Egypt. J. Aquat. Biol. & Fish., Vol. 20, No. 3: 15 – 33 (2016) ISSN 1110 – 6131

Effect of stocking density and water exchange period on growth performance, feed utilization and body chemical composition on Rabbitfish *Siganus rivulatus* juvenile under laboratory condition

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ABSTRACT

Two trials were conducted to determine the best stocking density and the optimum of water change period on growth performance and feed utilization of rabbitfish juvenile (Initial body weight 0.948 g ± 0.124). Stocking density was tested in the first trial, which consisted of four treatments. The fish were stocked at 10 fish/m^3 and 20, 30 and 40fish/ m^3 in four treatments respectively. The results showed significant differences between the treatments and cleared that, stocking density 10 and 20 fish / m^3 were the better than 30 and 40 fish / m^3 in growth and feed utilization parameters. The results affirmed that, an increase of fish number over 20 fish/ m^3 lead to a decrease of growth and feed utilization parameters. The second trial designed to evaluate different four periods of the water exchange at rate 50 % of the water volume.

The water was exchanged every day, every two days, every three days and every four days in the first, second, third and fourth treatments respectively. The results revealed significant differences between the treatments and cleared that, the best total weight gain and feed conversion ratio were achieved with the third treatment (water exchanged every three days) and the water quality was within the acceptable limits for fish growth in all treatments.

Keywords: Rabbitfish, stocking density, water exchange، water quality, growth performance, feed utilization

INTRODUCTION

Marbled spine foot rabbitfish *Siganus rivulatus* is a potential candidate for warm water marine aquaculture diversification (Lam, 1974). Rabbitfishes belong to the genus *Siganus* of the family siganidae (Woodland, 1990). Siganids are herbivorous marine and brackish water fishes that are found throughout the indo-west pacific (Woodland, 1983), and the more common species are the objects of traditional subsistence and commercial fisheries throughout this region. There has been interest in the culture of these fishes in ponds or cages in several areas (Duray, 1990).

Rabbitfish are considered to be excellent food fish in many parts of the world especially in the eastern Mediterranean and indo-pacific regions (Lam, 1974) and are economically important and relatively easy to rear and thus considered suitable for aquaculture (Hara *et al*., 1986). Additionally, rabbitfish have a high market value in Eastern Mediterranean countries (Stephanou and Georgiou, 2000), invaded the eastern Mediterranean via the Suez canal.

Marbled spine foot rabbitfish *Siganus rivulatus* is one of the most important commercial marine fish in Egypt. Whereas Egypt production of rabbitfish was about 1363 ton in 2014, Mediterranean Sea took part in 822 ton production, Red Sea (466 ton) and lakes (75 ton) according to (GAFRD, 2014). In previous years, lake Qaroun was developed by rabbitfish fry and appeared the first production in 2010 and reached this production about (1 ton), a maximum rabbitfish production of lake Qaroun about 5ton obtained in 2012, (GAFRD, 2014).

Because stocking density is the most important factor affecting intensive fish culture, extensive research has been carried out on the effects of stocking density on tilapia production in different intensive culture systems. Sadly, the available information has revealed controversial results. This controversy may have been due to the differences in species, sizes, nutrition and feeding, culture systems and water quality. This means that the relationship between stocking density and tilapia growth and survival is a function in a number of biological and physical factors (El- Sayed, 2002).

In aquaculture, stocking density is the concentration which fish are stocked into a system (Gomes *et al.*, 2006). Stocking density directly influences survival, growth, behavior, water quality and feeding. Stocking density is widely recognized as a critical husbandry factor in intensive aquaculture because it represents a potential source of chronic stress, which may affect physiology and behaviour of farmed fish (Ellis *et al.*, 2002)

Barton and Iwama (1991) said that, stocking density may or may not cause detrimental effects on fish survival and growth, depending on the species of fish being reared. Moreover, the rearing at inappropriate stocking densities may impair the growth, reduce immune competence and induce abnormal behaviour (Montero *et al.,* 1999). Due to the diversity of physiological stress response in fish, these effects appear to be species-specific and to be mainly dependent on the sensitivity of fish to the deterioration of water quality at high stocking density and the increase of social interactions at very low and/or very high stocking densities (Barton, 2002 and Papoutsoglou *et al.,* 2006). Consequently, inappropriate stocking densities may lead to poor welfare and compromise the health conditions of farmed fish, thus affecting also the profitability of the aquaculture industry (Huntingford *et al.,* 2006).

Generally, increases in stocking density resulted in directly increase on the stress condition, causing a reduction in growth rate and food utilization (Sharma and Chakrabarti, 1998). On the other hand, in very low densities, fishes may not form shoals and may feel unprotected. Consequently, identifying the optimum stocking density for a species is a critical factor not only to enable efficient management and to maximize production and profitability, but also for optimum husbandry practices (Leatherland and Cho 1985 and Rowland *et al.*, 2006).

The water exchange also improves dissolved oxygen and flushes out harmful substances, such as undigested food, faeces and other metabolites, such as ammonia, nitrite and nitrates (Mires, 1982). It is no surprise therefore, that seed output from ponds filled with new water is higher than from ponds with water used for long periods (Bhujel, 2000). This suggests that pond water should be frequently changed partially or completely; however, the exchange rate and frequency depend on water availability and cost, as well as the type of culture system.

There is no known standard for the frequency of water change in static systems and the subject matter has been poorly studied; previous research had focused on the effect of isolated water quality parameters (Oxygen, pH, CO2, etc.) on the growth performance of fish (Buentello *et al.,* 2000 and Boyd, 2001).

Increased summer temperature and photoperiod generally increase both primary production and organic loads in intensive fish ponds. Under such conditions, the level of faeces and other total solids and dissolved metabolites, such as ammonia and nitrites, in the water will increase. The accumulation of these metabolites has been reported to negatively affect the performance of cultured fish. Therefore, frequent total or partial water exchange and/or aeration will become necessary (El-Sayed, 2006).

