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Growth and Survival of Thai Climbing Perch (*Anabas testudineus*) and Snakeskin Gourami (*Trichogaster pectoralis*) Reared in Brackish Water in Cement Pond in Salt-affected Soil

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Abstract

Thai climbing perch (*Anabas testudineus*) and snakeskin gourami (*Trichogaster pectoralis*) are freshwater fish species commercially grown in Southeast Asian countries. This research investigated survival rate and growth performances of Thai climbing perch and snakeskin gourami when cultured in brackish water (7.50 ppt) in salt affected soil. The experiment was conducted in a brackish water cement ponds for 6 months. Water quality was also measured at 2-month intervals. The results found that average daily weight gain (DWG) of Thai climbing perch and snakeskin gourami was 0.597±0.017 and 0.048±0.010 g/day, respectively. Co-culture between the fish species had a DWG of 0.592± 0.022 and 0.038±0.004 g/day for Thai climbing perch and snakeskin gourami, respectively. At the end of the study, the productivity of Thai climbing perch weight was 121.67±2.89 kg and snakeskin gourami weight was 24.15±2.10 kg. In addition, higher survival rate of 93.11±4.07% for Thai climbing perch and 52.00±17.02% for snakeskin gourami (T3) reared in brackish water was obtained in co-culture system (T3) compared with Thai climbing perch (T1, 87.33 ± 5.78%) and snakeskin gourami (T2, 43.89±15.87 %). Water quality at the end of the experimental period found the difference in each treatment. The results showed that T1 found the highest values of many water quality parameters. This study highlights the culture of freshwater fish in brackish water has advantages for fish farming in salt affected soil.

Introduction

In Nakhon Ratchasima, Thailand, the spread of salt into the land is a serious problem. The most severe of 20,480 square kilometers area is salty, 768 square kilometers found serious saline soil problem, 320 square kilometers found moderate saline soil problem, and potential saline problems might occur up to 3,360 square kilometers in a mainly agricultural area (Land Development Department of Nakhon Ratchasima Province, 2013). The phenomenon is increasing the salt concentration in freshwater (freshwater salinization), leading to significant effects on aqautic organisms.

Freshwater salinization, an increase in osmotic pressure, is one of the factors limiting the growth and development of aquatic life (Kaushal et al., 2021). In

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natural salinity water, most salts are sodium chloride where content are sodium ions and chloride ions. These cation and anion concentration are regulated by osmo-regulation and salinity stress aesthetic processes, which are the systems that maintain a balance of water and mineral salts between aquatic life and the environment. In freshwater fish, an increase in salinity results in hyperosmotic physiological changes. Therefore, fish have a great need to use energy to regulate osmosis pressure in order to maintain the balance of the body. If severe osmosis pressure occurs, it can lead to the death of the fish (Tippayada et al., 2015).

Thai climbing perch (*Anabas testudineus*) is a freshwater species that is commonly found in paddy fields, wells, irrigation channels, and drains (Yunus, 2018). Snakeskin gourami (*Trichogaster pectoralis*) is aqua cultured freshwater species in Thailand. They can survive in various aquatic ecosystems and submerge with aquatic vegetation such as rice paddies, shallow ponds, swamps and sluggish, or standing water (Sugiyama et al., 2004). These two species of fish are very common fishes in Thailand.

Thai climbing perch and snakeskin gourami are resistant to polluted water and salt tolerance. The aquaculture fish is increasing the economy in the water with high salinity and reared in clean water. The dominant feature of Thai climbing perch and snakeskin gourami is their resistance to water contamination and tolerance to salinity (Amornsakun et al., 2004; Bhaskar et al., 2015; Chotipuntu & Avakul, 2010; Khatun et al., 2019; Kazi et al., 2016; Shinsuke et al., 2010). These fishes have evolved osmoregulatory mechanisms to thrive in a variety of aquatic conditions. However, salinity tolerances of freshwater fish vary among species and with their developmental stages (Chotipuntu & Avakul, 2010). Chotipuntu (2003) reported that most adult freshwater fish can live in salinity between 7-13 ppt.

