Stocking density effects on survival, growth performance, feed utilization, and carcass composition of meagre, *Argyrosomus regius* (Asso, 1801) fingerlings reared in fiberglass tanks using underground saltwater

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Abstract. Four stocking densities (50, 100, 150, and 200 fish m^{-3}) of meagre (*Argyrosomus regius*) fingerlings with an initial weight of 2.47 g were tested. Fish were stocked in fiberglass tanks and fed on a 47/17 protein/lipids ratio pelleted diet for 60 days. The survival rate, growth, feed utilization, and carcass composition were evaluated. Results indicated that predatory behavior increased with increasing fish density leading to a decrease in meagre's survival rate. Growth performance indices decreased with increasing fish density without significant ($p > 0.05$) differences between density 50 and 100 fish m^{-3}. At lower stocking density, fish exhibited lower content of moisture and higher content of protein. A significant difference in the content of protein and lipids between density 200 fish m^{-3} and the other densities was recorded. Also, feed utilization indices (feed conversion ratio (FCR), productive protein value (PPV), %, and protein efficiency ratio (PER)) showed better values for lower densities and significant differences between density 200 fish m^{-3} and the other densities. From the results mentioned above, it could be concluded that the best stocking density of meagre is 50-100 fish m^{-3} using a well-balanced artificial diet.

Key Words: *Argyrosomus regius,* stocking density, saltwater wells, survival, fish performance.

Introduction. Increasing the population density globally to about seven billion people increased the demand for aquatic food; hence, increased expansion and intensification of aquaculture production are highly required to face the human population's continuous growth (Crab et al 2012). However, FAO (2020) reported that the annual growth rate of aquaculture production during the period 1970-2004 has reached 8.8%, while the average was 5.3% in the period 2001-2018, higher than the capture fisheries, which was around 0.5%. Also, FAO (2012) stated that aquaculture is predicted to increase 5-fold until 2050 to meet this growing demand. Healthy diets high in protein value are necessary to ensure that the ever-increasing population does not suffer sickness and diseases. Harvest of wild fish, crustaceans, and other aquatic species cannot keep up with the growing human population demand. Therefore, aquaculture is required to meet human demand; it also relieves wild species' strain to continue to be a significant source of healthy protein diets (Sadek 2010; Mutter 2011).

Although meagre (*Argyrosomus regius*) could be a suitable candidate species for the diversification of aquaculture in the Mediterranean region, it has been scored at the eighth position of twenty-seven species evaluated (Quéméner et al 2002). Meagre belongs to the Sciaenidae family, and it is a carnivorous species. It inhabits the Mediterranean and the Black Seas and occurs along the Atlantic coast of Europe, where it lives in inshore and shelf waters close to the bottom, as well as in surface and midwaters from 15 to about 200 m (Whitehead et al 1986). It can be adapted easily to captivity exhibiting high growth rates (Quéro & Vayne 1997; Quèmèner et al 2002) and can tolerate wide ranges of temperature and salinity. Its lean and high lipid quality flesh makes meagre a species with high nutritional value (Quèmèner et al 2002; Poli et al 2003).

Although many studies on the effect of stocking density on fish performance have been published, it is still challenging to obtain information on each species' better densities. The best densities are affected by different culture systems, fish species, and fish age (Ellis et al 2002). The stocking density is one of the most critical parameters affecting growth performance and productivity in fish farming activities. A specific stocking density can have either positive or negative effects on fish growth, and this interaction seems to be species-specific (Merino et al 2007). Ellis et al (2002) concluded that stocking density is "an important factor for fish welfare, but cannot be considered in isolation from other environmental factors", which is the opinion of the majority of the researchers and workers in the aquaculture industry, especially for fish with higher sensitiveness to environmental conditions.

No information is available on the ability of meagre to live in a high density. Therefore, the present study evaluates the effect of different stocking densities on survival, growth performance, feed utilization, and chemical composition of meagre fingerlings reared under an intensive fish culture system using underground saltwater.