In general, a little information is available on this subject. Continuous water exchange generally sustains the good quality of culture water, while low or zero water exchange may reduce the quality of the water. In addition, at a very high water flow rate, the fish spend a substantial amount of dietary energy for continuous swimming, leading to reduced growth and increased mortality (El-Sayed *et al*., 2005). At a low water flow rate, uneaten food, faeces and other fish metabolites may accumulate in fish tanks and adversely affect the water quality. This means that proper water exchange and flow rates should be adopted in order to obtain maximum fish performance (El-Sayed, 2006).

The present study aimed to determine the best stocking density and the optimum period of the water exchange to obtain the best growth performance, feed utilization and chemical body composition of rabbitfish *Siganus rivulatus* juvenile.

MATERIALS AND METHODS

The present study was conducted using the research facilities of Shakshouk Fish Research Station, Fayoum Governorate, National Institute of Oceanography and Fisheries (NIOF), Egypt. Rabbitfish (*Siganus rivulatus*) juveniles were obtained from (Mediterranean Sea) Maadia region- Behaira Governorate- Egypt. The initial average weight (W_1) for these juveniles was 0.948 g ± 0.124 (SE standard error) and initial average length (L_1) was3.97 cm ± 0.200 (in date, 7-8-2015).

The fish were acclimatized to be adapted to water salinity of Lake Qaroun which (33‰) for one week before size sorting and removal of large and small fish.

Diet preparation

One artificial diet was formulated by hand and used in this study with the first trial and the second trial (Table 1), the dietformulated to be almost containing 35% crude protein.

Table 1: Ingredient and chemical analysis proximate of the experimental diet.

Ingredients	**(g/100 g)**
Fish meal (72%CP)	22
Extruded full fat Soybean meal (37% CP)	43
Wheat bran minutes	28
Fish oil	4
Super yeast	1
Starch	1.7
Vit. & Min. & premix	0.3
Total	100
chemical analysis % on Dry matter basis	*As fed*
Moisture (M)	6.94
Dry matter (DM)	93.06
Crude protein (CP)	36.44
Ether extract (EE)	13.78
Crude fiber (CF)	3.10
Nitrogen free extract (NFE)	39.02
Ash	7.66
Gross energy (GE, Kcal/g)*	5.09
Protein / Gross energy (P/GE)	7.16

Notice:-Chemical analysiswas determined according to (A.O.A.C, 1984) and NFE was calculated by difference.

*, Calculated according to NRC (1993).

The first trial: Effect of stocking density

This trial was one way began 15/8/2015 and ended 26/11/2015, (103 days). Average initial weight (W_1) of juvenile was 0.948±0.124 g, initial average length (L_1) was 3.97 cm ± 0.200and initial condition index (CI_i) 1.51 gcm^{-3}.Itwas conducted to investigate the optimum stocking rate of rabbitfish juvenile.

Experimental hapas

The indoor hapas laboratory was made of plastic, this trial consisted of eight hapas, and each two hapas were put in large concrete pond ($10m^3$). The dimensions of each hapa were 3m length, 2m width and m height and the water volume of each hapa was 4 m^3.

Trial design and distribution of fish in hapsa

This trial consisted of four treatments including four of different stocking rate**.** In first treatment stocking rate was 10 fish per m^3, the second treatment stocking rate was 20 fish per m^3, the third and the fourth treatment stocking rate were 30 and 40 fish per m^3. Fish fed on diet (35% CP) Table (1) feeding rate was 5%of fish body weight and fish fed twice daily. The water exchange was made every two day for about 35% of water volume.

The second trial: Effect of the water exchange period

This trial also was conducted to investigate the optimum period of water exchange of rabbitfish juvenile growth and began 15/8/2015 and ended 17/11/2015, (95 days). Average initial weight (W_1) of juvenile was 0.948±0.124 g, initial average length (L_1) 3.97 cm ± 0.200 and initial condition index (CI_i) was 1.51 gcm^{-3}.

Experimental ponds

The indoor ponds laboratory were made of concrete, this trial was carried out in eight concrete ponds. The dimensions of each pond were 2m length, 2m width and m height and the water volume of each pond was $2m^3$.

Trial design and distribution of fish in ponds

This trial consisted of four treatments including four of different period of water exchange, where 50% of water volume was exchanged. In the first, second, third and fourth treatments, the water exchanged was made every day, two days, three days and four days, respectively. Fish fed twice daily on diet (35% CP) Table (1) feeding rate was 5% of fish body weight and fish were stocked at 40 fish per m^3.

The system of running water in experimental units (hapas and ponds) in two trials

The system contained on water pump, sand filter unit and two large tanks (1000 liter/tank) used to storage the water at a point between the water source (Lake Qaroun water) and experimental units. The water pump was drowning the water from water source to the sand filter unit, hence to the large tanks and hence to experimental units.

The system of aeration in experimental units (hapas and ponds) in two trials.

The system contained on air pump or blower connected to a network of plastic pipes this pipes transport the air to each experimental unit, the air was controlled by tap of each pond or tank, and the air diffusers was used to distribute of air in all experimental unit trends.

Water quality of the indoor (hapas and ponds) laboratory (in the experimental units).

The water quality of the indoor tanks laboratory (in the experimental units) were measured of each trial. Temperature, pH, salinity and EC were measured daily at 1pm; dissolved oxygen (DO) was measured every week and Nitrite (NO_2), Nitrate (NO_3), Ammonia (NH_4) were measured every two weeks. by centigrade thermometer; Orion digital pH meter model 201;Refractometer (VITAL Sine SR-6, China);

Conductivity meter model (YSI.SCT-33) and oxygen meter (Cole Parmer model 5946) respectively. While NO_2, NO_3 and NH_4were measured by the chemical methods according to (Mullin and Riley, 1955 and APHA, 1992).

Measurements of growth performance and some of the internal organs

Final condition index (CI_f), Total weight gain (TG), average daily gain (ADG), Relative growth rate (RGR), specific growth rate (SGR), survival rate (SR), hepatosomatic index (HSI), viscerosomatic index (VSI), feed intake g/ fish (FI), feed conversation ratio (FCR), feed conversation efficiency (FCE), protein efficiency ratio (PER), protein productive value (PPV), energy efficiency ratio (EER), energy productive value (EPV) and lipid retention (LR).

