 30 cm depth from each pond. Dissolved oxygen and temperature were measured at 30 cm depth by an oxygen-meter (YSI model 58, Yellow Spring Instrument Co., USA). Salinity was measured by salinity-meter (YSI model 33, Yellow Spring Instrument Co., USA). Unionized ammonia, total ammonia, and pH were measured colorimetrically using Hach kits (Hach Co., USA). Total hardness and total alkalinity were determined by titration according to Boyd (1984).

Parameters of growth performance:

At the end of the experiment, ponds were drained and fish were harvested, counted, and weighed. Growth performance was estimated and feed utilization was calculated as follows:

Weight gain = W_2 - W_1;

Daily weight gain (DWG; g/day) = weight gain / days of the experiment;

Specific growth rate (SGR; % g/day) = 100 (Ln W_2 – Ln W_1) / days of the experiment; Where W_1 and W_2 are the initial and final fish weights, respectively;

Feed conversion ratio (FCR) = feed intake / weight gain;

Net fish production = final fish weight (kg/feddan) - weight of fish stocked at initial (kg/feddan).

Statistical analysis:

The obtained data of fish growth, production, and feed utilization were subjected to one-way ANOVA. Differences between means were tested at the 5% probability level using Duncan test. All statistical evaluations were run using the programs (SAS, 1985).

RESULTS

Water quality parameters:

The variations in water quality parameters are presented in Figures 1 and 2. Water pH in D1 was lower than that of D2 and D3 during the experimental period. pH ranges were 8.45 – 8.59, 8.53 – 8.69, and 8.61 –

8.72 for D1, D2, and D3, respectively. Dissolved oxygen decreased significantly from August up to the end of the experiment in all treatments ($P < 0.05$). Dissolved oxygen was higher in D1 than that of D2 and D3 and its ranges were 3.72 – 5.63, 3.47 – 5.52, and 3.18 – 3.41 mg/L for D1, D2, and D3, respectively. Unionized ammonia was approximately the same in May and June in all treatments but it increased by increasing the rearing period reaching the maximum value in September and October. Moreover, unionized ammonia in D3 was higher than that of D1 and D2 and its ranges were 0.24 – 0.27, 0.24 – 0.28, and 0.25 – 0.31 mg/L for D1, D2, and D3, respectively. Water total alkalinity gradually increased with increasing the rearing period in all treatments with slight differences. Total alkalinity was not affected by fish density in this study and its ranges were 285.5 – 347.7, 282.2 – 343.6, and 277.6 – 341.1 mg/L as CaCO3 for D1, D2, and D3, respectively. On the other hand, water total hardness gradually decreased with increasing the rearing period and the lowest values were obtained in October in all treatments with slight differences. Water total hardness ranges were 7100 – 7270, 7200 – 7300, and 7300 – 7550 mg/L as CaCO3 for D1, D2, and D3, respectively. Water salinity was not affected by different stocking densities and its range was 12.0 – 12.3 g/L for all treatments.

Fish growth and production:

Concerning fish growth, Figure 1 shows the mean weight of striped mullet gradually increased up to the end of the experimental period. The final weight decreased significantly with increasing fish density and the maximum fish weight was obtained at D1 (183.4 g), while the lowest final weight of fish was obtained in D3 (123.6 g). Similarly, weight gain, daily weight gain, and SGR decreased significantly with increasing fish density ($P < 0.05$; Table 1). However, the highest weight gain, daily weight gain, and DGR were obtained at D1

(179.9 g, 0.99 g/day, and 2.16 % g/day, respectively), whereas the lowest values were obtained at D3 (120.1 g, 0.66 g/day, and 1.94 % g/day, respectively). The amount of feed supplemented to each pond significantly increased with increasing fish density ($P < 0.05$; Table 1). It was 2318.3, 2722.7, and 2989.5 kg feed/feddan for D1, D2, and D3, respectively. Subsequently, FCR increased with increasing fish density ($P < 0.05$; Table 1). FCR values were 1.64, 1.83, and 2.15 for D1, D2, and D3, respectively. Moreover, fish survival was not significantly affected by fish density and it was 98.1, 98.4, and 96.35% for D1, D2, or D3, respectively (Table 2).

