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Effect of feeding level &fish densit[illegible] and food conversion of cultured white-spotted rabbitfish (*Siganus canaliculatus* Park, 1797)

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SUMMARY

The effects [of three feeding levels (5, 10 and 15)% of fish weight on food conversion rate (FCR) and specific growth rate (SGR) of juvenile white-spotted rabbitfish (*Siganus canaliculatus* Park, 1797)] were studied in aquariums fish laboratory of Sammaliah Island–Abu Dhabi during first May to 30 June of 2001. Statistical analysis proved that there are significant differences between FCR (2.46, 1.98 and 4.77) and SGR (1.97, 3.44 and 3.22) for white-spotted rabbitfish reared at different feeding levels (5, 10 and 15) % respectively. The effects of three fish density (40, 80 and 120) fish/m^3 of fingerlings on FCR and SGR were studied in floating cages of Sammaliah Island during 3rd July to 20-November of 2002. Statistical analysis proved that there are significant differences between FCR (2.12, 2.52 and 1.71) and SGR (2.07, 2.23 and 2.75) for white-spotted rabbitfish reared at different feeding densities (40, 80 and 120) fish/m^3 respectively. It has been found that 10% feeding level and density of 120 fish/m^3 give better results from economical point of view.

Introduction

White-spotted rabbitfish inhabit coral reefs and estuaries, and also found in clear waters several kilometers far away from coasts (١١). Maximum total length of 33 cm for white-spotted rabbitfish was recorded in India (٧). The main food materials of white-spotted rabbitfish are plants, weeds and benthic algae (16).There are five species of siganus fishes recorded in Jeddah region of the Red Sea, but *Siganus rivulatus* is the most common (5). In the UAE waters there are two species of sigan fishes, white-spotted rabbitfish and streaked spinefoot, *Siganus javus* (13, 3 and 8). The culture of white-spotted rabbitfish is successful because of three reasons: (1) they had successful induced spawning (10, 1 and 14), (2) they accepted very well commercial fish food and (3) they reached marketable size (100 g) during one growing season (Personal Observations). Rabbitfish might have value as a service species in marine cages based on their ability to graze on net bio-fouling organisms (9). The purpose of this experiment was to determine the optimum and economical feeding level and fish density for reared white-spotted rabbitfish.

Materials and methods

The experiment of feeding levels effect was conducted in the fish laboratory of Sammaliah Island-Abu Dhabi from first May to 30 June of 2001, were nine aquariums were used with dimensions (80×40×35) cm. Juvenile white-spotted rabbitfish obtained from induced spawning which was carried on in the Marine Resources Research Center-Ummal Quwain Emirate-UAE. Fifty juveniles with an average weight of 0.41 g were put in each aquarium. Three feeding levels (5, 10 and 15) % of fish weight were tested with three replicates. Ground commercial fish food with 35% protein was used. Fishes were fed six days a week (Friday excluded), two times a day, the first in the morning and the second in the afternoon. The water was changed by siphon three times a weak. The measurements of total fish weight were taken periodically (nearly two weeks) and food weights were changed after each weighing.

The experiment of fish density effects was conducted in floating cages of Sammaliah Island-Abu Dhabi from 3rd July to 20-November of 2002. Six cages of dimensions (2.5 × 2.5 × 2.0) meters were used. Three fish densities were tested with two replicates. The volume of each cages nearly 8 cubic meters, so 300 fish (of average weight 3.6 g) were put in cage 1 and 2 each to get fish density of 40 fish per cubic meters. To get fish density of 80 fish per cubic meters, 600 fish (of average weight 4.3 g) were put in cages 3 and 4 each, while 900 fish (of average weight 2.5 g) were put in cages 5 and 6 each to get fish density of 120 fish per cubic meters. Ground commercial fish food with 35% protein was used with feeding level 15% of fish weight. Fishes were fed six days a week (Friday excluded), two times a day, the first in the morning and the second in the afternoon. No weighing for fish occurred from the beginning of the experiment till 14 October because of high temperatures (about 34°C) that affected fish during handling, so the amount of fish food was doubled at 25-August. Unconsumed food noticed in the cages lead to reducing feeding level from 15% to 7% of fish weight after fish weighing.