Material and Method. This work was carried out in the Fish Rearing Laboratory at El-Max Research Station, National Institute of Oceanography and Fisheries (NIOF), in cooperation with the Faculty of Agriculture (Saba Basha) Alexandria University. The experiment was designed to investigate the effect of the stocking density on meagre fish.

Experimental design and culture condition. This experiment was performed during May-June 2016 and continued for 60 days using four treatments in three replicates. Four stocking densities (50, 100, 150, and 200 fish m^{-3}) were tested using fiberglass tanks (250 liters of water). Meagre fingerlings with an initial weight of 2.47±0.1 g and an initial length of 6.7 cm were used. Fish were fed 5 times daily for satiation on a manually formulated pelleted diet containing 47/17 protein/lipids recommended from the previous experiment (Abdel-Rahim et al 2019a). The ingredients and chemical composition of the experimental feed are mentioned in the previous study. Fish were kept under natural light (12:12 h, light:dark schedule). The daily water exchange was 25%.

Water analysis. Oxygen, ammonia, temperature, and pH were measured weekly for all treatments. Temperature, together with pH, was measured by a portable pH Meter (HI 8424) (HANNA Instrument). Dissolved oxygen was measured by a HI-9142 (HANNA Instrument). Salinity was measured using a YSI EcoSense EC300 conductivity/salinity meter. Total ammonia nitrogen (TAN) was monitored using YSI Professional Plus Multiparameter Instrument (YSI Incorporated, Yellow Springs, Ohio USA). The concentration of un-ionized ammonia-N was calculated as a percentage of TAN using the data of pH, temperature, salinity, and TAN. Samples of water were taken from the water source to measure salinity, pH, total hardness, and the heavy metals content, as illustrated in Table 1.

Table 1

Chemical analyses of the underground saltwater

Parameter	*Measuring unit*	*Content*
Salinity	ppt	32±0.5
pH	-	7.75±0.003
Manganese	µg L^{-1}	85.2±1.08
Iron	µg L^{-1}	99.3±2.2
Copper	µg L^{-1}	5.3±0.005
Zinc	µg L^{-1}	6.5±0.002
Cadmium	µg L^{-1}	40.0±1.0
Chrome	µg L^{-1}	66.0±2.0
Cobalt	µg L^{-1}	50.0±2.0
Nickel	µg L^{-1}	70.0±5.0
Lead	µg L^{-1}	28.0±3.0
Total hardness	mg L^{-1}	87.0±0.5

Growth performance and feed utilization efficiency. At the end of the experiment, fish were collected, counted, and weighed. The growth performance and feed utilization parameters were determined as follows:

$$\text{Weight gain} = Wt - Wo$$

$$\text{Average daily gain (ADG)} = Wt - Wo/n$$

$$\text{Specific growth rate (SGR) \% day}^{-1} = (\ln Wt - \ln Wo)\ 100/n$$

$$\text{Relative growth rate \%} = 100 \text{ X (average final weight / average initial weight)}$$

where: n = number of days;

W0 = initial weight at the beginning of the experiment (g);

Wt = final weight at the end of the experiment (g).

At the end of the experiments, the survival rate was calculated based on the following equation:

$$\text{Survival (\%)} = 100 * \text{(final fish number / initial fish number)}$$

Biweekly samples of fish fingerlings were measured with weight and length. Also, data of fish weight and length were used to calculate condition factor according to the following formula:

$$\text{Condition factor (K value)} = 100 * \text{(final weight (gram) / cubic final length)}$$

Feed conversion ratio (FCR) and protein efficiency ratio (PER), protein productive value (PPV), and energy utilization (EU) were estimated according to the following equations:

$$\text{Feed conversion ratio (FCR)} = \text{dry matter feed intake / gain}$$

$$\text{Protein efficiency ratio (PER)} = \text{gain/protein intake}$$

$$\text{Protein productive value (PPV \%)} = 100 * (Pt - P0/\text{protein intake (g)})$$

where: P0 = protein content in fish carcass at the start;

Pt = protein content in fish carcass at the end.

$$\text{Energy utilization (EU, \%)} = 100 \text{ [Energy gain (Kcal/100g) / Energy intake (Kcal/100g)]}$$

$$\text{Energy gain (Kcal)} = E_t - E_0$$

where: E_t = energy content in the fish carcass (Kcal) at the end;

E_0 = energy content in fish carcass (Kcal) at the start.