Thai climbing perch and snakeskin gourami reared in brackish water will give opportunity for fish farming located in salt affected soil. Consequently, this study investigated the survival rate, growth and performances of the fresh water fish which were cultured in brackish water.

Materials and methods

1. Experimental site and cement pond preparation

The experiment was carried out for a period of 6 months in 12 experimental ponds located at Ban Pho Subdistrict, Muang District, Nakhon Ratchasima, Thailand (15.012560N, 102.182460E). The ponds were of the same size (1.0 x 3.0 x 1.5 m) (Fig.1) and similar in shape and depth. After construction, the ponds were prepared by filling with water for 2 weeks.

Fig. 1 Cement pond used in this study

2. Brackish water preparation

The water used was pumped from a 17 m depth groundwater, in salt-affected soil, Nakhon Ratchsima, Thailand and sat for 1 week before use. Salinity was maintained at 7.50 ppt and measured with a pH meter (TLEAD, pH-009LA).

3. Fish species and maintenance

Thai climbing perch (*A. testudineus*) and snakeskin gourami (*T. pectoralis*) used in this study (Fig.2) were purchased from local farms in Nakhon Ratchsima, Thailand. Mono- and co-culture systems were carried out with 4 treatments because stocking a range of species with various eating habits enabled for more efficient use of the ecosystem's available food, boosting economics and sustainability. Average weight of Thai climbing perch and snakeskin gourami (900 fish/ species) was 11.50-12.00 g and 15.00-15.50 g, respectively. The experiment was carried out in 12 ponds with 4 treatments and 3 replicates were designed. Among them, 3 were brackish water (7.50 ppt) and another was fresh water (<1 ppt).

The following shows the treatment number, the number of fish species and water type:

Treatment 1: 300 of Thai climbing perch reared in brackish water

Treatment 2: 300 of snakeskin gourami reared in brackish water

Treatment 3: 150 of Thai climbing perch combined with 150 of snakeskin gourami reared in brackish water

Treatment 4: 150 of Thai climbing perch combined with 150 of snakeskin gourami reared in fresh water

The fish feeding operated by feed formulated diet of no less than 25% protein, 2 time a day (09.00 am and 03.00 pm) at a rate of 5% body weight. Small fish at 1.5 to 4.0 cm in size were feed during one to eight-weeks with feed pellets floating 1.0-1.5 mm. At 3-4 months when the fish were larger, the weight of 25-100 g, the feed pellets increased to floating size 2.5-3.5 mm. At 5-6 months when the fish weight gained to 100-250 g, feed pellets increased to floating size 5.5 mm. After 1 hour of feeding, fish abnormality were observed.

4. Growth performance and survival rate determination

To study the effect of salinity on the growth performance, fish were collected by a sampling of the growth of the fish. The survival rate of fish reared in cement ponds random sampling, the number of fish caught and then released again (Capture-recapture sampling) (Chao, 1989), which holds the number three times, once every two months.

The study of the fish growth and productivity by random sampling and counting the total numbers of fish were calculated by the equations as follow (Bhaskar et al., 2015):

The average daily weight gain, DWG (g/day)

DWG = (final weight (g) - initial weight (g))/ experimental time (day)

Percentage weight gain, PWG (%)

PWG = (final weight (g) - initial weight (g))/(initial weight of fish (g)) x 100

Survival growth rate, SGR (%)

SGR = (number of fish at the end of the experiment/ number of fish at an initial time of the experiment) x 100

5. Water quality analysis

The water quality in each pond was measured at 2-month intervals. pH value was measured directly by a portable pH meter (TLEAD, pH-009LA). Salinity, total dissolved solid (TDS), conductivity (EC) was measured by bench meter (Hanna, HI 4321), biochemical oxygen demand (BOD), nitrogen, chloride, and phosphate were also measured by standard methods for the examination of water and waste water (American Public Health Association, 2005).