Food conversion rate (FCR) and specific growth rate (SGR) was estimated by the following equations (4):

$$FCR = \frac{\text{Weight of food consumed}}{\text{Increased weight of fish}}$$

$$SGR = \frac{\log w_2 - \log w_1}{t_2 - t_1} \times 100$$

Where w_2 is weight of fishes at time t_2 and w_1 is weight of fishes at time t_1. Daily growth rate was estimated by divided increasing of fish weight on number of days, while final fish production was estimated by dividing total fish weight at the end of experiment on the volume of cages (8 cubic meters). The complete randomized design used to statistical analysis of the results at 0.05 level of significance (2).

Results

Table (1) Shows increment in average weight of juveniles white-spotted rabbitfish reared in aquariums at different feeding levels. Initial weights were (0.36, 0.47 and 0.41) g and final weights were (1.16, 2.48 and 2.45) g for feeding levels (5, 10 and 15) % of fish weight respectively after 62 days. Table (2) shows the average of food conversion rate and specific growth rate for juveniles white-spotted rabbitfish reared in aquariums at different feeding levels. Food conversion rates (2.46, 1.98 and 4.77) were obtained with different feeding levels (5, 10 and 15) % of fish weight respectively. No significant differences ($p<0.05$)between specific growth rate (3.44, 3.22) for Juveniles white-spotted rabbitfish reared in aquariums at (10 and 15) % feeding levels respectively, while there are significant differences between them and the specific growth rate (1.97) of juveniles that reared in 5% feeding level (table, 2). Figure (1) shows growth in weight of juveniles white-spotted rabbitfish reared in aquariums at different feeding levels, where fishes reared in 5% feeding level had slower growth.

The results of fish density experiment were summarized in tables (3, 4 and 5). Table (3) shows the measurements of white-spotted rabbitfish fingerlings reared in floating cages at different densities, where maximum fish weight (114 g) achieved by fishes reared in cage 5 at fish density of 120 fish per cubic meter, while minimum fish weight (44.5 g) reached by fishes reared in cage 2 at fish density of 40 fish per cubic meter. Figure (2) shows weight increments of white-spotted rabbitfish fingerlings reared in floating cages at different fish densities. Fishes reared in floating cages at fish density of 120 fish per cubic meter grew faster than fishes reared in fish density of 40 and 80 fish per cubic meter, where final average weight reached by the first was 82.2 g comparing with (67.5 and 65.7) g for the second two fish densities respectively (figure, 2).

Table (4) shows the average values of food conversion rates and specific growth rates for white-spotted rabbitfish fingerlings reared in floating cages at different feeding densities. Fingerlings of white-spotted rabbitfish reared at fish density of 120 fish per cubic meter showed best results, where they have highest specific growth rate (2.75) and lowest food conversion rate (1.71), while fishes reared at density of 40 and 80 fish per cubic meter have food conversion rates of (2.12 and 2.52) and specific growth rates of (2.07 and 2.23) respectively.

Table (5) shows average values of final fish weights, daily growth rates and final fish productions for fingerlings white-spotted rabbitfish reared in floating cages at different feeding densities. Fishes reared at density of 40 and 80 fish per cubic meters have nearly the same daily growth rate (0.46 and 0.44) g/day respectively, while fishes reared at density 120 fish per cubic meter have daily growth rate of 0.57 g/day. Final fish productions increased with increasing fish density, where they are (2.53, 4.93 and 9.25) kg/m^3 for feeding densities of (40, 80 and 120) $fish/m^3$ respectively.

Table (1) Increments in average weight of juveniles white-spotted rabbitfish reared in aquariums at different feeding levels.

Feeding Level (%)	Average Weight of Fishes (g)				
	1/5/2001	12/5	26/5	13/6	30/6
5	$0.36_{\pm 0.06}$	$0.41_{\pm 0.10}$	$0.54_{\pm 0.12}$	$0.74_{\pm 0.14}$	$1.16_{\pm 0.18}$
10	$0.47_{\pm 0.12}$	$0.55_{\pm 0.12}$	$0.83_{\pm 0.21}$	$1.58_{\pm 0.24}$	$2.48_{\pm 0.29}$
15	$0.41_{\pm 0.10}$	$0.78_{\pm 0.15}$	$1.34_{\pm 0.24}$	$1.91_{\pm 0.25}$	$2.45_{\pm 0.29}$

Table (2) Food conversion rate and specific growth rate of juveniles white-spotted rabbitfish reared in aquariums at different feeding levels.

