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紅色吳郭魚鹹水養殖之可行性研究

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STUDIES ON THE FEASIBILITY OF RED TILAPIA CULTURE IN SALINE WATER*

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ABSTRACT

Having a glorious reddish coloration and lacking black peritoneum, red tilapia (Oreochromis sp.) are very similar to the precious sea bream (Chrysophrys major). It has been proved that red tilapia are preferred over common tilapia by the consumers in Taiwan; the meat of red tilapia cultured in saline water is quite suitable for preparing "Sashimi"; their culture in the sea water and brackish water usually results in a lower fecundity, and can prevent excessive recruitment in the culture pond. The aim of this study is to evaluate the feasibility of red tilapia culture in saline water. Red tilapia were cultured separately in sea water (34‰), brackish water (17‰) and fresh water (1.5-2.0‰) for comparison. In mixsex rearing experiment, the results showed that the red tilapia reared in brackish and sea water grew faster than those reared in fresh water. But in all male rearing experiment, the best growth was obtained from the fish reared in fresh water. The results also showed that the variation of body weight from saline water was larger than that from fresh water. The territoriality and mating behavior probably cause the differences in growth among the fish reared in three different salinity of waters. The only disadvantage for the red tilapia cultured in saline water is that they are easily bruised, and attacked by fish lice resulting in a lose of appetite and even death. However, disinfection treatment after handling for measurements will reduce this symptom. Considering the above fact, red tilapia can be cultured in saline water satisfactorily. It is thus suggested that a project for culturing red tilapia in shallow sea or in cages in sea bay should have a good promise in the future.

INTRODUCTION

Red tilapia (Oreochromis sp.) is a hybrid produced by the interbreeding between O. niloticus and the mutant of O. mossambicus. The habit of red tilapia is extremely similar to that of the common mouthbrooding tilapia. Red tilapia is also omnivorous, reproductive and euryhaline, and is highly resistant to diseases.

Having a glorious reddish coloration and lacking black coloration on peritonium, red tilapia look very similar to sea bream (Chrysophrys major), and are highly preferred by the consumers. The meat of red tilapia cultured in saline water is quite suitable for preparing "Sashimi". Culturing the red tilapia in sea water and brackish water usually results in a lower fecundity, and can prevent excessive recruitment in the culture pond (Chervinski and Yashouv, 1971). The aim of this experiment is to evaluate the feasibility of red tilapia culture in saline water.

MATERIALS AND METHODS

Experiment I

The red tilapia used in this experiment had a mean body weight of 18 g, and were produced by the same group of spawners in the fresh water.

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* Contribution A No. 49 from the Tungkang Marine Laboratory.

They were reared in a 1.8 ton fiber glass tank for a week, and then separated randomly into three treatment groups (A_1, B_1, C_1). They are, A_1: fresh water (S = 1.5‰); B_1: brackish water (17‰); C_1: sea water (34‰). Every treatment was carried out in triplicate. Thirty animals were reared in each tank. The fish were acclimated gradually from fresh water to brackish water in one day, and acclimated to sea water in two days; they were not fed during the acclimation.

The experimental F.R.P. tanks are rectangular (2 x 1.2 x 0.75 m), with rearing water kept at 1.3 - 1.4 ton usually. Each tank was equipped with a filtering system to filter the floating debris and algae by air-lift method (Fig. 1); about 3 tons of water passed through the filter per