Fish and feed analytical methods. At the beginning and at the end of the experiment, samples of fish and feed were collected to analyze the proximate compositions of the diets and fish, including the moisture, protein, lipid, and ash contents according to AOAC (2000) methodology.

To calculate carcass gross energy content (Kcal/100g) in fish samples, we used the following formula:

$$\text{Fish gross energy (GE) (kcal/100g DM)} = \text{(protein content x 5.64)} + \text{(lipid content x 9.44)}$$

To calculate gross energy content in feed samples, we used the following formula:

$$\text{Feed gross energy (GE) (kcal/100g DM)} = \text{(protein content x 5.64)} + \text{(lipid content x 9.44)} + \text{(carbohydrate (NFE) content x 4.11)}$$

Statistical analysis. Results are given as the mean±SEM. The data on the investigated traits (water quality, survival, growth performance, condition factor, feed utilization, and whole-body chemical composition of meagre) were analyzed with one-way analysis of variance (ANOVA) using SPSS version 16 statistical package (SPSS Company Inc.; SPSS, 1997) to evaluate the differences among the tested treatments. The differences in each experimental treatment were assessed using Duncan's multiple range test.

Results and Discussion

Water quality parameters. Water quality parameters were monitored weekly, and the results were summarized in Table 2 with no significant ($p > 0.05$) differences between treatments regarding temperature, pH, TAN, and ammonia. Data of dissolved oxygen showed significant ($p < 0.05$) differences among treatments, decreasing dissolved oxygen content with increasing stocking density. Water quality parameters were similar to those recommended for warm water marine fish species. For optimum growth, fish require a minimum dissolved oxygen concentration of approximately 5.0 mg L^{-1} (Aquafarmer 2004). Cooke et al (2000) reported that rainbow trout (*Oncorhynchus mykiss*) oxygen consumption was 12% higher at 60 kg m^{-3} than at 30 kg m^{-3}. The loss of energy for fish breathing is higher at high stocking density. Also, Maucieri et al (2019) found that dissolved oxygen was significantly different, with the lowest value recorded with the highest fish stocking density. Un-ionized ammonia (NH_3) concentrations should be kept below 0.05 mg L^{-1} (Timmons et al 2002), and levels of NO_2-N should be below 1.0 mg L^{-1}, while nitrate (NO_3-N) concentration levels should be lower than 10 mg L^{-1} (Pillay & Kutty 2005). All the previous parameters are recommended for aquaculture systems. Moreover, under intensive fish culture systems, high stocking densities together with insufficient water renovation in the tanks could decrease water quality (i.e., increase in ammonium or nitrite concentrations), compromising the growth of specimens (Foss et al 2009; Sinha et al 2012; Ferreira et al 2013).

Table 2

Means (±SEM) of meagre's water quality parameters, *Argyrosomus regius* under different stocking densities

Parameters	*Stocking density, fish m^{-3}*			
	50	*100*	*150*	*200*
Temperature, °C	24.37±0.13	24.37±0.03	24.57±0.03	24.53±0.20
pH	7.76±0.003	7.75±0.003	7.74±0.000	7.75±0.003
DO, mg L^{-1}	7.42 ± 0.22^a	7.27 ± 0.13^a	6.58 ± 0.25^b	5.90 ± 0.18^c
TAN, mg L^{-1}	0.20±0.003	0.24±0.006	0.27±0.040	0.28±0.044
NH_3, mg L^{-1}	0.0072	0.0086	0.0097	0.01

Note: The values with a different superscript in the same row are significantly different ($p < 0.05$).