These parameters were calculated according the following equations:

($CI_{f,\ g/cm^3}$) = (W_2/ $L^3{}_2$) × X Whereas,W_2: is final weight,L_2: is the final length of fish in cm andX: is a constant equal to 100 (Anderson and Gutreuter, 1983), TG, g = final weight (W_2) – initial weight (W_1), ADG, g/day = average weight gain, g / experimental period, day, RGR, % = [(W_2 - $W_{1)}$ / W_1] × 100, SGR, % /day = [(ln W_2- ln W_1)/t] × 100 whereas ln: is the natural log., and t: is the time in days, SR% = (Number of fish at end/ Number of fish at start) × 100, (HSI, %) = (liver weight/body weight) ×100 and (VSI, %) = (weight of viscera and associated fat tissue/body weight) ×100.

Measurements of feed utilization efficiency

FI, g/fish feed intake during the trial period/ the final number of fish for this trial, FCR = feed intake, g / weight gain, g., FCE, % = (weight gain, g./ feed intake, g) × 100, PER= Weight gain, g/ Protein intake, g., PPV, % = (Retained protein, g/ Protein intake, g) × 100, EER = Weight gain, g/ Energy intake, Kcal, EPV, % = (Retained Energy, Kcal/ Energy intake, Kcal) × 100, LR, % = (Retained lipid, g/ lipid intake, g) × 100.

Chemical analysis of feeds and whole fish body

The conversional chemical analysis of diet and whole body fish samples were carriedout as described by (A.O.A.C, 1984) and Gross energy (GE) was estimated for formulated diets the factors 5.64, 9.44 and 4.11 Kcal/g for CP, EE and carbohydrates respectively were used (NRC, 1993), for fish 5.5 and 9.5 Kcal/g for protein and fat respectively (Viola *et al.*, 1981).

Statistical analysis

The analysis of variance and LSD of Duncan Waller were used to compare treatment means. Data were analyzed using statgraphic package software (SPSS, 2007) SPSS Inc. Released 2007. SPSS for Windows, Version 16.0. Level of significant was 0.05.

RESULTS AND DISCUSSION

1 The first trial: Effect of stocking density

Water quality of the first trail

Water quality parameters recorded in this experiment were shown in Table (2). The averages of water temperature, water pH, water salinity, electrical conductivity (EC), dissolved Oxygen, and nitrite (NO_2), nitrate (NO_3), ammonia (NH_4) concentration in all treatments were not affected by the high stocking rate and within the acceptable limits for rabbitfish, juveniles *Siganus rivulatus*, as reported by (Westernhagen and Rosenthal, 1975, Huguenin and Colt, 1989, Meade, 1989, Davis, 1993, Lawson, 1995, ANZECC, 2000, EPA, 2003, Saoud *et al.*, 2007a and Saoud *et al.*, 2008).

Table 2: Means (±SE) of water quality parameters

Items	Treatments (Stoking density fish/ m³)			
	(T1)10Fish/ m³	(T2) 20Fish/ m³	(T3)30Fish/ m³	(T4) 40 Fish/ m³
Temperature (ºC)	25.643±0.322	25.667±0.331	25.558±0.301	25.505±0.317
pH	8.310±0.177	8.360±0.181	8.133±0.154	8.117±0.182
Salinity ‰	33.472±0.199	33.525±0.272	33.425±0.181	33.335±0.170
ECmS/cm*	49.726±1.725	50.000±2.000	49.095±0.140	49.150±0.050
DO mg/l	7.300±.322	7.280±0.310	7.200±0.420	7.113±0.443
NO_2 mg/l	0.068±0.002	0.069±0.011	0.073±0.001	0.071±0.003
NO_3 mg/l	0. 465±0.004	0.460±0.001	0.470±0.014	0.482±0.002
NH_4mg/l	0.239±0.001	0.244±0.005	0.389±0.005	0.442±0.001

*,mS/cm, millisiemens/centimeter

Effect of stocking density on growth performance of rabbitfish (*Siganus rivulatus*) juvenile:

The results of growth performance, survival rate and some internal organs parameters of rabbitfish juvenile under different stocking rates were shown in **Table (3).** The results showed a significant differences at level (0.05) between the treatments in final condition index (CI_f, gcm^{-3}), length (L_2,cm) , final weight (W_2), total weight gain (TG,g), average daily gain (ADG, g/day), relative growth rate (RGR, %) specific growth rate (SGR,%/day) and survival rate (SR, %). The highest (W_2, g), (TG,g), (ADG, g/ day) and (SGR,%/day) were obtained with stocking density 10 fish and 20 fish /m³ likewise no significant differences between those treatments. The highest (L_2, cm) was recorded by stocking density (T2) 20 fish / m³ followed by stoking density (T3) 30 fish/ m³, (T4) 40fish / m³. While, the lowest (L_2, cm) was obtained with stocking density (T1) 10 fish/ m³. The highest CI_f(gcm^{-3}) was recorded by (T1) and no significant differences between (T1, T2 and T3) in (CI_f, gcm^{-3}). The highest (RGR, %) was recorded by (T2) followed by (T1, T3 and T4 respectively). The best (SR, %) was obtained with (T1) followed by (T2, T3 and T4 respectively). Also there are significant differences at level ($p \leq 0.05$) between the treatments inthe internal organs parameters. The highest (HSI, %) was recorded by (T2) followed by (T1, T3 and T4 respectively) and the highest (VSI, %) was recorded by (T3) followed by (T2, T1 and T4 respectively).

Table 3: Effect of stocking density on growth performance of rabbitfish (*Siganus rivulatus*) juvenile.