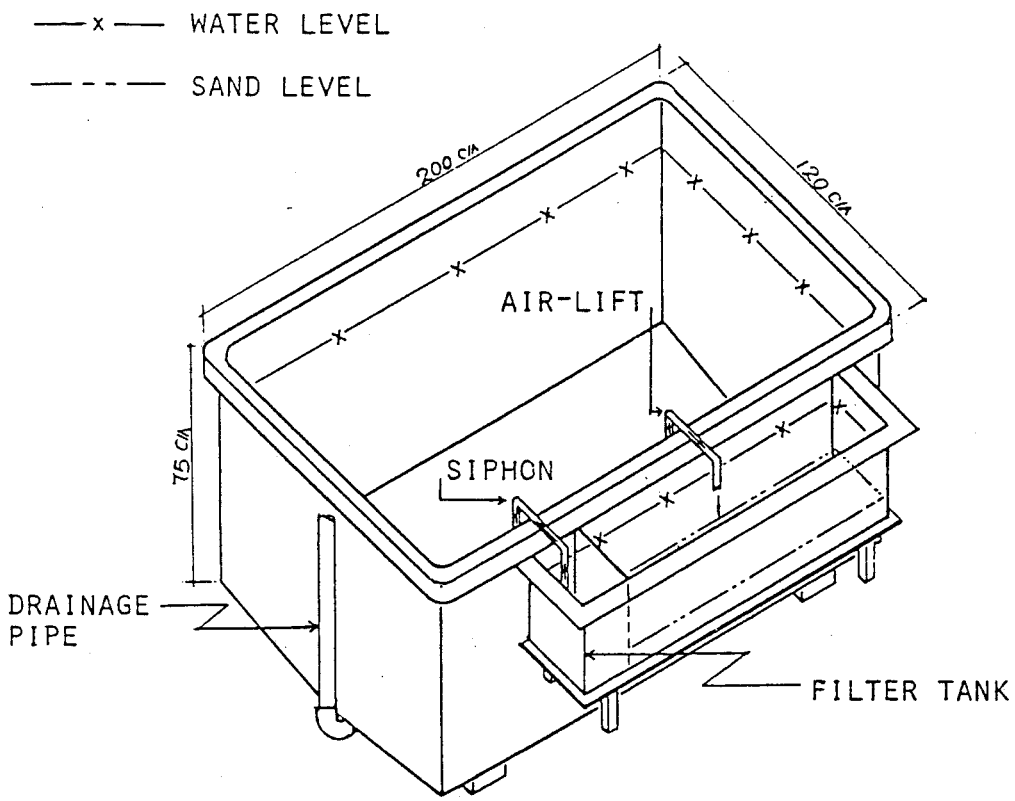

Fig. 1. Schematic diagram of experimental tank with filter.

day. A translucent fiberglass sheet was used to shelter from strong sunshine and rain to prevent the development of mass floating algae and the dilution of rearing water. The fish were fed with pellet feed twice a day at 8:30 AM and 4:30 PM with a daily feeding rate of 5-8% of total body weight. The ingredients and composition of the pellet feed of about 2 mm diameter are shown in Tables I and II. Faeces were siphoned out with a plastic tube before feeding. Water was added when the water volume in the tank was below 1.3 ton. The salinity and temperature were recorded every day, pH, NH_4^+-N and dissolved oxygen every four days, and the body weight of fishes were measured every ten days during the experiment. The experiment lasted 40 days.

Experiment II

The red tilapia used in this experiment had also been divided into three treatment groups: A_2, fresh water (2‰); B , brackish water (17‰);

TABLE I The ingredients of feed used in Experiments I and III

Ingredients	Percentage
White fish meal	20
Wheat germ	72
Chlorella powder	3
Mineral mixture	2
Vitamin mixture	2
Fish liver oil	1

TABLE II The composition of feed used in Experiments I, II and III

Composition	Experiment I, III	Experiment II
Crude protein	28.50	24.0
Crude lipid	6.50	2.8
Carbohydrates	47.66	52.2
Moisture	10.88	13.0
Crude ash	6.46	2.0
Crude fiber	-	6.0

C_2, sea water (34‰). They were reared in three octagon outdoor ponds (20 m^2). Three hundred fish with a mean body weight of 11 g were reared in a pond. Every pond was provided with enough aeration. There were no replications in this experiment. The methods of acclimation of red tilapia from fresh water to sea water were the same as in the Experiment I. The feeding rate was 3-5% of total body weight of fish, and the fishes were fed twice a day with No. 2 tilapia pellet feed manufactured by the private feed company. The compositions of feed are also shown in Table II. Water temperature and salinity were recorded every day, pH, D.O. and NH_4^+-N every five days, and the body weights of fish were measured every three weeks during the experiment. This experiment was performed for 12 weeks.