Fig. 2 Fish species used in this study, *A. testudineus* (right), *T. pectoralis* (left)

6. Economic analysis

An economic analysis was performed to estimate the net profit by deducting the gross income from the gross cost. The analysis was based on local market prices for harvested fish and all other items in 2016. The cost of cement pond was $65.03 USD/per pond. The prices for Thai climbing perch and snakeskin gourami were $0.048 USD/ per fish and $0.065 USD/per fish and all fish feed was $117.12 USD. The selling price for Thai climbing perch and snakeskin gourami was estimated at $2.60 and $2.28 USD/kg, respectively.

7. Statical analysis

All experiments were repeated at 3 replicates and all data were analyzed by percentage, average, and standard deviation and compared mean by ANOVA.

Results and discussion

1. Growth performance and survival rate

The growth of Thai climbing perch and snakeskin gourami culture in brackish water cement ponds at the initial time of this study showed the Thai climbing perch fish averaged from 11.50 to 12.00 g in weight; width of 1.40 to 1.50 cm and length of 3.40-3.55 cm in body size. The snakeskin gourami was 15.00 to 15.50 g in weight; width of 1.75-1.80 cm and length of 3.50 to

3.85 cm in body size. After 6 months, the results shown in treatment 1 found the Thai climbing perch had an average of 3.93±0.12 cm, a length of 12.69±0.30 cm, and an average weight of 121.67±2.89 g. In treatment 2, the snakeskin gourami had a body equivalent to 2.88±0.20 cm in width and 9.73±0.35 cm in length; the average weight of the fish was 24.15±2.10 g. Treatment 3 (Thai climbing perch and snakeskin gourami) found a total average weight of 71.60±2.57 g; Thai climbing perch had an average weight of 121±4.58 g; the body was 4.46±0.23 cm in width and 14.38±0.16 cm in length. The snakeskin gourami had an average weight of 22.20±0.80 g; the body was 3.47±0.27 cm in width and 9.01±0.32 cm in length. While treatment 4 (Thai climbing perch and snakeskin gourami in freshwater) resulted in the Thai climbing perch body size of 4.23±0.23 cm in width, 13.47±0.81 cm in length; with an average weight of 121.67±0.58 g. Snakeskin gourami had a body size of 3.03±0.40 cm in width and 9.67±0.58 cm in length; a weight of 23.83±1.15 g per fish (A total weight of T4 was 72.75±0.87 g). The results of the average weight of Thai climbing perch and snakeskin gourami are shown in Fig. 3.

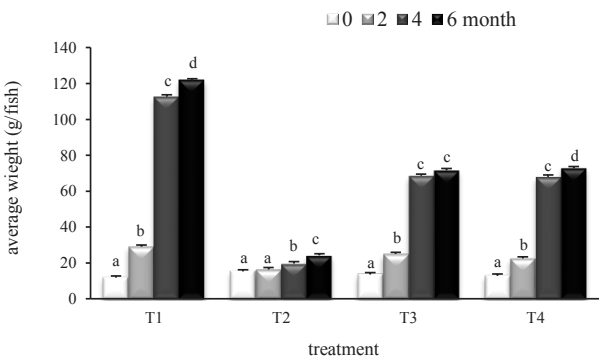

Fig. 3 The growth of fishes for 6 months. T1: Thai climbing perch, T2: snakeskin gourami, T3: Thai climbing perch x snakeskin gourami (T1-T3 cultured in brackish water) and T4 Thai climbing perch x snakeskin gourami (cultured in fresh water). Lowercase letter above the bar, values are the mean ± SD of three replicates, indicating statistically significant differences at $p < 0.05$ (DMRT) within each treatment

Average daily weight gain, DWG (g/day), the initial weight was 11.83 g forThai climbing perch, and 15.23 g for snakeskin gourami. The final weights were 121.67 g for Thai climbing perch in T1 and 24.15 g for snakeskin gourami in T2 at 6 months. Thus, the DWG of Thai climbing perch was about 00.597 g/day (T1); snakeskin gourami was 0.048 g/day (T2). The results of T3 found an average weight of 121 g for Thai climbing perch and 22.20 g for snakeskin gourami. The DWG of Thai climbing perch was 00.597 g/day and snakeskin gourami was 0.038 g/day as shown in Table 1.