Feeding Level (%)	Date 2001	Food Conversion Rate	Average FCR	Specific Growth Rate	Average SGR
5	1/5/ to 12/5	3.34	$2.46_{\pm 0.66}$	1.66	$1.97_{\pm 0.40}$
	12/5 to 26/5	1.74		2.08	
	26/5 to 13/6	2.36		1.66	
	13/6 to 30/6	2.42		2.5	
10	1/5/ to 12/5	2.28	$1.98_{\pm 0.41}$	3.31	$3.44_{\pm 0.67}$
	12/5 to 26/5	1.51		4.24	
	26/5 to 13/6	1.77		3.59	
	13/6 to 30/6	2.36		2.62	
15	1/5/ to 12/5	1.7	$4.77_{\pm 3.09}$	5.65	$3.22_{\pm 1.91}$
	12/5 to 26/5	2.62		3.8	
	26/5 to 13/6	6.72		2.0	
	13/6 to 30/6	8.05		1.44	

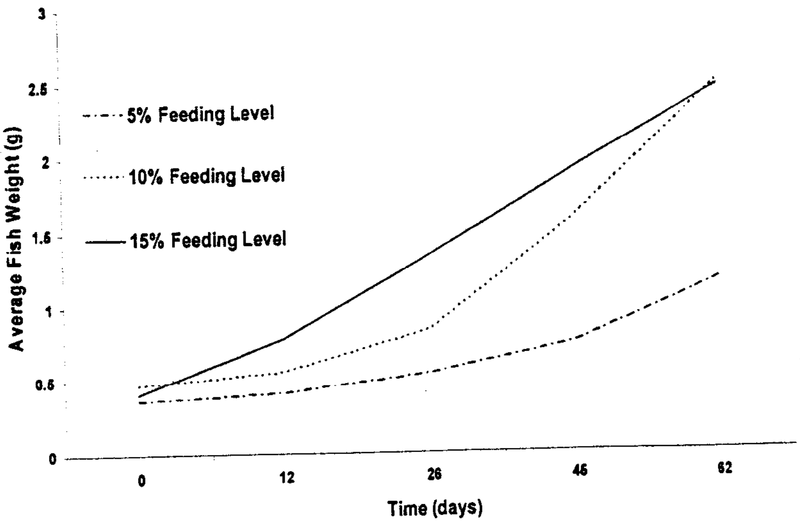

Figure (1) Growth in weight of juveniles white-spotted rabbitfish in aquariums at different feeding levels.

Table (3) Measurements of white-spotted rabbitfish fingerlings reared in floating cages at different densities.

Cage No.	Fish Density (fish/ m^3)	Measurement Date							
		3/7/2002			14/10/2002			20/11/2002	
		No. of examined fish	Average Fish Weight (g)	Daily Food Weight (g)	No. of examined fish	Average Fish Weight (g)	Daily Food Weight (g)	No. of examined fish	Average Fish Weight (g)
1	40	66	3.4$_{\pm1.51}$	153	32	42.8$_{\pm9.16}$	899	40	90.6$_{\pm17.85}$
2	40	93	3.8$_{\pm1.53}$	171	57	21.4$_{\pm6.31}$	449	64	44.5$_{\pm9.46}$
3	80	113	4.1$_{\pm1.58}$	369	56	16.8$_{\pm3.70}$	706	70	67.9$_{\pm15.07}$
4	80	130	4.4$_{\pm1.67}$	396	48	32.2$_{\pm8.62}$	1352	77	63.6$_{\pm15.27}$
5	120	150	1.9$_{\pm0.90}$	257	60	21.3$_{\pm6.22}$	1792	67	114$_{\pm17.87}$
6	120	126	3.0$_{\pm1.49}$	405	38	22.6$_{\pm6.42}$	1898	44	50.4$_{\pm11.94}$

Table (4) Food conversion rates and specific growth rates of white-spotted rabbitfish fingerlings reared in floating cages at different densities.