Experiment III

This experiment had also been divided into three treatments: A_3, fresh water (1.5‰); B_3, brackish water (17‰); C_3, sea water (34‰). The red tilapia used in this experiment were all male with a mean body weight of 104 g, and were larger than those used in the Experiments I and II. Because the body weights of red tilapia were larger in this experiment, the acclimation time from fresh water to brackish water and sea

water were much longer than that in the Experiments I and II. It took two and three days respectively. The experiment was carried out in winter, however, every tank was provided with a heater to keep water temperature at 27 ± 2°C. Other conditions such as the filter, determination of pH, D.O. and NH_4^+-N were the same as those in the Experiment I. Several fish were taken randomly from each treatment after the experiment, and 0.5 ml of blood was taken with caudal puncture from each fish for osmolarity measurement. The chemical composition of dorsal muscle of these fish had also been measured.

RESULT

The results of Experiments I and II show that the red tilapia reared in both sea water and brackish water grow better than those reared in fresh water; and those reared in sea water grow slightly better than those reared in brackish water (Figs. 2 and 3). There is a significant difference among the results obtained from A_1, B_1 and C_1 in Experiment I ($F = 4.56$; $df = 2, 84$; $P < 0.05$), and also among the results obtained from A_2, B_2 and C_2 in Experiment II ($F = 9.58$; $df = 2, 859$; $P < 0.01$). The results of Experiment III (A_3, B_3 and C_3) show that the best growth was obtained from A_3 (fresh water, 1.5‰), followed by C_3 (sea water, 34‰) and B_3 (brackish water, 17‰) (Fig. 4). The differences among A_3, B_3 and C_3 are statistically significant ($F = 10.75$; $df = 2, 75$; $P < 0.01$).

In experiments I and II, although the growth of red tilapia reared in brackish water and sea water is better, the individual variation in growth is larger than those reared in the fresh water. The standard deviation of A_1, B_1, C_1, A_2, B_2 and C_2 is 12.7, 15.3, 18.3, 47.5, 58.4 and 57.7 respectively (Table III). The male red tilapia grows 1.55 times faster than females in the fresh water, 1.53 times in the brackish water, and 1.62 times in the sea water (Table III). The mean survival rate of red tilapia reared in the brackish water (95%) is the highest, followed by those reared in the fresh water (93.7%) and in the sea water 90.4%) (Table III).

TABLE III Summary of stocking, survival rate and growth of red tilapia reared in fresh water, brackish water and sea water in Experiments I, II and III

Experiment	Treatment	Stocking (No./pond)				Survival rate (%)	Av. weight (g)				Growth ratio ♂:♀	Daily weight gain (g)
		initial	final				initial	final				
			♀	♂	total			♀	♂	mean		
I	A_1	30	5	24	29	96.67	18.24 ± 3.27	-	-	51.47 ± 12.66	-	0.83
	B_1	"	9	21	30	100.00	18.38 ± 5.65	-	-	56.08 ± 15.32	-	0.94
	C_1	"	8	20	28	93.33	17.51 ± 3.50	-	-	58.58 ± 18.25	-	1.03
II	A_2	300	161	122	283	94.33	11.35 ± 4.53	65.00	100.69	85.30 ± 47.52	1.55	0.88
	B_2	"	176	119	295	98.33	11.35 ± 4.53	77.72	118.53	102.06 ± 58.40	1.53	1.08
	C_2	"	151	133	284	94.67	11.35 ± 4.53	77.90	126.22	103.59 ± 57.70	1.62	1.10
III	A_3	30	-	27	-	90.00	104.97 ± 20.71	-	-	159.18 ± 34.00	-	1.35
	B_3	"	-	26	-	86.67	104.10 ± 20.61	-	-	147.88 ± 33.22	-	1.10
	C_3	"	-	25	-	83.33	104.20 ± 19.20	-	-	152.58 ± 35.50	-	1.21

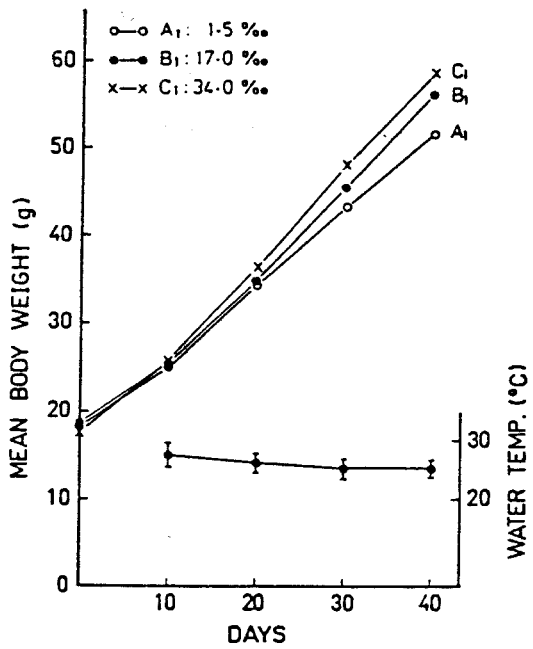

Fig. 2. The growth of red tilapia reared in fresh water, brackish water and sea water in Experiment I.