Growth performance. Final body weight, average daily gain (ADG), and specific growth rate (SGR, %) are shown in Table 3. The presented data showed that growth performance indices decreased significantly ($p < 0.05$) with increasing stocking density. The best results were recorded at a stocking density of 50 fish m^{-3} treatment. The current results agree with Ellis et al (2002), Larsen et al (2012), Maucieri et al (2019), and Oké & Goosen (2019). The results obtained in this experiment are better than those obtained by Millán-Cubillo et al (2016) for meagre. Negative effects of high density on fish performance are generally associated with water quality deterioration or/and increased aggressive behavior (Ellis et al 2002). In red seabream (*Pagrus major*), lower stocking densities showed superior weight gain over higher densities (Biswas et al 2007). In white seabream, *Diplodus sargus*, a high stocking density led to reduced growth performance (Karakatsouli et al 2007). Specific growth rate (SGR) of the European carp (*Cyprinus carpio*) was 0.79% d^{-1} vs. 0.68% d^{-1} for low aquaponic stocking density and high aquaponic stocking density, respectively (Maucieri et al 2019).

Several studies have examined the effect of stocking densities on the growth and metabolism of different commercial fish species, such as gilthead sea bream, *Sparus aurata* (Montero et al 1999), red porgy, *Pagrus pagrus* (Laiz-Carrión et al 2012), Senegalese sole, *Solea senegalensis* (Salas-Leiton et al 2008; Andrade et al 2015), Atlantic salmon, *Salmo salar* (Hosfeld et al 2009), European seabass, *Dicentrarchus labrax* (Lupatsch et al 2010), African catfish, *Clarias gariepinus* (Oké & Goosen 2019) or the European carp (Maucieri et al 2019). These studies have demonstrated that high stocking densities induce negative consequences on several physiological processes due to activation of stress pathways (Barton 2002). The decreased SGR was recorded at increasing density levels on several species such as Atlantic cod (*Gadus morhua*) (Lambert & Dutil 2001), brook charr (*Salvelinus fontinalis*) (Vijayan & Leatherland 1988), gilthead seabream (Canario et al 1998) and largemouth bass (*Micropterus salmoïdes*) (Petit et al 2001), the rainbow trout (Rasmussen et al 2007), and most salmonid (Larsen et al 2012). Higher stocking densities were reported to cause chronic stress associated with captivity, which reduced the growth rate because of the reallocation of energy towards activities aimed at restoring homeostases such as respiration, locomotion, and hydro-mineral regulation, and tissue repair (Biswas et al 2007). Other energy-loss vital functions were higher at high stocking density, leading to low growth and worse feed assimilation. The high number of individual m^{-3} that reduced fish's ability to see and access feed is another possible reason for the low growth and high feeding conversion ratio of fish in high stocking density (Ellis et al 2002).

However, Liu et al (2014) found that Atlantic salmon stocked at higher stocking densities did not significantly affect the SGR. This contrasts with the traditional opinion that high stocking density harms food intake of fish, e.g., in Atlantic cod (Lambert & Dutil 2001) and rainbow trout (Boujard et al 2002; Ellis et al 2002). Removing waste products was higher in tanks of high stocking density and combined with a high level of nitrates in the used recirculation system.