Items	Treatments (Stocking density fish/m)				SED*
	10 fish/m^3	20 fish / m^3	30 fish / m^3	40 fish / m^3	
(W_1), g	0.948	0.948	0.948	0.948	-
(L_2), cm	7.99^c	8.81^a	8.32^b	8.03^c	0.018
(CI_f, gcm^{-3})	1.20^a	0.90^b	0.94^b	0.90^b	0.013
(W_2), g	6.17^a	6.22^a	5.42^b	4.69^c	0.031
(TG), g	5.22^a	5.27^a	4.47^b	3.74^c	0.031
(ADG), g/day	0.050^a	0.051^a	0.043^b	0.036^c	0.001
(RGR),%	550.60^b	555.90^a	471.51^c	394.51^d	0.077
(SGR/day, %)	1.81^a	1.82^a	1.69^b	1.55^c	0.018
(SR, %)	77.5^a	71.25^b	57.5^c	58.75^c	0.500
Some of the internal organs parameters					
(HSI, %)	1.50^b	1.96^a	1.48^b	1.23^c	0.077
(VSI, %)	18.34^b	19.12^a	19.38^a	16.51^c	0.66

(a, b, c and d) Average in the same row having different superscripts significantly different at ($P \leq 0.05$).
*, SED is the standard error of difference

These results cleared that the decreasing stocking density affected positively on growth parameters. Whereas, (T2) 20fish/m^3 and (T1) 10fish / m^3 were better than

(T3) 30 fish / m^3 and (T4) 40fish/ m^3. The (T4) 40 fish / $m^3$was the worst and the lowest in all growth parameters. In spite of the statistical analysis did not clear significant differences between (T2) and (T1) in (W_2, g), (TG,g), (ADG, g/day) and (SGR,% day) still (T2) obtained the highest values with this parameters as well as the (T2) was the highest values in all parameters except (CI_f, gcm^{-3}) and (SR,%). The (T2) was the best in all treatments and stocking density above 20fish/ m^3 affected negatively on growth and survival rate. These results are in agreement with Bukhari (2005)who reported that, the correlation analysis showed that increasing stocking rate have a significant negative effect on rabbitfish weight increment. Abou-Zied and Ali (2012) who stated that as stocking density increased, the growth performance values decreased indicating an inverse relationship between stocking density and growth parameters. Saleh *et al.* (2016) reported that, four different stocking densities (10, 20, 30 and 40 fish / m^3) were tested for *Solea aegyptiaca*, the highest final weights of sole fish were recorded with stocking density 10 and 20 fish / m^3. Niazie *et al.* (2013) said that, statistically significant difference was observed between growth rate of different densities, as with increasing density, growth rate was significantly lower ($p<0.05$). Moreover, the highest specific growth rate was observed in low-density. In the same trend, Mollahand Nurullah (1988) found that decreasing stocking densityraises the growth rate in *Clarias macrocephalus.* Also, the growth in lower density was better than the higher density. In addition to El-sayed (2002) concluded that increasing growth and specific growth rates had a negative correlation with stocking density and was significantly decreased with increasing density.

Moreover, Khatune-Jannat *et al.* (2012) and Gholipour *et al.* (2007) in Thai climbing perch (*Anabas testudineus*) and rainbow trout (*Oncorhynchus mykiss*) respectively, concluded that increasing density has a negative effect on growth and specific growth rates, and the effect of stocking density can varied with the species. Adverse effects on growth performance at high stocking densities were observed in juveniles bluegills (*Lepomis macrochirus*), amur sturgeon (*Acipenser schrenckii*), and Nile tilapia (*Oreochromis niloticus*) (Yi and Kwei Lin, 2001, Anderson *et al.,* 2002 and Ni *et al.,* 2014a).

Generally, increases in stocking density results in directly increase on the stress condition, causing a reduction in growth rate and food utilization (Sharma and Chakrabarti, 1998). Inappropriate stocking densities may lead to por welfare and compromiso the health conditions of farmed fish, thus affecting also the profitability of the aquaculture industry (Huntingford *et al.,* 2006).Most of the studies on stocking density of different cultured fish species suggested that crowding of fish usually leads to suppressed growth rates (Holm *et al.,* 1990, Bjornsson, 1994, Irwin *et al.,* 1999 and Yousif, 2002). Also, Kebus *et al.* (1992) conducted that, social stress causing chronic stress response this leads in turn to impaired fish growth, presumable due to the mobilization of dietary energy by physiological alterations provoked by stress response.

Likewise, density was known to be a potential density source of stress (Pickering, 1993) which had a significant effect on fish growth rate (Fox and Flowers, 1990). Environmental stressors are the main factors that limit fish performance under aquaculture conditions (Ellis *et al.* 2002).

On the other hand, many studies have examined the effects of density on growth, but the results do not always agree such as Bukhari (2005) found that, final weight of the rabbitfish in three stocking rates did not differ significantly ($P>0.05$), Saoud *et al*. (2007b) they found that, no apparent effects of stocking density (10, 20, 30, 40 fish per 52-l aquarium) on the survival and growth of rabbitfish at the levels tested. Ebrahimi *et al.* (2010) and Hardy and Audet (1990) reported that density was not affected on growth rate in giant gourami (*Osphronemus goramy*) and Brock charr, respectively. Furthermore, other researchers have reported results where fish such as Arctic charr or European sea bass grew faster at high stocking densities (Wallace *et al.* 1988, Jørgensen *et al.* 1993 and Papoutsoglou *et al.* 1998).

The present study revealed that, the higher density affected on survival rate and was supported by Yousif *et al.* (2005) the survival rate of the rabbitfish fish under higher stocking density was lower than that of the fish under the lower stocking density. Mensah *et al.* (2013) reported that, the highest density recorded the least survival, could be attributed to overcrowding which led to competition forspace and food. Bukhari (2005) said that, correlation analysis showed that higher stocking rates may affect survival negatively ($r=-1.00$, $P<0.01$). In contrast, the high density has no significant effect on survival rate that is consistent with the findings of Saoud *et al.* (2007) on rabbitfish (*Siganus rivulatus*) and Saleh *et al.* (2016) who reported that, survival rate was within the range 85-90% without any differences at level ($p\leq0.05$) between the different densities of sole fish.

The final condition index (CI_f) was the best in (T1), this in similar with Lambert and Dutil (2001) found a negative effect of an increased stocking density of cod *Gadus morhus* on the condition index.