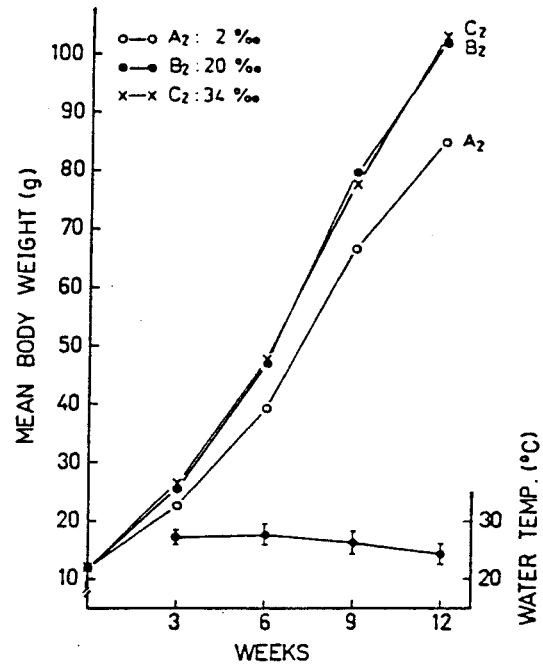

Fig. 3. The growth of red tilapia reared in fresh water, brackish water and sea water in Experiment II.

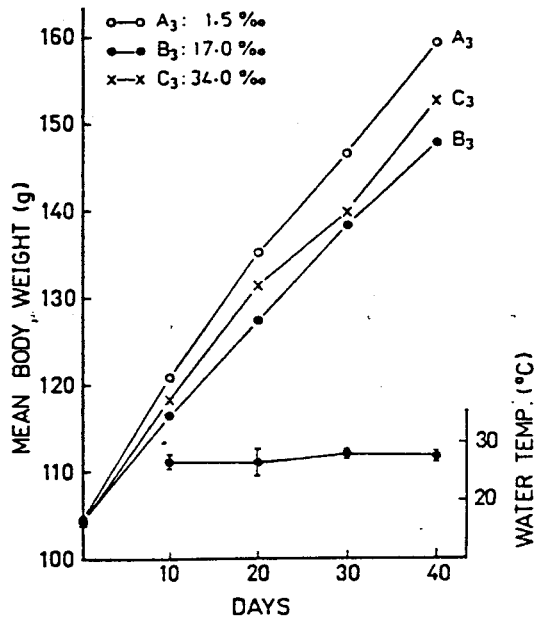

Fig. 4. The growth of red tilapia reared in fresh water, brackish water and sea water in Experiment III.

The condition factors of red tilapia reared in fresh water, brackish water and sea water in Experiments I and II are shown in Table IV and

TABLE IV The condition factors of red tilapia reared in fresh water, brackish water and sea water in Experiments I and II

Experiment	Treatment	Initial	Final
I	A_1	34.17 ± 2.93 (90)	38.56 ± 5.27 (87)
	B_1	32.05 ± 2.97 (90)	41.04 ± 6.12 (90)
	C_1	31.32 ± 3.37 (90)	40.34 ± 5.45 (85)
II	A_2	34.98 ± 4.53 (80)	42.22 ± 6.03 (78)
	B_2	34.98 ± 4.53 (80)	44.17 ± 4.58 (77)
	C_2	34.98 ± 4.53 (80)	42.90 ± 6.36 (80)

Note: Figures in parentheses are number of fish measured.