Table 3

Means (±SE) of growth performance, condition factor, and meagre survival, *Argyrosomus regius* reared under different stocking densities in underground saltwater

Parameters	*Stocking density, fish m^{-3}*			
	50	100	150	200
Final weight, g $fish^{-1}$	11.29 ± 0.79^{a}	10.18 ± 0.42^{ab}	8.94 ± 0.66^{bc}	7.78 ± 0.21^{c}
Weight gain, g $fish^{-1}$	8.81 ± 0.77^{a}	7.68 ± 0.40^{ab}	6.51 ± 0.59^{bc}	5.32 ± 0.23^{c}
ADG, g $fish^{-1}$ day^{-1}	0.15 ± 0.013^{a}	0.13 ± 0.01^{ab}	0.11 ± 0.01^{bc}	0.09 ± 0.004^{c}
SGR, % $fish^{-1}$ day^{-1}	2.52 ± 0.12^{a}	2.34 ± 0.08^{ab}	2.16 ± 0.09^{bc}	1.91 ± 0.06^{c}
Condition factor, K value	0.99 ± 0.01^{a}	0.90 ± 0.07^{a}	0.70 ± 0.01^{b}	0.69 ± 0.04^{b}
Survival rate, %	70.67 ± 1.33^{a}	62.67 ± 2.67^{ab}	53.51 ± 3.16^{bc}	49.33 ± 7.42^{c}

Note: The values with a different superscript in the same row are significantly different ($p < 0.05$).

Survival rate and condition factor. Data of fish survival rate and condition factor are shown in Table 3. The results clearly showed that the higher percentage of survival rate (70.67%) was obtained at a density of 50 fish m^{-3} treatment, while the lowest survival rate (49.33%) was obtained at 200 fish m^{-3}. In general, the available results about the effects of stocking density on the meagre survival rate are minimal. Abdel-Rahim et al (2019a) recorded higher survival percent (80-86.67%) of meagre when tested with salinities between 16-32%, while survival percent reduced to 58.33% when tested with salinity 8 ‰. Millán-Cubillo et al (2016) found that the survival rate for meagre was not significantly affected by stocking density. Still, water quality should be in the optimum range with good stability of the feed. The obtained values of survival rate in this experiment are in conjunction with other researchers for different marine fishes' species (Rowland et al 2006; Abou et al 2007; Karakatsouli et al 2007; Dicu et al 2013; Rayhan et al 2018; Maucieri et al 2019).

Survival is a key indicator of health status. Fish survival was high in our experiment, but the differences significantly showed that meagre's survival is affected by stocking density. Wallat et al (2004) reported that average survival was 96.7% for the low density and 94.2% for the high density for trout cultivation in cages. Yi et al (1996) also noted that caged large tilapia's survival decreased with increased stocking density from 30 to 70 fish m^{-3} due to low morning dissolved oxygen in ponds and recommended 50 fish m^{-3} to be used in floating cages in ponds. A similar trend was observed in white seabream, where a high stocking density led to reduced survival (Karakatsouli et al 2007). Generally, high density is considered a potential source of stress, negatively affecting survival rates (Rowland et al 2006). In stellate sturgeon (*Acipenser stellatus*) fingerlings, high stocking densities showed decreased survival (Dicu et al 2013). Similar results were found by Rayhan et al (2018), who observed a significant increase in the mortality (from 0 to 7.2%) of juveniles of tilapia with increasing stocking density from 0.52 to 1.58 kg m^{-3}.

The condition factor (K) is another way to evaluate fish health based on its relative fatness. The results of condition factors (K) revealed that the treatments with the 50 fish m^{-3} and 100 fish m^{-3} treatments were higher than the other levels. The best value of K (0.99) was obtained at a density of 50 fish m^{-3} treatment. The present study's overall results are consistent with the limited published data for juvenile meagre (Estévez et al 2011; El-Dahhar et al 2016; Abdel-Rahim et al 2019a, b). According to Adeyemi et al (2009), a negative allometric growth pattern in fish implied that the weight increases at a lesser rate than the cube of the body length. Idodo-Umeh (2005) and Abowei & Hart (2009) reported that the length-weight relationship of fish, also known as growth index, is an important management tool used in estimating the average weight at a given length growth. Karnatak et al (2021) found that condition factor (K) varied significantly among the tested stocking density treatments and was considerably better at 50 fingerlings m^{-3} after 180 days. The mean condition factor in intensive farms often is less than 1. In contrast, the values of condition factors in the natural water resources are higher than in the intensive rearing tanks (Akyol & Gamsiz 2010) with a mean condition factor close to 2.0. Therefore, the obtained values in this study agree with other researches.