Table 1 The average daily weight gain (DWG) of fishes cultured for 6 months

Treatment	Description	DWG (g/day)
T1	Thai climbing perch cultured in brackish water	0.597±0.017
T2	Snakeskin gourami cultured in brackish water	0.048±0.010
T3	Thai climbing perch Snakeskin gourami cultured in brackish water	0.592±0.022 0.038±0.004
T4	Thai climbing perch Snakeskin gourami cultured in fresh water	0.597±0.002 0.054±0.010

The survival rate at the end of the study is shown in the Table 2 below. The survival rate of 87.33±5.78% and 43.89±15.87% was observed in Thai climbing perch and snakeskin gourami in T1 and T2, respectively. Co-culture of Thai climbing perch and snakeskin gourami gave the survival rate higher than separately cultured, which was found in the T3 and T4. Hasan et al. (2010) reported that the survivable rate of Thai koi (*A. testudineus*) at 90 days of the experiment were about 73-83% when cultured in nylon hapas. Baisya et al. (2012) found that the survivable rate of snakeskin gourami (*T. pectoralis*) was 97 % of the fry weaned at day 24. Therefore, it might be due to the different culture systems and species variation.

Table 2 Survival rate of Thai climbing perch and snakeskin gourami cultured in brackish water cement ponds for 6 months

Treatment	Description	Survival rate (%)
T1	Thai climbing perch cultured in brackish water	87.33±5.78
T2	Snakeskin gourami cultured in brackish water	43.89±15.87
T3	Thai climbing perch Snakeskin gourami cultured in brackish water	93.11± 4.07 52.00±17.02
T4	Thai climbing perch Snakeskin gourami cultured in fresh water	94.44±0.96 76.67±2.89

2. Water quality

The water quality parameters of the four treatments were detected from four different times at 0, 2, 4 and 6 months during the experimental period which are shown in Table 3. A pH value in the ponds ranged from 6.5 to 7.8, which is the optimum pH levels for fish to live. The pH level outside of 6.5-9.5 could have an adverse effect on the growth and development of fish. TDS increased along with the increaseof time in all treatments especially T1 showed the highest TDS and BOD up

to 15,300 and 285 mg/L at the end of experiment, respectively. As illustrated in Table 3, the amount of time (listed in months) markedly changed the water quality, particularly TDS and BOD as well as all water quality parameters of the T1, T2 and T3, which were significantly higher than T4. Increment of nitrate-nitrogen was observed and the highest level of 132.20 mg/L was obtained in T1 at 6 months. Phosphate in the water slightly increased between 0.23 to 0.42 mg/L in T1-T3. Nevertheless, chloride and phosphate levels in all experiments gradually increased.

3. Economic analysis

Investment of cost-benefit of Thai climbing perch and snakeskin gourami culture in brackish water cement ponds had a total budget of $322.08 USD that included buying fish at $204.96 USD, and fish feed was $117.12 USD (1 USD = 30.74 Baht at CE 2021), and the cement pond cost of $65.03 USD per cement pond. The cost-benefit of Thai climbing perch culture in brackish water cement ponds found the weight of 184 kg and the total of $479.48 USD led to $2.60 USD per kilogram. The snakeskin gourami weight of 14.50 kg was $2.28 USD per kilogram, totaling $33.02 USD, and selling fish at $512.54 USD. Thus, the profit of this study was $190.46 USD (Not including the cement pond construction budget). However, if the cement pond construction budget was included, it would be profitable at the second or third fish culturing. The cost-benefit analysis found high profit occurs in the long term. This result is consistent with those of fed fish with vegetables by Patthumma (2013) as well as tilapia by Chaisuri (2012), which released the Thai climbing perch sizes starting from 27.40 to 32.25 g of 100 fish in cement circular water containing 200 liters and water volume of 332 liters of tilapia because the Thai climbing perch behavior is to jump. Thai climbing perch have respiratory organs that can live in highly polluted water. The fish fed with 30% protein, is the same with the tilapia fish but for a shorter period of 3 months. According to the study by the Pollution Control Department Ministry of Natural Resources and Environment (2006) on the amount of waste from the tilapia fish farming in cages of the Chao Phraya River at Chainat Province in 2002, these fish fed by the protein building at 32-35% and found that the FCR means rose by 1.5 and digestibility of protein in the diet of fish was 85% excreta of fish from fish production at 1,000 kg, the amount of nitrogen entering the water totaled 1,600 g and 1,400 g of phosphorus.