The initial biomass of striped mullet was 28, 35, and 42 kg/fedan for D1, D2, and D3, respectively (Table 2). It is noticed that the highest total and net production was obtained at D2 (1518.3 and 1483.3 kg/feddan, respectively, whereas the lowest values were obtained at D3 (1428.3 and 1386.3 kg/feddan, respectively). These results indicate that the optimum stocking density of striped mullet was 10000 fish/feddan (Table 2).

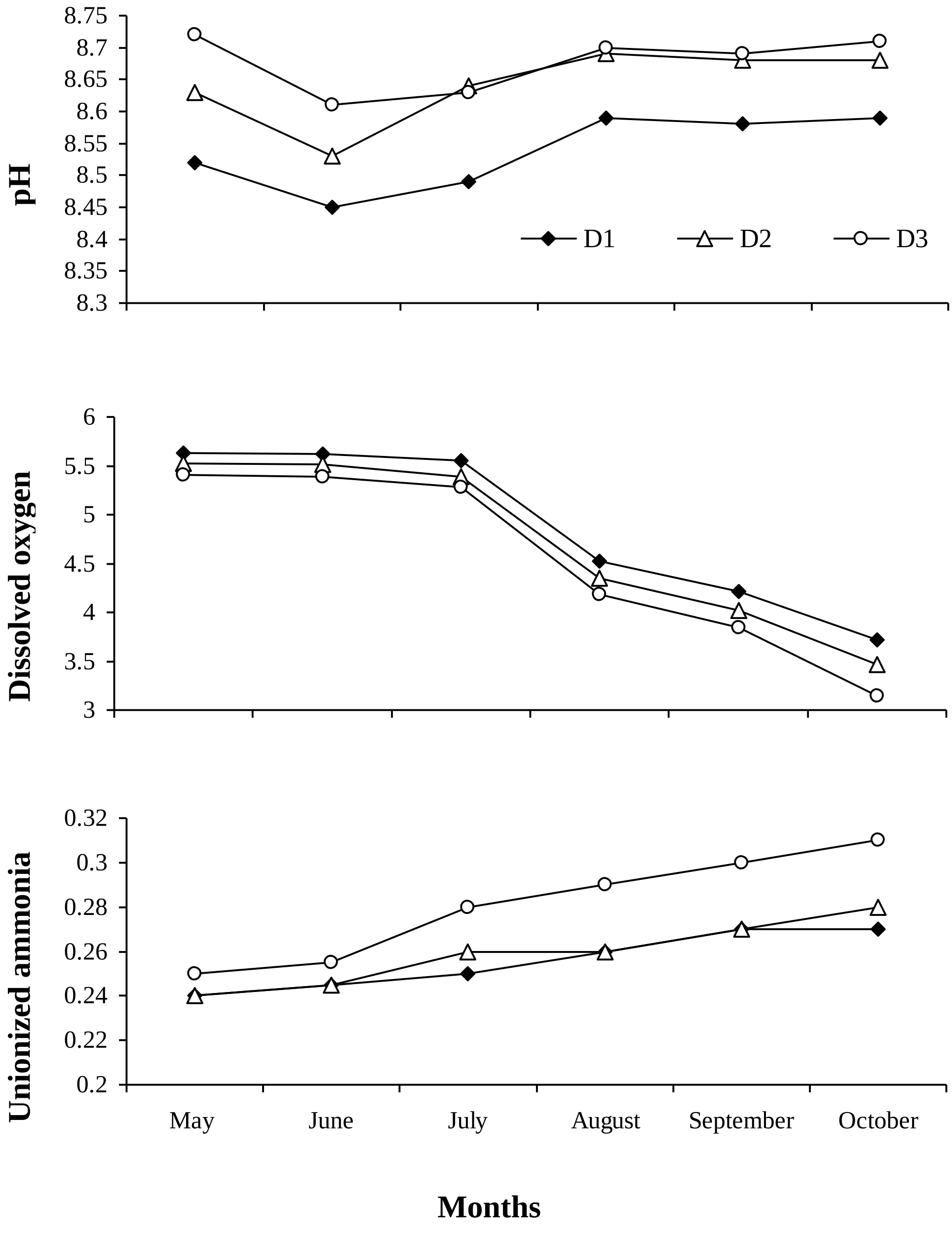

Figure 1. Monthly variations in pH, dissolved oxygen (mg/L), and unionized ammonia (mg/L) in fertilized earthen ponds stocked with different densities of striped for 6 months. D1, D2, and D3 = 8000, 10000, and 12000 fish/feddan, respectively.