HSI decreased with increasing stocking density and relatively increasing of VSI up to (T3) 30fish/m^3 and decreased with (T4) 40fish/m^3, this in agreement with Leather land and Cho (1985) reported that HSI was significantly lower at high stocking density .Moreover, Ni *et al.* (2014b) cleared that, HSI decreased with the high density of Amur sturgeon (*Acipenser schrenckii*). In the Same trend VSI dcreased with increasing density, this reduction was interpreted by *Ni et al.* (2014b) they reported that, probably due to a worse nutritional state and an increased lipid mobilization at high stocking density.

Effect of stocking density on feed utilization efficiency of rabbitfish (*Siganus rivulatus*) juvenile:

Results of feed utilization efficiency were shown in Table (4).The data of feed utilization for juvenile trial showed significant differences at level (0.05) between treatments in feed intake (FI, g/fish), feed conversion ratio (FCR), feed conversion efficiency (FCE, %) protein efficiency ratio (PER), protein productive value (PPV, %), energy efficiency ratio (EER), energy productive value (EPV, %) and lipid retention (LR, %). The highest (FI, g/fish) was obtained with (T3) 30fish/$m^3$and followed by (T4, T2 and T1 respectively). No significant differences were found at level ($P\leq0.05$) between (T1 and T2) in feed conversion ratio (FCR) but a significant differences at level (0.05) were found between (T1,T2) and other the treatments.

The (T1) 10 fish/ m^3 had the highest (FCE, %), (PER), (PPV, %) and (EER) followed by (T2, T3 and T4 respectively).

The (T3) had the highest (PPV, %) and no significant differences were found at level (0.05) between (T1 and T2) in (PPV, %). The (T2) 20 fish/ m^3 had the highest (LR, %) followed by (T1, T4 and T3, respectively).

The results in Table (4) showed that, the (T3) had the highest (FI, g/Fish) this is naturally because the (T3) was higher in the stocking density than (T1, T2) and its growth rate was higher than (T4). These results cleared that, the lower stocking densities obtained the best of the feed utilization efficiency parameters. Not only the best (FCR) were observed by (T1 and T2) but also all parameters of the feed utilization efficiency were surpassed with (T1 and T2) comparable to the higher stocking densities (T3 and T4 respectively) while (T4) was the worst in all treatments of the feed utilization efficiency parameters.

Table 4: Effect of stocking density on Feed utilization efficiency of rabbitfish (*Siganus rivulatus*) juvenile.

Items	**Treatments (stocking density fish/m^3)**				**SED***
	10 fish/ m^3	**20 fish/ m^3**	**30 fish/ m^3**	**40 fish/ m^3**	
(FI, g/Fish)	13.09^d	14.33^c	16.68^a	15.30^b	0.0700
(FCR)	2.50^c	2.70^c	3.73^b	4.09^a	0.1000
(FCE, %)	39.87^a	36.77^b	26.79^c	24.44^d	0.0140
Protein utilization					
(PER)	1.09^a	1.00^b	0.73^c	0.67^d	0.0100
(PPV, %)	51.40a	42.30^b	32.79^c	26.98^d	0.1000
Energy utilization					
(EER, g/Kcal)	0.078^a	0.072^b	0.051^c	0.048^c	0.0018
(EPV, %)	49.40^b	49.54^b	58.92^a	32.12^c	0.0700
Lipid utilization					
(LR, %)	113.30^b	127.85^a	81.46^d	83.66^c	0.2750

(a, b, c and d) Average in the same row having different superscripts significantly different at ($P \leq 0.05$).
*, SED is the standard error of difference

Assurance of these results, it was supported by El-Sayed (2002) who found a negative correlation between growth and feed efficiency in Nile tilapia stocked at various densities. Abou-Zied (2015) said that, the lowest density of African catfish obtaind the best (FCR). Mensah *et al.* (2013) reported that, the higher density affected negatively on (FCR) of Nile tilapia fry. Gholipour *et al*. (2007) found that, feed conversion of rainbow trout ratio at lower densities were better than those at higher densities.

On the other hand, Niazie *et al.* (2013) found a feed conversion ratio significantly increased to increasing density. So that the highest feed conversion ratio was observed in the density of. Such as process of changes of feed conversion ratio in different densities show a significant positive correlation between increasing density and feed conversion ratio.

In this study, reducing the feed conversion ratio indicate better efficiency of food intake in lower densities may be associated with the lake of competition for feed at the higher densities. A decrease in efficiency of feed use may be an indicator of stress caused by high stocking density, may be more a consequence of reducing food intake that comes together with crowding stress and less with the strategy of individuals to adapt (Rafatnezhad and Falahatkar 2011). The crowding has shown to interfere with feeding efficiency of many fish species (Beitinger, 1990, Montero *et al.,* 1999 and Yousif, 2004).

On the contrary, these results in disagreement with Yousif *et al.* (2005) the relatively increased FCR values obtained for both treatments are not surprising bearing in mind that the feed administered to the experimental fish was in fact shared by other wild fish fry freely entering the cages. In another study on giant gourami (*Osphronemus goramy*), Ebrahimi *et al*. (2010) concluded that feed conversion ratio had not significant difference at different densities. Likewise, Papoutsoglou *et al*. (1998) found that, feed conversion ratio of European sea bass was lower at higher densities.

Effect of stocking density on body chemical composition and energy content of whole body rabbitfish (*Siganus rivulatus*) juvenile:

Body chemical composition and energy content of whole body rabbitfish (*Siganus rivulatus*) juvenile sat the beginning and the end of the experimental period were shown in Table (5). Body chemical composition and energy content of whole body rabbitfish juvenile were affected by stocking density at the end of the experimental period. Moisture (M), dry matter (DM), crude protein (CP), ether extract (EE) contents and gross energy (GE, Kcal/g) of fish body whole body significantly differed at level (0.05) the treatments. The (T1) had the highest (CP) followed by (T3, T2), while the (T4) had the lowest (CP).The (T2) had the highest (EE) followed by (T4, T3 and T1 respectively). The (T2) had the highest (GE, Kcal/g) followed by (T4) and (T3) but the (T1) was the lowest between the treatments.

Table 5: Effect of stoking density on body chemical composition and energy content (on DM basis) of whole body rabbitfish (*Siganus rivulatus*) juvenile.