Density (fish/m^3)	Date (2002)	Food Conversion Rate	Average FCR	Specific Growth Rate	Average SGR
40	3/7 to 14/10	1.63	$2.12_{\pm 0.69}$	2.24	$2.07_{\pm 0.25}$
40	14/10 to 20/11	2.61		1.89	
80	3/7 to 14/10	2.73	$2.52_{\pm 0.30}$	2.57	$2.23_{\pm 0.48}$
80	14/10 to 20/11	2.31		1.89	
120	3/7 to 14/10	1.06	$1.71_{\pm 0.91}$	3.44	$2.75_{\pm 0.98}$
120	14/10 to 20/11	2.35		2.06	

Table (5) Daily growth rate and final production of white-spotted rabbitfish fingerlings reared in floating cages at different densities.

Fish Density (fish/m^3)	Average Fish Weight (g)			Daily Growth Rate (g/day)	Final Production (kg/m^3)
	3/7/2002	14/10/2002	20/11/2002		
40	$3.6_{\pm 1.53}$	$32.1_{\pm 12.71}$	$67.6_{\pm 26.18}$	0.46	2.53
80	$4.3_{\pm 1.64}$	$24.5_{\pm 9.97}$	$65.8_{\pm 15.27}$	0.44	4.93
120	$2.5_{\pm 1.32}$	$22.9_{\pm 6.30}$	$82.2_{\pm 19.73}$	0.57	9.25

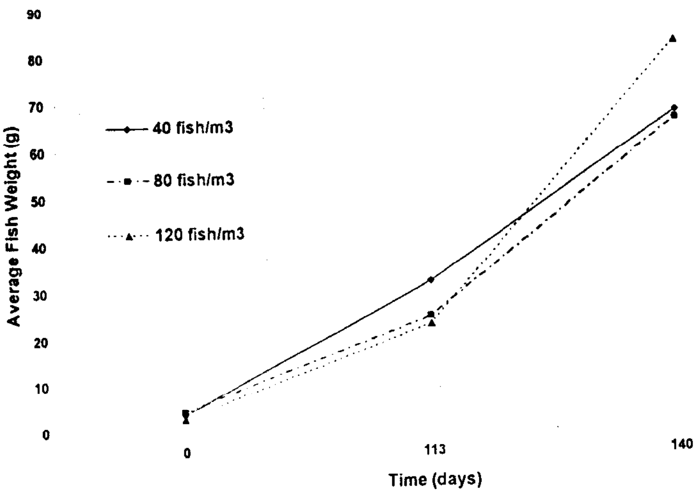

Figure (2) Growth in weight of fingerlings white-spotted rabbitfish reared in floating cages at different fish densities.

Discussion

Statistical analysis for the results showed that there are significant differences between food conversion rates and specific growth rates for juveniles white-spotted rabbitfish reared in aquariums at different feeding levels. It seems that 10% feeding level gave the most optimum growth in comparison with other levels (5% and 15%). The amount of food given for fish reared at 5% feeding level was not enough, so it resulted in lowest specific growth 1.97 and lowest final fish weight 1.16 g. This result can be strengthened by laboratory observations of attacking given food very quickly in comparison with fish reared at other feeding levels (10% and 15%).

Juveniles of white-spotted rabbitfish reared at 15% feeding level gave un good food conversion rate (4.77) in comparison with other levels (5% and 15%). It can be concluded that these fishes didn't consume all the amount of food. This result can be strengthened firstly by daily unconsummated food that was found in aquariums of 15% feeding level in comparison with other two feeding levels, and secondly by nearly same values of specific growth rates and final fish weights for fishes reared at 10% and 15% feeding level. From previous results and observations, feeding level of 10% can be recommended for commercial fish farms, but it is necessary to mention here that this feeding level must be reduce when fish become larger. More researches are needed to determine optimum feeding levels for different sizes of white-spotted rabbitfish.

The results of this experiment are similar to the results of the experiments in the Marine Resources Research Center of Ummal Quwain Emirate–UAE, where previous experiment finds that food conversion of white-spotted rabbitfish was (2.1-2.4) when reared on commercial pellets at a rate of feeding level 10%. After 146 days of experiment, it was found that better growth and survival rates of white-spotted rabbitfish could be achieved through a combination diet comprising of compound feed and fresh sea algae equivalent to about (50-75)% of fish body weight (15).