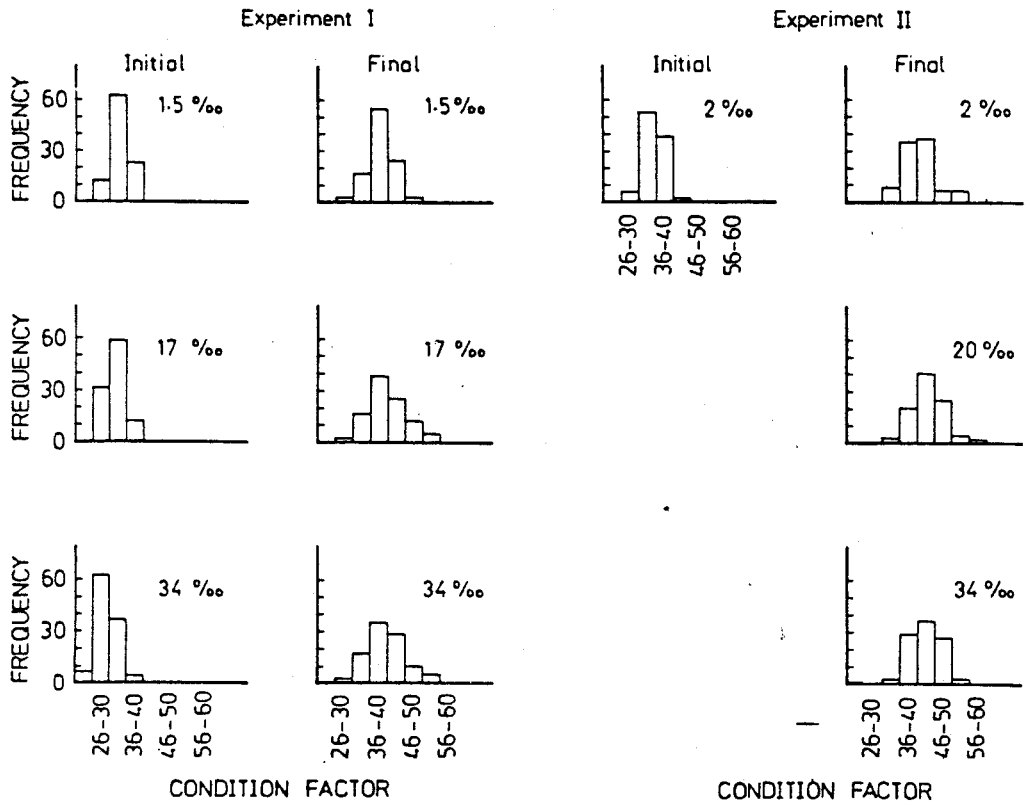

Fig. 5. The condition factor distribution of red tilapia reared in three different saline waters in Experiments I and II [Condition factor $= \frac{\text{Body weight}}{(\text{Body length})^3} \times 10^3$].

Fig. 5. The average condition factors obtained from the red tilapia reared in the brackish water, 41.04 $\pm$ 6.12 (S.D., n = 90) and sea water, 40.34 $\pm$ 5.45 (n = 85) are significantly larger than those reared in the fresh water, 38.56 $\pm$ 5.27 (n = 87) in the Experiment I ($F = 12.06$; df = 2, 259; $P < 0.01$); however, the difference obtained in the Experiment II is not significant ($F = 2.29$; df = 2, 232; $P > 0.05$).

The osmolarity of the serum of red tilapia reared in three different salinities of waters in Experiment III are shown in Table V. The average osmolarity of red tilapia reared in fresh water, brackish water and sea water is 305 $\pm$ 16.39 (S.D.), 340 $\pm$ 19.15 and 349 $\pm$ 39.95 mos/kg respectively. In spite of the difference in osmolarity of rearing waters (54, 562 and 1,042 mos/kg), there is not significant difference in osmolarity of serum ($F = 3.56$; df = 2.28; $P > 0.05$).