Items	Start	Treatments (Stoking density fish/ m^3)				SED*
		(T1)10 fish/ m^3	(T2)20 fish/ m^3	(T3)30 fish/ m^3	(T4)40 fish/ m^3	
(M, %)	81.48	69.28^a	66.93^c	67.97^b	67.98^b	0.014
(DM, %)	18.52	30.72^c	33.04^a	32.03^b	32.02^b	0.044
(CP, %)	62.02	49.26^a	44.95^c	47.62^b	44.62^d	0.044
(EE, %)	11.78	34.94^c	42.39^a	36.78^c	40.00^b	1.053
Ash, %	24.03	11.04	11.72	11.14	11.18	1.452
(GE, Kcal/g)	4.53	6.03^c	6.50^a	6.11^c	6.25^{ab}	0.100

(a, b, c and d) Average in the same row having different superscripts significantly different at ($P \leq 0.05$).
*, SED is the standard error of difference

No significant differences in ash between all treatments. This results was similar to Abou-Zied (2015) reported that, crude protein of whole body African catfish at the end of experiment was significantly affected by stocking density and the least (CP) was recorded by the highest density. As well as Saleh *et al.* (2016) found that, the highest (CP) and the lowest (EE) was obtained with the least density of whole body sole fish. The results contradicted with El-Sayed (2002) who said that body composition of Nile tilapia fry not significantly affected by stocking density.

The second trial: Effect of the water exchange period

Water quality of the second trail

Water quality parameters recorded in this experiment are shown in Table (6). In this trail the averages of water quality parameters were statistical analyzed to indicate the differences between the treatments. The statistical analysis revealed significant differences at level (0.05) in water pH, electrical conductivity (EC), dissolved Oxygen (DO), nitrite (NO_2), nitrate (NO_3) and ammonia (NH_4) concentration. The fourth treatment (water exchange every four days) was the highest in water pH, nitrite (NO_2), nitrate (NO_3) and ammonia (NH_4) concentration followed by the third treatment (T3, water exchange every three days) and the second treatment (T2, water exchange every two days).While, the first treatment (T1, water exchange every day) was the lowest in this parameters. The (T1) had the highest concentration of (DO) while the (T4) had the lowest concentration of (DO).

Although, there were significant differences between the treatments and increased of the water exchange period, which negatively affected on the water quality such as (T4) but all averages of water quality parameters in these treatments were proportions for rabbitfish juvenile growth and within the acceptable limits for rabbitfish (*Siganus rivulatus*) juvenile as reported by (Westernhagen and Rosenthal, 1975, Huguenin and Colt, 1989, Meade, 1989, Davis, 1993, Lawson, 1995, ANZECC, 2000, EPA, 2003, Saoud *et al*., 2007a and Saoud *et al*., 2008).

Table 6: Means (±SE) of water quality parameters

Items	Treatments (water exchange at rate 50% of water volume)				SED**
	(T1) Every day	(T2) Every two days	(T3) Every three days	(T4) Every four days	
Temperature (°C)	26.544±0.296	26.007±0.285	25.797±0.278	25.710±0.266	0.707
pH	8.080±0.184^{c}	8.062±0.170^{c}	8.152±0.122^{b}	8.320±0.230^{a}	0.013
Salinity ‰	33.648±0.002^{c}	33.651±0.001^{c}	33.720±0.010^{b}	33.778±0.004^{a}	0.007
ECmS/cm*	46.550±0.104^{b}	47.100±0.041^{ab}	47.300±0.091^{a}	47.525±0.165^{a}	0.223
DO mg/l	6.560±0.004^{a}	6.565±0.006^{a}	6.132±0.008^{b}	6.062±0.008^{c}	0.014
NO_2 mg/l	0.050±0.001^{b}	0.062±0.001^{b}	0.068±0.022^{b}	0.162±0.002^{a}	0.007
NO_3 mg/l	0.101±0.022^{d}	0.216±0.038^{c}	0.320±0.130^{b}	0.333±0.048^{a}	0.001
NH_4mg/l	0.559±0.051^{d}	0.578±0.065^{c}	0.588±0.077^{b}	0.602±0.325^{a}	0.002

(a, b, c and d) Average in the same row having different superscripts significantly different at (P≤0.05).
*,,mS/cm, millisiemens/centimeter
**, SED is the standard error of difference

Effect of water exchange period on growth performance of rabbitfish (*Siganus rivulatus*) juvenile:

Effect of water exchange period on growth performance of rabbitfish juvenile were showed in Table (7). The results demonstrated that, the detrimental effect of the water exchange every day and two days. There were significant differences between treatments in (W_2, g), (TG, g), (ADG, g/day), (RGR, %) and (SR, %) and No significant differences were found between the treatments in (L_2, cm), (CI_f, g/cm^3), (HSI, %) and (VSI, %). The third treatment T3had highest (W2, g), (TG, g), (ADG, g) and (RGR, %) followed by the T4, the T1 and the T2 respectively. While no significant differences between the (T1) and the (T2) in (W_2, g), (TG, g), (ADG, g/day) and (SGR/day, %)

Table 7: Effect of water exchange period on growth performance of rabbitfish (*Siganus rivulatus*) juvenile.

Items	Treatments (water exchange at rate 50% of water volume)				SED*
	(T1) Every day	(T2) Every two days	(T3) Every three days	(T4) Every four days	
(w_1), g	0.948	0.948	0.948	0.948	-
(L_2), cm	8.00	7.90	7.87	8.05	0.707
(CI_f, g/cm^3)	1.07	1.09	1.40	1.30	0.316
(W_2), g	5.52^{c}	5.49^{c}	6.86^{a}	6.80^{b}	0.018
(TG), g	4.58^{c}	4.55^{c}	5.92^{a}	5.86^{b}	0.018
(ADG), g/day	0.048^{b}	0.047^{b}	0.062^{a}	0.061^{a}	0.0018
(RGR),%	488.29^{c}	484.04^{d}	629.78^{a}	623.40^{b}	0.070
(SGR/day, %)	1.86^{b}	1.85^{b}	2.09^{a}	2.08^{a}	0.012
(SR, %)	78^{b}	85^{a}	71.25^{c}	73.75^{c}	1.01
Some of the internal organs parameters					
(HSI, %)	1.90	1.35	2.47	2.39	0.44
(VSI, %)	20.21	20.82	23.26	20. 96	1.60

(a, b, c and d) Average in the same row having different superscripts significantly different at (P≤0.05).
*, SED is the standard error of difference

The best (SR, %) was achieved with (T2) and (T1) respectively and No found significant differences were found between the (T4) and (T3) in (SR, %), this result is in agreement with (Okomoda *et al.,* 2016).