Chemical composition of meagre fish. The chemical composition of the meagre's initial weight at the start of the experiment, was higher in protein and lower moisture, lipid, and ash contents than those at the end of the experiment, as illustrated in Table 4. Moisture content was significant ($p < 0.05$) affected by stocking density. On the other hand, there were significant ($p < 0.05$) differences in protein, lipid, and ash content among stocking densities. Protein content decreased significantly ($p < 0.05$) with increasing fish density and the higher level was obtained at 50 fish m^{-3} (63.25%). Oké & Goosen (2019) found that increasing fish density from 5 fish m^{-3} to 10 fish /m^2 decreased African catfish' protein content from 56.54 to 54.80%. Lipid content increased significantly ($p < 0.05$) with increasing fish density. The deposited higher lipid content was obtained at 200 fish m^{-3} (21.20%). This result agrees with the findings of Oké & Goosen (2019), who found that the stocking density has dramatically increased African catfish's lipid content. Liu et al (2016) hypothesized that fish reared at high densities showed increased body fat deposition as an adaptive stress response, confirmed by increased cortisol levels in the blood as a reactive anti-stress measure. Ash content increased significantly ($p < 0.05$) with increasing fish density, and the higher level was obtained at 200 fish m^{-3} (22.91%). This result agrees with the findings of Oké & Goosen (2019). They found that African catfish' ash content increased from 14.7 to 23.08% due to increasing fish density from 5 to 10 fish m^{-3}.

Table 4

Means (±SEM) of meagre's fish chemical composition, *Argyrosomus regius* reared under different stocking densities in the underground saltwater

Parameters	*Initial*	*Stocking density, fish m^{-3}*			
		50	*100*	*150*	*200*
Moisture, %	70.77±0.68	70.63±0.87^{b}	71.56±0.11^{ab}	72.27±0.62^{ab}	73.31±0.55^{a}
Protein, %	62.05±0.50	63.25±1.34^{a}	61.66±3.37^{ab}	58.94±0.14^{ab}	55.89±1.01^{b}
Lipids, %	18.43±0.55	18.60±0.12^{b}	19.50±1.84^{ab}	20.00±0.36^{ab}	21.20±1.25^{a}
Ash, %	19.52±0.25	18.15±1.22^{b}	18.84±1.71^{ab}	21.06±0.45^{ab}	22.91±1.45^{a}

Note: The values with a different superscript in the same row are significantly different ($p < 0.05$).

The carcass composition of meagre tissues has been found to change with salinity, temperature, diet type, diet quality, stocking density, light, and fish size (Castillo-Vargasmachuca et al 2017; Abdel-Rahim et al 2019a, b). The increase in stocking density can alter the immunological responses and physiological processes, mainly those related to metabolism and behavior (Schram et al 2006). It has been noticed that inappropriate stocking densities can alter lipid metabolism, mostly triglycerides, in brook charr (Vijayan et al 1990). In gilthead sea bream, different stocking densities altered fatty acid metabolism, decreasing hepatic oleic acid. A monounsaturated fatty acid is essential as an energy source, mainly in higher stocking densities (Montero et al 1999). High biomass could activate stress response affecting negatively different metabolic pathways related to lipid, carbohydrate, and protein metabolism. Low biomass could suppose inadequate use of space, higher production costs, and lower profitability (Laiz-Carrión et al 2012).

Feed utilization efficiency. Table 5 illustrates meagre's feed utilization efficiency, reared at different stocking densities. Recorded results showed significant ($p < 0.05$) differences between treatments concerning utilization efficiency indices. An increase in FCR value with increasing fish density was detected. The best value of FCR was obtained with 50 fish m^{-3} treatment (1.88), and the worst one was recorded at 200 fish m^{-3} (3.10). In the same direction, data of PER showed a decrease in its value with increasing stocking density.