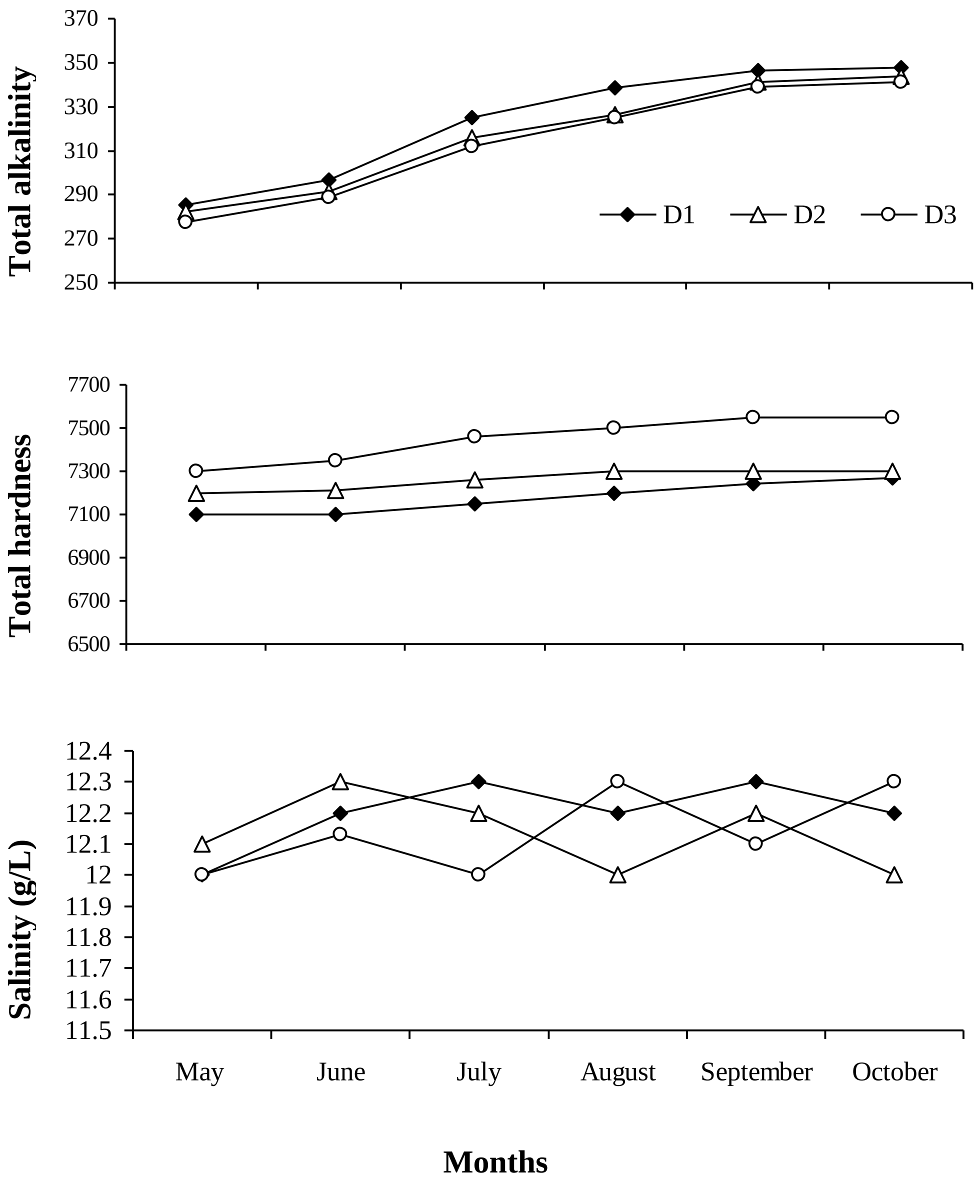

Figure 2. Monthly variations of total alkalinity (mg/L as $CaCO_3$), total hardness (mg/L as $CaCO_3$), and water salinity (g/L) in fertilized earthen ponds stocked with different densities of striped mullet for 6 months. D1, D2, and D3 = 8000, 10000, and 12000 fish/feddan, respectively.