Table (7) cleared that, the third treatment T3 (water exchange every three days) was the best in all treatments in the growth performance parameters followed by the (T4) (water exchange every four day) and this affirmed that, the water quality did not has role or effect on growth performance parameters and increased of the water exchange period positively affected on growth performance, this attributed to repeat the anxiety, the hassle and the stress every day or every two days with both the (T1) and (T2) were caused by the exchange water and reduce of the volume water and then adding water from the taps and continuous interference with the dynamics of the pond system on a daily basis as a result of frequent disturbance of the water surface and possible frequent changes in water quality. The fish can be highly affected by an increase of stress (Tom, 1998, Moyle and Cech, 2000 and Poon *et al.,* 2002).

The results in agreement with Absalom and Omenaihe (2000) who observed that the less the frequency of wáter replacement, the betterthe growth performance and survivalrate of the fishfry. Okomoda *et al.* (2016) demonstrated that frequency of water renewal has significant effect on growth performance and nutrient utilization of African catfish fingerlings. Fish constantly disturbed by daily water change had lesser growth performance compared to those raised in culture pond in which water was renewed every week and ever four days. In addition to Chamberlain and Hopkins (1994) reported that water exchange and feed protein level had no impact on the performance of tilapia reared intensively in earthen ponds if sufficient aeration was provided.

The results were in partial agreement with (El-Sayed *et al*., 2005) who cleared that, continuous water exchange generally sustains the good quality of culture water, while low or zero water exchange may reduce the quality of the water. In addition, at a very high water flow rate, the fish spend a substantial amount of dietary energy for continuous swimming, leading to reduced growth and increased mortality. Assurance of this, Ghanawi *et al.* (2010) demonstrated that *S. rivulatus* juveniles reared in circular tanks without water current grow faster than when maintained in tanks with water movement and reported growth differential is probably associated with an increase in energy demands required to hold position against currents (Jobling *et al.* 1993).

The results fall off Ajiboye *et al*. (2015) who indicated that water exchange was a critical factor that should be considered in growth of catfish and reported that the water change every day and two days achieved the highest final weight and specific growth rate compared to the water change every three, four and five days. Jha and Barat (2005) also found that, a daily water exchange appeared positively effect on weight gain of Ornamental carp (*Cyprinus carpio*).

Effect of water exchange period on Feed utilization efficiency of rabbitfish (*Siganus rivulatus*) juvenile:

As in Table (8).The results cleared that, there are significant differences at level (0.05) in all feed utilization efficiency parameters between the treatments. The (T1) had the highest (FI, g/fish); while the (T2) had the lowest (FI, g/fish).The best (FCR) was achieved by the (T3) followed by the (T4); while the worst (FCR) was obtained with the (T1) and the (T2) respectively; the same trend was (FCE). The (T3) had the highest (PER, g), (PPV, %), (EER, g/Kcal) and (EPV, %) followed by the (T4), the (T2) and the (T1) respectively. The highest (LR, %) was achieved by the (T3) then the (T4) and (T2); but the (T1) had the lowest (LR, %) in all the treatments.

Table 8: Effect of water Exchange period on feed utilization efficiency of rabbitfish (*Siganus rivulatus*) juvenile.

Items	Treatments (water exchange at rate 50% of water volume)				SED*
	(T1) Every day	(T2) Every two days	(T3) Every three days	(T4) Every four days	
(FI, g/Fish)	13.53^{a}	11.57^{d}	12.88^{c}	13.42^{b}	0.018
(FCR)	2.95^{a}	2.54^{b}	2.17^{d}	2.29^{c}	0.014
(FCE, %)	33.85^{d}	39.32^{c}	45.96^{a}	43.66^{b}	0.014
Protein utilization					
(PER)	0.92^{d}	1.08^{c}	1.26^{a}	1.19^{b}	0.014
(PPV, %)	52.95^{d}	55.25^{c}	63.41^{a}	57.52^{b}	0.014
Energy utilization					
(EER, g/Kcal)	0.066^{c}	0.077^{b}	0.090^{a}	0.085^{ab}	0.004
(EPV, %)	36.47^{d}	47.60^{c}	58.08^{a}	52.84^{b}	0.071
Lipid utilization					
(LR, %)	60.84^{d}	100.47^{c}	128.58^{a}	117.09^{b}	0.014

(a, b, c and d) Average in the same row having different superscripts significantly different at ($P\leq0.05$).
*, SED is the standard error of difference

The results in Table (8) confirmed that, the third treatment T3was the best in all the feed utilization efficiency parameters in comparison with the other treatments in addition to the (T4) was the better than the (T2) and the (T1).

In spite of Table (6) showed that, the (T1) and the (T2) were the better than the (T3) and the (T4) in the water quality parameters; nevertheless, the (T3) and the (T4) were better than the (T2) and the (T1) in the feed utilization parameters. This consider in taken of the water quality in this study was good for rabbitfish juvenile growth and the long of water exchange period dos not effect on the water quality. Hence, the positive effect of the long of water exchange period in the feed utilization parameters which observed in the (T3) and the (T4) may be returned to the (T1) and (T2) fish consumed the larger amount of energy to parry the repeated stress, harassment or disturbance resulting from the water exchange operation every day or every two days than the (T3) and (T4) fish. This led to decreased in all the feed utilization parameters and increased in (FI, g/fish) of the (T1) and (T2) fish in contrast with the (T3) and (T4). This results in partial agreement with Ghanawi *et al.* (2010) who demonstrated that, *S. rivulatus* juveniles reared in circular tanks without water current had better FCR than those maintained in tanks with water movement, whereas when no current was present fish swam freely in the tanks and maintained position near feed and an increase in energy demands required to hold position against currents. Okomoda *et al.* (2016) found that, no significant differences in (FCR) between water renewed daily and water renewed after four days of *Clarias gariepinus* fingerlings.