TABLE V The osmolarity of rearing water and serum of red tilapia in Experiment III

Treatment	Rearing water		Mean body weight (g)	Fish serum osmolarity (mos/kg)		Difference between serum and rearing water (mos/kg)
	salinity (‰)	osmolarity (mos/kg)		Range	Mean	
A_3	1.5	54	190.74	280-335	305.00 $\pm$ 16.49	251
B_3	17.0	562	175.24	310-365	340.00 $\pm$ 19.25	222
C_3	34.0	1,042	160.09	267-450	349.00 $\pm$ 40.00	693

TABLE VI The chemical composition of dorsal muscle of red tilapia reared in fresh water, brackish water and sea water in Experiment III

Treatment	Crude protein	Crude lipid	Carbohydrate	Moisture	Crude ash
A_3	17.91	1.47	2.82	76.33	1.47
B_3	18.53	1.18	3.04	75.86	1.39
C_3	19.14	0.88	2.85	75.50	1.63

The composition of dorsal muscle of red tilapia reared in three different salinity of waters are shown in Table VI. The protein level is highest in the red tilapia reared in sea water (19.14%), and is lowest in those reared in fresh water (17.91%). The crude lipid is highest in the red tilapia reared in the fresh water (1.49%) and lowest in those reared in the sea water (0.88%); the ash level of C_3 (1.63%) is the highest among three treatments.

The mean pHs in Experiment I (A_1, B_1, C_1), II (A_2, B_2, C_2), and III (A_3, B_3, C_3) are shown in Table VII; the values for A_1, B_1, C_1, A_2, B_2, C_2, A_3, B_3, and C_3 are 8.03, 7.78, 7.57, 8.08, 7.66, 7.64, 8.17, 7.75, and 7.54 respectively. The dissolved oxygen remained over 3.07 ppm because there were sufficient aeration in every treatment; the average D.O. in three experiments was 6.16 ppm. The NH_4^+-N of Experiments I and III did not change much during the experiment, and stayed below 0.75 ppm on the average because filters were used in the experiment. The NH_4^+-N of A_2 in Experiment II is higher than the values recorded for other treatments because of the use of under-ground water of high NH_4^+-N content. The higher NH_4^+-N seemed to cause a decreased feeding in fish.

TABLE VII The summary of water quality in Experiments I, II and III

Experiment	Treatment	pH		DO		NH_4^+-N	
		Range	Mean	Range	Mean	Range	Mean
I	A_1	8.53-7.35	8.03	6.80-3.07	5.29	0.12-0.55	0.33
	B_1	8.31-7.06	7.78	6.27-3.66	5.23	0.14-0.63	0.41
	C_1	7.91-7.28	7.57	6.47-3.92	5.14	0.15-0.74	0.33
II	A_2	8.72-7.80	8.08	9.90-6.34	7.75	0.10-4.00	1.12
	B_2	7.98-7.45	7.66	7.22-6.84	6.66	0.10-0.28	0.13
	C_2	8.02-7.30	7.64	7.39-5.80	6.60	0.10-0.68	0.18
III	A_3	8.42-7.92	8.17	7.38-5.10	6.30	0.10-1.80	0.71
	B_3	8.04-7.50	7.75	6.99-4.98	6.47	0.10-1.50	0.75
	C_3	7.77-7.30	7.54	6.69-6.08	6.02	0.14-1.50	0.60

DISCUSSION

Several species of tilapia are euryhaline, but the ability of adaptation to sea water varies greatly. T. zillii can survive even at salinity 42-42.79‰ and water temperature 23-24°C in Suez Bay (Bayoumi, 1969), and can breed at a salinity of 29‰ in Lake Qarun, Egypt (El Zarka, 1956). O. mossambicus also can breed at a salinity of 30‰ (Vaas and Hofstede, 1952). The growth of O. aureus reared at salinity of 40.8-44.6‰ is very similar to that reared in fresh water (Chervinski and Yashouv, 1971); the daily growth rate of O. aureus can reach 1.97 g/day at a salinity of 54‰ (Chervinski and Zorn, 1974). The tolerance to coldness is higher for O. aureus reared at salinity 5‰ than at fresh water (Chervinski, 1966). There is also a variation in the adaptability to salinity within the same

species of tilapia from different localities. For example, O. mossambicus can spawn at a salinity of 34‰ in our laboratory.