Table 3 Water quality parameters at 2-month intervals for 6 months

Treatments	Parameters	Duration (month)			
		0	2	4	6
T1 (Thai climbing perch cultured in brackish water)	pH	6.89	7.24	7.12	7.11
	TDS (mg/L)	609	297	542	15,300
	DO (mg/L)	1.63	0.47	2.45	0.92
	BOD (mg/L)	1.50	3.00	45.00	285.00
	Chloride (mg/L)	3.26	4.55	5.26	17.00
	Nitrate (mg/L)	1.10	2.67	20.00	132.20
	Phosphate (mg/L)	0.02	0.43	0.38	0.42
T2 (Snakeskin gourami cultured in brackish water)	pH	6.89	7.79	7.35	7.67
	TDS (mg/L)	609	268	486	6,090
	DO (mg/L)	1.63	2.75	3.00	0.97
	BOD (mg/L)	1.50	4.00	12.4	157.50
	Chloride (mg/L)	3.26	4.20	3.44	5.70
	Nitrate (mg/L)	1.10	1.60	18.54	77.30
	Phosphate (mg/L)	0.02	0.20	0.22	0.25
T3 (Thai climbing perch combined with snakeskin gourami cultured in brackish water)	pH	6.89	7.77	7.40	7.81
	TDS (mg/L)	609	368	512	8,010
	DO (mg/L)	1.63	3.82	3.42	0.97
	BOD (mg/L)	1.50	2.45	8.45	60.00
	Chloride (mg/L)	3.26	5.15	4.20	3.25
	Nitrate (mg/L)	1.10	0.67	10.00	29.70
	Phosphate (mg/L)	0.02	0.10	0.25	0.23
T4 (Thai climbing perch combined with snakeskin gourami cultured in fresh water)	pH	7.05	6.50	6.45	6.45
	TDS (mg/L)	145	245	445	445
	DO (mg/L)	6.00	4.50	4.00	4.00
	BOD (mg/L)	1.50	1.60	3.60	45.20
	Chloride (mg/L)	0.02	0.20	1.00	1.00
	Nitrate (mg/L)	0.01	0.20	1.30	12.30
	Phosphate (mg/L)	0.00	0.10	0.15	0.30

Conclusion

The study highlighted that the Thai climbing perch has tolerance to the lowest water quality (also, high salinity) more than snakeskin gourami. The productivity and survival rate of Thai climbing perch was higher than snakeskin gourami when cultured in brackish water (7.50 ppt). The result suggests that the culture of freshwater fish in brackish water has advantages for fish farming in salt affected soil. Thai climbing perch and snakeskin gourami can be cultured and has salt tolerance in brackish water cement ponds. The cost-benefit analysis found that high profit is attainable in the long term. The results on aquaculture fish in brackish water cement ponds lead to the following suggestion. Farmers would rather culture Thai climbing perch because they are resistant to salinity water and can thrive in low water quality. Local agencies involved in tackling the poverty of salinity areas can encourage fish farming with further processing of fish, including dried fish and pickled fish as professional development.

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References

American public Health Association. (2005). *Standard Methods for the Examination of water and Wastewater* (21st ed.). Washington, D.C.: American Public Health Association.

Amornsakun. T., Sriwatana, W., & Promkaew, P. (2004). Some aspects in the early life stage of Siamese gourami, *Trichogaster pectoralis* (Regan) larvae. *Songklanakarin Journal of Science and Technology, 26*(3), 347–356.

Baishya, S., Kalita, K., Phukan, B., Dutta, M.P., & Bordoloi, R. (2012) Growth performance of snakeskin gourami, *Trichogaster pectoralis* (Regan 1910) through weaning strategies. *An International Quarterly Journal of Life Sciences, 7*(3), 553-556.