On the other hand, Ajiboye *et al*. (2015) found that the water change every day and two day achieved the better (FCR) than the water changed every three, four and five day. Some studies may be in the same trend, Nastova *et al.* (2012) investigated the influence of a different number of water exchanges per day on the growth of rainbow trout (*Salmo truta)* and reported that, the lowest value of food conversion was achieved with 72 water exchanges per day proving thereby that food was utilized most efficiently under these conditions.

Effect of water exchange period on body chemical composition and energy content of whole body rabbitfish (*Siganus rivulatus*) juvenile:

Body chemical composition and energy content of whole body rabbitfish (*Siganus rivulatus*) juvenile at the beginning and the end of the experimental period are shown in Table (9). Body chemical composition and energy content of whole body rabbitfish juvenile at the end of the experimental period were affected by the period of water exchange. Moisture (M), drymatter (DM), crudeprotein (CP), etherextract (EE), ashcontents and grossenergy (GE, Kcal/g) of fish who lebody significantly differed at level (0.05) between the treatments. The (T1) had the highest (CP) followed by the (T2, T3 and T4 respectively).Despite the insignificant differences between the (T3, T4 and T2) in (EE) and (GE, Kcal/g), the (T3) had the highest (EE) and (GE, Kcal/g) followed by (T4 and T2) while the (T1) had the lowest (EE) and (GE, Kcal/g). The (T1) was the highest in ash while the lowest ash was noticed in the (T3) without any significant differences in ash content between these treatments.

Table 9: Effect of water exchange period on body chemical composition and energy content (on DM basis) of whole body rabbitfish (*Siganus rivulatus*) juvenile.

Items	Start	Treatments (water exchange at rate 50% of water volume)				SED*
		(T1) Every day	(T2) Every two days	(T3) Every three days	(T3) Every four days	
(M, %)	81.48	71.06^{b}	68.64^{d}	68.74^{c}	71.27^{a}	0.0137
(DM, %)	18.52	28.94^{c}	31.36^{a}	31.26^{b}	28.73^{d}	0.0137
(CP, %)	62.02	57.95^{a}	53.18^{b}	52.02^{c}	50.10^{d}	0.044
(EE, %)	11.78	22.58^{b}	31.22^{a}	34.90^{a}	33.49^{a}	1.45
Ash, %	24.03	19.47^{a}	15.61^{ab}	14.05^{b}	16.97^{ab}	1.42
(GE, Kcal/g)	4.53	5.33^{b}	5.89^{a}	6.18^{a}	5.94^{a}	0.137

(a, b, c and d) Average in the same row having different superscripts significantly different at ($P \leq 0.05$).
*, SED is the standard error of difference

The results in Table (9) cleared that the (EE) and (GE, Kcal/g) increased with increasing the period of water exchange whereas the (T3) was the highest followed by The (T4), the (T2) and (T1) respectively. This consider in consequence of the (T1 and T2) spent more energy to cope with repetitive stress resulting from the ponds filling and emptying at the rate of water exchange than their counterparts the (T3 and T4) according to Yogata and Oku (2000).

CONCLUSION

In view of the present study results we found that, the high stoking density lead to increase competition between the individuals or fish causing more energy consumption to increase competitiveness, and cause negatively effects on growth performance and feed utilization efficiency of rabbitfish juvenile. Also, the results cleared that an increased the period of water exchange up to every three days lead to improve in the growth rate and feed utilization of rabbitfish juvenile provided that, not deteriorate in the water quality parameters and are within the acceptable limits for growth rabbitfish juvenile. Significance of these differences may be lead to reduce production costs, the water conservation and reduce the use of water pumps. the present study results concluded that an increased the fish number above 20fish /m^3 lead to decrease in the growth performance and feed utilization of rabbitfish juvenile; in addition to the water exchange every three days at rate 50% of the water volume lead to improve the growth performance and feed utilization efficiency of rabbitfish juvenile.

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ARABIC SUMMARY

تأثير كثافة التخزين وفترة تغيير المياه على مظاهر النمو ، كفاءة الأستفادة من الغذاء والتركيب الكيميائى للجسم لصغار أسماك السيجان (البطاطا) تحت ظروف المعمل

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أجريت تجربتين على صغارأسماك السيجان (البطاطا) وزنها الابتدائى ٠.٩٨٤ ±٠.١٢٤ جرام ، لتحديد أفضل كثافة تخزين والفتره المثلى لتغيير المياه للحصول على أفضل نمو وأعلى استفادة من الغذاء. التجربة الاولى أختبرت أربع كثافات مختلفة داخل هابات وضعت فى أحواض كبيرة (١٠ متر مكعب) داخل المعمل (١٠-٢٠-٣٠-٤٠ سمكة / متر مكعب) وأظهر التحليل الاحصائى اختلافات معنوية بين المعاملات وأن زيادة الكثافة عن ٢٠ سمكة /المتر المكعب تؤثر سلبيا على مظاهرالنمو والكفاءة الغذائية.

التجربة الثانيةأجريت داخل المعمل ايضا فى أحواض أسمنتية، أختبرت أربع فترات مختلفة لتغيير المياه بمعدل ٥٠% من حجم المياه بكل معاملة فكانت المعاملات كالتالى (تغيير المياه كل يوم ، تغيير المياه كل يومان، تغيير المياه كل ثلاثة ايام و تغيير المياه كل أربعة ايام) أظهرت النتائج أن جودة المياه فى المعاملات الاربعة كانت فى الحدود المقبولة لنمو الاسماك و تغيير المياه كل ثلاثة ايام أعطى أفضل معدل نمو وأفضل كفاءة غذائية وقلل من استهلاك المياه ومضخات رفع المياه المتكرر يوميا او كل يومان كما حدث فى المعاملتين الاولى والثانية.