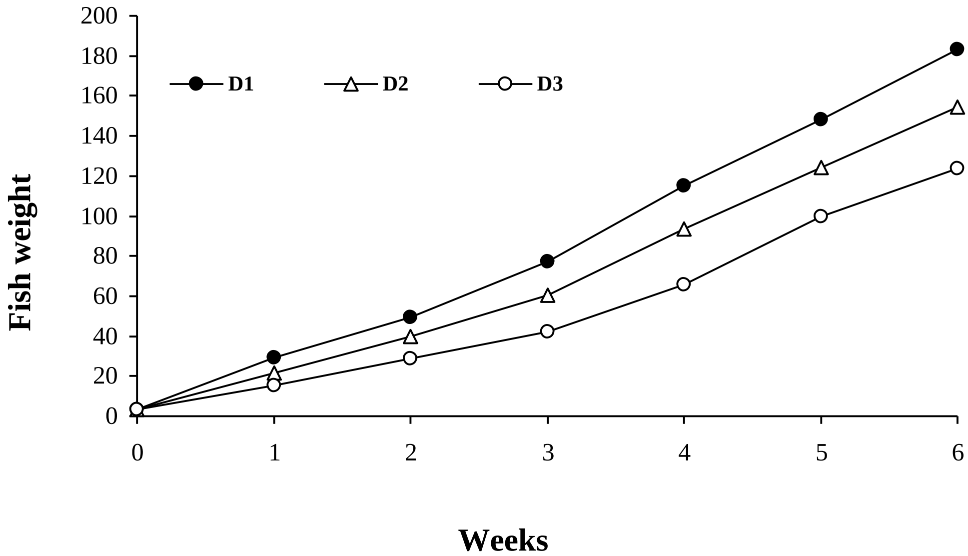

Figure 3. Change in mean weight (g) of striped mullet reared in fertilized earthen ponds under different stocking densities and supplemented with artificial diet for 6 months. D1, D2, and D3 = 8000, 10000, and 12000 fish/feddan, respectively.

Table 1. Effect of different stocking density on growth and productive performance of striped mullet reared in fertilized earthen ponds and supplemented with artificial diet for 6 months. D1, D2, and D3 = 8000, 10000, and 12000 fish/feddan, respectively.

	D1	D2	D3
Initial body weight (g)	3.5	3.5	3.5
Final body weight (g)	183.4 [a]	154.3 [b]	123.6 [c]
Weight gain (g)	179.9 [a]	150.8 [b]	120.1 [c]
Daily weight gain (g/day)	0.99 [a]	0.83 [b]	0.66 [c]
Specific growth rate (% g/day)	2.16 [a]	2.07 [b]	1.94 [c]
Feed intake (g feed/fish)	295.4 [a]	276.7 [b]	258.7 [c]
Pond feed intake (kg feed/feddan)	2318.3 [c]	2722.7 [b]	2989.5 [a]
Feed conversion ratio	1.64 [c]	1.83 [b]	2.15 [a]
Fish survival (%)	98.1	98.4	96.3

Means having the same letter in the same row are significantly different at $P < 0.05$.

Table 2. Effect of different stocking density on fish survival and productive performance of striped mullet reared in fertilized earthen ponds and supplemented with artificial diet for 6 months. D1, D2, and D3 = 8000, 10000, and 12000 fish/feddan, respectively.