The same trend was observed for productive protein values (PPV). The highest (22.18%) value was recorded at 50 fish m^{-3}, and the lowest one (9.64%) was for the 200 fish m^{-3}. Also, the lowest energy utilization (EU) value was recorded in the highest fish density of 200 fish m^{-3} (20.44 %) but, the highest value was (33.07%) at 50 fish m^{-3}. The present study results are compared with other researchers, such as Li et al (2012) and Millán-Cubillo et al (2016), Abdel-Rahim et al (2019a, b). In the study carried out by Millán-Cubillo et al (2016), they obtained that FCR was 1.25 and 0.86 in the high stocking density and extra high stocking density treatments, respectively, which are higher than those observed by other authors (Ortega & de la Gándara 2007) for meagre. FCR (1.55 vs. 1.86) of European carp decreased when stocking density increased (Montero et al 1999). An increase in feed conversion ratio with the increasing stocking density was found in 70% of the studies investigated by Ellis et al (2002).

Table 5

Means (±SEM) of Meagre's feed utilization efficiency, *Argyrosomus regius* reared under different stocking densities in the underground saltwater

Parameters	*Stocking density, fish m^{-3}*			
	50	*100*	*150*	*200*
FCR	1.88 ± 0.07^{bc}	2.37 ± 0.14^{b}	2.46 ± 0.29^{b}	3.10 ± 0.10^{a}
PPV, %	22.18 ± 1.33^{a}	16.43 ± 2.06^{b}	14.56 ± 1.74^{b}	9.64 ± 0.35^{c}
PER, g	1.18 ± 0.04^{a}	0.94 ± 0.05^{b}	0.93 ± 0.12^{b}	0.72 ± 0.02^{b}
ER, %	33.07 ± 1.33^{a}	26.56 ± 1.28^{b}	25.99 ± 2.86^{bc}	20.44 ± 0.90^{c}

Note: The values with a different superscript in the same row are significantly different ($p < 0.05$).

Li et al (2012) reported that stocking density is inversely related to feeding consumption. Decreases in daily feeding intake were observed at increasing density levels on several species such as Atlantic cod (Lambert & Dutil 2001), brook charr (Vijayan & Leatherland 1988), gilthead seabream (Canario et al 1998) and largemouth bass (Petit et al 2001). Castillo-Vargasmachuca et al (2012) indicated that snapper stocked at a high density in cages (12.2 kg m^{-3} net yield) showed an FCR of 2.6 while the FCR was 2.2 when the net yield was 6.9 kg m^{-3}; the FCR was, therefore, higher at the highest density. One of the commonly reported effects of an increased density is a reduction in food conversion efficiency. Braun et al (2013), tested the effects of different stocking densities of juvenile dourado, *Salminus brasiliensis* cultivated in cages on growth and stress. In the study of Braun et al (2013), the authors observed chronic stress with increasing stocking densities. Similar studies have revealed that the FCR increases with increasing density (Rowland et al 2006) because of social interaction and innate survival strategies. Decreases in the apparent feed conversion ratio (AFCR) may also be related to increased energy expenditure due to higher activity levels and growth limitations under captivity conditions (Ellis et al 2002). Karnatak et al (2021) concluded that FCR and PER values were highest 1.95 and 1.65, respectively at 50 fingerlings m^{-3} compared with 75 and 100 fingerlings m^{-3}. The variation in the obtained results of feed utilization indices between the present study and other studies may be attributed to the differences in feed quality and feed stability.

Conclusions. It can be concluded that the stocking density of 50 fish m^{-3} is the most suitable one for *Argyrosomus regius* fingerlings to achieve the highest survival, growth performance, and the best feed utilization indices, and fish biochemical analyses. Due to the high predation rates in meagre fish, which have been confirmed by few previous experiments and many field observations, this study recommends that the density of juvenile should not exceed 100 fish m^{-3} for technical and economic considerations.

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