Bhaskar. P., Pyne, S.K., & Ray, A.K. (2015). Growth performance study of Koi fish, *Anabas testudineus* (Bloch) by utilization of poultry viscera, as a potential fish feed ingredient, replacing fishmeal. *International Journal of Recycling of Organic Waste in Agriculture, 4,* 31–37.

Chaisuri, S. (2012). *The difference in yield ratio of tilapia with crops, the proportion of different fish and plants* (Research report). Khon Kaen: Department of Fisheries, Faculty of Agriculture Khon Kaen University.

Chao, A. (1989). Estimating population size for sparse data in capture-recapture experiments. *Biometrics, 45,* 427-438.

Chotipuntu, P. (2003). *Salinity sensitivity in early life stages of an Australian freshwater fish, murray cod (Maccullochella peelii peelii Mitchell, 1838)* (Doctoral dissertation). Australia: University of Canberra.

Chotipuntu, P., & Avakul, P. (2010) Aquaculture potential of climbing perch, *Anabas testudineus*, in brackish water. *Walailak Journal of Science and Technology, 7*(1), 15-21.

Hasan, M., Ahammad, A.K.S., & Khan, M.M.R. (2010). A preliminary investigation into the production of Thai koi (*Anabas testudineus*) reared in nylon hapas in Bangladesh. *Bangladesh Research Publications Journal, 4,* 15-23.

Kaushal, S.S., Likens, G.E., Pace, M.L., Reimer, J.E., Maas, C.M., Galella, J.G., ... Woglo, S. A. (2021). Freshwater salinization syndrome: From emerging global problem to managing risks. *Biogeochemistry, 154,* 255-292.

Kazi, B.U., Mohammad, M., Abul, B., Sanjib, B., Saiful, I., Yahia, M., Seunghan L., & Sungchul, C.B. (2016). Culture potential of Thai climbing perch (*Anabas testudineus*) in experimental cages at different stocking densities in Kaptai Lake, Bangladesh. *Aquaculture, Aquarium, Conservation & Legislation - International Journal of the Bioflux Society, 9*(3), 564-573.

Khatun, D., Hossain, M., Rahman, M., Islam, M., Rahman, O., Kalam Azad, M., ... Mawa, Z. (2019). Life-history traits of the climbing perch *Anabas testudineus* (Bloch, 1792) in a Wetland ecosystem. *Jordan Journal of Biological Sciences, 12*(2), 175-182.

Land Development Department of Nakhon Ratchasima Province. (2013). *Salinity management Committee soil Conservation measures and documentation and water and soil management land development.* Nakhon Ratchasima: Department Ministry of Agriculture and Cooperatives.

Patthumma, C. (2013). *Production of cultured fish Thailand with a growing proportion of fish plants differ* (Research report). Khon Kaen: Department of Fisheries, Faculty of Agriculture Khon Kaen University.

Pollution Control Department Ministry of Natural Resources and Environment. (2006). *Fish farming is environmentally friendly.* Bangkok: Ministry of Natural Resources and Environment.

Shinsuke, M., Sayaka, I., & Shoji, K. (2010). Growth and morphological development of laboratory-reared larval and juvenile snakeskin gourami *Trichogaster pectoralis. Ichthyological Research, 57,* 24–31.

Sugiyama, S., Staples, D., & Funge-Smith, S. (2004). *Status and potential of fisheries and aquaculture in Asia and the Pacific.* Bangkok: Food and Agriculture Organization of the United. Nations Regional Office for Asia and the Pacific.

Tippayada, N., Doolgindachbaporn, S., & Suksri A. (2015). Effect of salinity levels on growth and survival of Asian redtail catfish (*Hemibagus wyckioides*). *Research Journal, 8*(1), 45-51.

Yunus, Y.B.M. (2018). *The effect of density on growth condition of Anabas testudineus. UKE ssays.* Retrieved June 19, 2020, from https://www.ukessays.com/essays/sciences/effect-density-growth-condition-climbing-1575.php?vref=1