	D1	D2	D3
Fish number (fish/feddan)	8000	10000	12000
Initial body weight (g/fish)	3.5	3.5	3.5
Initial fish weight (kg/feddan)	28	35	42
Total fish count at final (fish/feddan)	7848	9840	11556
Fish survival (%)	98.1	98.4	96.3
Final body weight (g/fish)	183.4 [a]	154.3 [b]	123.6 [c]
Total fish production (kg/feddan)	1439.3 [b]	1518.3 [a]	1428.3 [b]
Net fish production (kg/feddan)	1411.3 [b]	1483.3 [a]	1386.3 [c]

Means having the same letter in the same row are significantly different at P <0.05.

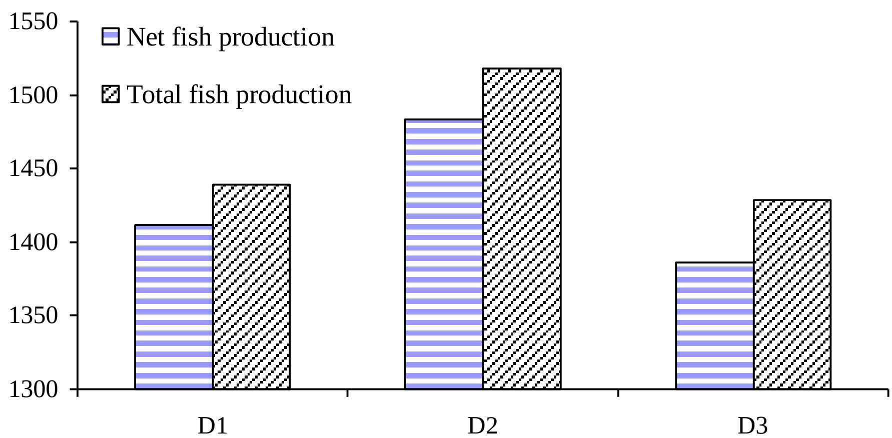

Figure 4. Net and total production (kg/feddan) of striped mullet reared in fertilized earthen ponds under different stocking densities and supplemented with artificial diet for 6 months. D1, D2, and D3 = 8000, 10000, and 12000 fish/feddan, respectively.

DISCUSSION

Effective water management in fishponds is one of the important factors contributing to the success of fish culture; it enhances fish growth and survival. Pond fertilization and feed supplementation play important roles in enhancing fish growth and productivity (Diana, 1997; Abd-El-Tawab and Yones, 2001; Thankur *et al*., 2004 and Abdel- Tawwab *et al*., 2007). Since the ponds had similar fertilization regime and they received the same types and amounts of fertilizers during this study, the differences in physico-chemical parameters among treatments were more or less insignificant. In this concern, Diana *et al*. (1996) reported that the efficient use of supplemental feed at a limiting rate, along with fertilizer and natural feeds did not adversely affect water quality. Moreover, the decrease of dissolved oxygen at the end of the experiment may be due to the fish growth that may need more oxygen. Generally, dissolved oxygen in this study was adequate for fish culture in the three treatments (Boyd, 1984).

In the present study fish growth decreased significantly with increasing fish density. This result may be been attributed to changes in fish metabolism. This effect is based on the assumption that chronic stress, due to the high density, increases the fish's overall energy demand, which is then unavailable for growth (Wendelaar Bonga, 1997). Likewise, high levels of locomotory activity have been shown to cause elevated metabolic rates as measured in rainbow trout (Cooke *et al*., 2000); however, the activity level of fish increased with increasing density resulting in energy demands. Piccolo *et al*. (2008) evaluated the effect of feed quality and stocking density on Dover sole (*Solea solea*) and found that fish stocked at low density showed a significantly higher growth and better feed utilization than the fish reared at high density. Pickering (1993) reported that high stocking density generates a chronic stress condition, and the stress response generates metabolic changes to cope with the increased energy demands imposed by a given adverse condition. Fish at high density groups were expending a larger amount of energy in social interactions resulted in a less growth. Such a metabolic response enhances the catabolic pathways to encourage the mobilization of energy stores that would affect fish growth over time (Pankhurst and van der Kraak, 1997; De Boeck *et al*., 2000; Trenzado et al., 2007).