Tilapia show schooling behavior during the juvenile stage, but show a strong territoriality after mature, especially the male fish. In addition to pursuing other male, adult male will also bite female for mating. This behavior will give a strong stress on weaker male and immature female, especially in small tanks and ponds. The stress causes the fish in the experimental tanks to become uneasy and lose appetite. The mating behavior of the tilapias probably causes the differences in growth among the fish reared in three different salinity of waters in these experiments. In Experiments I and II, the breeding ability of red tilapia in brackish and sea water had been greatly inhibited, and mating behavior is not conspicuous; therefore, the growth of the tilapia is better than in the fresh water. In Experiment III, the red tilapia in fresh water grow better than in saline water, because in this experiment only male tilapia were reared, and all male red tilapia only show territorial behavior but not mating behavior. On the other hand, there is a strong display of both mating and territorial behaviors in male and female tilapia in fresh water treatment of Experiments I and II.

In Experiments I and II, both of mating and territorial behaviors had caused a decreased feeding in the tilapia reared in fresh water, and therefore the growth of red tilapia reared in the saline water is better than that in fresh water. The growth rate of tilapia reared in fresh water began to slow down when fish attained a body weight of 35 g, because some of the red tilapia at this stage had become mature, and the display of mating behavior become stronger and stronger. In addition, the higher NH_4^+-N in rearing water may also cause a poor growth in the red tilapia that are reared in the fresh water in Experiment II.

Because of the display of mating and breeding behavior of red tilapia reared in the saline water were not so strong as that reared in the fresh water, their condition factors are larger (Table IV and Fig. 5); however, the standard deviation of mean body weight for the red tilapia reared in the saline water are larger than that in the fresh water in Experiments I and II (Table III).

The osmolarity of the serum of Tilapia rendalli reared in fresh water stays at 255 mos/kg, and increases up to 340 mos/kg when being put into a saline water of 18‰ directly; and they will die when being put into a saline water of 19‰ directly, and the osmolarity of the serum will reach 460 mos/kg (Whitfeld and Blaber, 1976). The average osmolarity of the red tilapia reared in fresh water and sea water in Experiment III are 305 and 349 mos/kg respectively. However, the standard deviation of osmolarity of the red tilapia reared in sea water (39.95) is larger than that reared in fresh water (16.39). Generally speaking, most of the red tilapia reared in saline water in this study show a rather high osmoregulatory ability, although some of the red tilapia had a poorer osmoregulation with osmolarity varying from 267 to 450 mos/kg.

CONCLUSIONS

From the results of the experiments, it is suggested that red tilapia can be cultured in brackish water and sea water, just as in fresh water, and will get good growth rate and high survival rate. However, in our experiences, red tilapia cultured in brackish water are easily bruised after measuring and selecting. This might cause retardation in osmoregulation, lose of appetite, infection of fish lice and even death. Thus treatments of disinfectant and/or decreasing the salinity of rearing water are necessary to reduce the damages.

At all, excellent growth of red tilapia reared in saline water has proved the feasibility of this culture, and it will create a brilliant prospect for culturing red tilapia in shallow sea or floating net-cage culture in sea bay.

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紅色吳郭魚鹹水養殖之可行性研究

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摘 要

紅色吳郭魚與名貴的嘉臘魚非常相似，同樣具有漂亮的鮮紅體色，且體內沒有黑色的腹膜。紅色吳郭魚亦比一般的黑色吳郭魚較易被消費者接受，在鹹水中養殖者尤其適合作爲生魚片的材料，且在海水或半鹹水中養殖者，通常生殖力較低，可以防止池魚過密的現象。此試驗之目標爲評估紅色吳郭魚在鹹水中養殖的可行性。將試驗魚分別飼育於海水（34‰）、半鹹水（17‰）及淡水（1.5～2‰）中，並進行雌雄混養實驗，結果顯示於半鹹水及海水中飼育的紅色吳郭魚比在淡水中飼養者成長爲快，然而若以全雄性養殖時，則反以淡水中養殖者成長較快。試驗的結果顯示在鹹水中養殖的紅色吳郭魚體重的變異比在淡水中者爲大，造成此項差異的原因，可能是因爲地盤性及交配行爲的不同。紅色吳郭魚在鹹水中飼育的缺點爲容易導致體表挫傷及魚蝨的攻擊，並因而喪失食慾，甚至死亡。然而若在捕撈測量體重後施以消毒，則可以減少此現象之發生。綜合以上之結果，在鹹水中養殖紅色吳郭魚，可以得到令人滿意的成果，故將來計畫在淺海中或以箱網在海灣中養殖紅色吳郭魚將具有光明之前途。