White-spotted rabbitfish fingerlings reared in floating cages at different fish density show an average values (2.12, 2.52 and 1.71) of food conversion rate and average values (2.07, 2.23 and 2.75) of specific growth rate for feeding densities (40, 80 and 120) fish/m^3 respectively. Statistical analysis of these results shows that there are significant differences between food conversion rates and specific growth rates for white-spotted rabbitfish fingerlings reared at different densities. These differences may be attributed to fish crowded in higher densities that reduce fish movement and then reduce the energy that loosed by this movement.

Statistical analysis proved that there are significant differences between final fish weights reached by white-spotted rabbitfish fingerlings reared in floating cages at different fish densities. Fingerlings reared at a density of 120 fish per cubic meter has faster daily growth rate in comparison with other two densities. Statistical analysis proved that there are significant differences between daily growth rates of fingerlings white-spotted rabbitfish reared in floating cages at different fish densities. The final fish production increased with increasing fish density, and Statistical analysis proved that there are significant differences between fish production for fish reared at different densities. From above results it is recommended to reared white-spotted rabbitfish in sea cages at a density of 120 fish/m^3.

It seemed that the results of this experiments about food conversion rates (1.98 and 1.71) for white-spotted rabbitfish reared in aquarium at 10% feeding level and in floating cages at fish density of 120 fish/m^3 respectively are considerable, especially when compared with FCR of the most common fishes used in commercial farms such as: [for common carp (*Cyprinus carpio*) the FCR was 1.72 (Huisman, 1976), for Tilapia (*Tilapia aurea*) reared in different salinities was (2.5-3.5), for largescale mullet (*Liza macrolepis*) was 4.45 and for yellowfin seabream (*Acanthopagrus latus*) was 2.24 (10) and finally for gilthead seabream (*Sparus aurata*) was 1.43 (12)] .

تأثير الكثافة السمكية ومستوى التغذية على النمو ومعدل التحول الغذائي لأسماك الصافي العربي white-spotted rabbitfish (*Siganus canaliculatus* Park, 1797)

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الملخص

تم دراسة تأثير ثلاثة مستويات تغذية (٥، ١٠، ١٥)% من وزن الاسماك على كل من معدل التحول الغذائي ومعدل النمو النوعي ليافعات أسماك الصافي العربي (White-spotted rabbitfish, *Siganus canaliculatus*, Park 1770)، وذلك في الاحواض الزجاجية لمختبر الاسماك في جزيرة السمالية–أبوظبي، للفترة من الاول من شهر مايس ولغاية الثلاثون من شهر حزيران. أظهرت التحليلات الاحصائية للنتائج وجود فروقات معنوية بين معدل التحول الغذائي (٢,٤٦، ١,٩٨، ٤,٧٧) ومعدل النمو النوعي (١,٩٧، ٣,٤٤، ٣,٢٢) لمستويات التغذية (٥، ١٠، ١٥)% بالتعاقب. كما تم دراسة تأثير ثلاثة كثافات سمكية (٤٠، ٨٠، ١٢٠) سمكة/م³ على معدل التحول الغذائي ومعدل النمو النوعي لأصبعيات أسماك الصافي العربي المرباة في الاقفاص البحرية العائمة لجزيرة السمالية، وذلك للفترة من الثالث من تموز لغاية العشرون من تشرين الاول لعام ٢٠٠٢. أظهرت التحليلات الاحصائية للنتائج وجود فروقات معنوية بين معدل التحول الغذائي (٢,١٢، ٢,٥٢، ١,٧١) ومعدل النمو النسبي (٢,٠٧، ٢,٢٣، ٢,٧٥) لأسماك الصافي العربي المرباة في كثافات سمكية مختلفة (٤٠، ٨٠، ١٢٠) سمكة/م³ بالتعاقب. أثبتت النتائج ان مستوى التغذية ١٠% من وزن الاسماك والكثافة السمكية ١٢٠/م³ تعطي أفضل النتائج من وجهة النظر الاقتصادية.

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