Moreover, these results are in agreement with those reported by Bakeer (2006), Eid (2006) and Abdel-Gawad and Salama (2007). They found throughout their studies that the mullet growth was significantly influenced by the different stocking density. Also, El-Sayed (2002) stated that fish growth was negatively correlated with stocking density.

Fish survival herein was not significantly affected by fish density. These results are in accordance with those of Abdelghany *et al*. (1995) who reported that the survival of striped mullet exceeded 97% and it did not appear to be affected by quantity or quality of food or density. Also, Eid (2006) reported that the survival of striped mullet did not appear to be affected by density. Contrarily, Abdel-Gawad and Salama (2007) reported that the survival of striped mullet was significantly affected by fish density.

The present study showed that the highest total and net production of striped mullet was obtained at D2 (10000 fish/feddan). In this regard, Eid (2006) found that the optimum stocking density of striped mullet is 10000 fish per feddan in fertilized brackish water ponds with artificial feeding. Bakeer (2006) reported that the best stocking rate of striped mullet in fertilized brackish-water ponds and fed supplementary diet was 2 fish/m^3 i.e. 8400 fish/feddan. Abdel-Gawad and Salama (2007) reported that the optimum density of striped mullet density reared in fertilized earthen ponds without feed supplementation was 4200 fish/feddan.

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تأثير كثافة الاستزراع على أداء نمو وانتاج أسماك البورى المرباة فى احواض ترابية مسمدة والمغذاة على علف صناعى

محمد نجيب بكير ، امل سيد حسن ، أحمد فاروق فتح الباب

قسم بحوث الانتاج ونظم الاستزراع السمكى – المعمل المركزى لبحوث الثروة السمكية بالعباسة

الملخص العربى

فى هذه البحث تم دراسة تأثير كثافات الاستزراع المختلفة على أداء نمو و انتاج أسماك البورى المرباة فى أحواض ترابية مسمدة و مغذاة على علف صناعى (٣٠% بروتين). أجريت التجربة في ستة أحواض ترابية مساحة كل منها فدان واحد (الفدان = ٤٢٠٠ متر مربع) حيث تم استزراع أسماك البورى (٣.١ – ٤.٥ جم) عند ثلاث كثافات هي ٨٠٠٠ و ١٠٠٠٠ و ١٢٠٠٠ سمكة فى الفدان لمدة ٦ شهور للمعاملة الأولي و الثانية و الثالثة علي التوالى . تم تسميد كل حوض بمعدل ٦٠ كيلوجرام زرق دواجن ، ٢٥ كجم أحادى سوبرالفوسفات و ١٠ كجم يوريا كل أسبوعين. وقد أشارت النتائج الي أن نمو اسماك البورى قد انخفض معنويا مع زادة كثافة الاستزراع حيث كان أعلي للكثافة الأدني و كان أدنى للكثافة الأعلي . فكان الوزن النهائي لأسماك البوري ١٨٣.٤ و ١٥٤.٣ و ١٢٣.٦ جرام لكل سمكة للمعاملات الأولي و الثانية و الثالثة علي التوالى . لم يوجد اختلاف معنوى فى معدل الاعاشة نتيجة لاختلاف كثافات الاستزراع و تراوحت بين ٩٦.٣ و ٩٨.٤% . كما لوحظ انخفاض العلف المستهلك لكل سمكة بينما زادت كمية العلف المقدمة لكل حوض مع زيادة كثافة الاستزراع. زاد معدل تحويل العلف مع زيادة كثافة الاستزراع حيث كان ١.٦٤ و ١.٨٣ و ٢.١٥ للمعاملات الأولي و الثانية و الثالثة علي التوالى. كانت قيم الإنتاج الكلى فى نهاية فترة التجربة (٦ شهور) ١٤١١.٣ و ١٤٨٣.٣ و ١٣٨٦.٣ كجم لكل فدان وذلك للمعاملات الأولي و الثانية و الثالثة علي التوالى . من هذه الدراسة يتضح ان افضل كثافة استزراع لاسماك البورى المرباة فى احواض ترابية مسمدة مع تقديم العلف الصناعى كانت ١٠٠٠٠ سمكة لكل فدان.