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Research Article

Concurrent culture of shrimp (*Penaeus monodon*) and monosex tilapia (*Oreochromis niloticus*) at different stocking ratio in brackishwater earthen ponds, Bagerhat, Bangladesh

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ABSTRACT

The study was conducted to evaluate the growth and production performance of shrimp *(Penaeus monodon)* and tilapia (*Oreochromis niloticus*) at different stocking ratio in earthen ponds in Bagerhat district of Bangladesh for a period of four months from March to July 2018. The experiment was designed as randomized block design and designated to three treatments based on stocking ratio with three replications. Post larvae and fingerlings of shrimp and tilapia were stocked at a stocking ratio of 3:1, 3:2 and 3:3 in T_1, T_2 and T_3, respectively. Water quality parameters were within suitable ranges for shrimp and tilapia during the culture. Higher growth (29.17 g) of shrimp was achieved in T_2 compared to T_1 (28.41 g) and T_3 (26.38 g). Higher production of shrimp was obtained in T_1 (664.79 kg/ha) than those of T_2 (630.07 kg/ha) and T_3 (485.37 kg/ha). But significantly ($p<0.05$) higher production of tilapia was found in T_2 (1509.63 kg/ha) and T_3 (1467.58 kg/ha) than T_1 (922.22 kg/ha). However, the combined production and net profit of shrimp and tilapia farming were significantly ($p<0.05$) higher in T_2 (2139.70 kg/ha, BDT 211209.13/ha) followed by T_3 (1952.95 kg/ha, BDT 161731.49/ha) and T_1 (1587.01 kg/ha, BDT 159445.90/ha). Therefore, concurrent culture of shrimp and tilapia at a stocking ratio of 3:2/m^2 may be suggested to disseminate at shrimp farmers' level for increasing shrimp and fish production as well as high economic profit.

INTRODUCTION

The giant tiger shrimp, *P. monodon* is the largest brackishwater marine shrimp, which is widely distributed throughout the Indo–Pacific region. It has been harvested from the sea and cultured in many countries around the world. It is commercially important in capture fisheries and is also regarded as one of the most suitable for aquaculture with many advantages. The most important characteristic of it is fast growth. It is a euryhaline and grows well in salinities from 5 to 25 ppt. It adapts well to intensified culture system (Liao, 1987) and one of the major export items in Bangladesh. Total shrimp production including capture had been increased from 1.74 lakh MT in 2003–04 to 2.45 lakh MT in 2016–17. The present shrimp farming area of Bangladesh covers an area of 272717 ha and its production was 904 kg/ha (DoF, 2018).

Polyculture of commercially important fish species is most popular all over the world especially in Asian countries (China and India). The first and most important issue in polyculture system is the possibility of increasing production per unit area by better utilization of natural food. In addition, species selection also plays a vital role in this system that all the species should be benefited by the available food such as plankton, detritus and others, without competing with each other. Of all the species of fish, tilapia is the most acceptable food fish in many countries of the world including Bangladesh (Rouse and Stickney, 1982). In a polyculture system, tilapia and shrimp can utilize different niches in the culture setting. In an extensive farm, tilapia can filter feed on phytoplankton and zooplankton in the upper water column. Shrimp spend most of the time in the pond bottom grazing on bacterial films on the bottom substrate and on the detritus settling from above. More importantly the fecal matter from the tilapia contributes to the detrital rain that supports the shrimp. The yield of shrimp is increased when tilapia are stocked into existing shrimp ponds (Anggawa, 1999).

Considering growth and production potential, feeding behavior and economic benefit of mixed culture of shrimp with monosex tilapia is being practiced in many countries. However, farmers in Bangladesh could not harvest shrimp efficiently due to viral and other bacterial diseases. Most of the farmers have no alternative way to accomplish their cash crop loss. So economic loss due to sudden shrimp crop failure could be partially minimized by the tilapia crop. Therefore, tilapia−shrimp polyculture with appropriate feeding strategies is technically feasible, economically attractive and environmentally friendly (Yuan *et al.*, 2010). Further, production and profitability of shrimp and tilapia polyculture depend on several factors, among them stocking ratio of shrimp and fish is one of the most imperative factors. Keeping the above facts in view, the present study was undertaken to assess the effect of stocking ratio of giant tiger shrimp and GIFT tilapia on their growth, production and economic analyses in brackishwater earthen ponds

MATERIALS AND METHODS

Study area and design

The experiment was carried out in nine brackishwater earthen ponds situated at Bagerhat sadar *upazila* of Bagerhat district in Bangladesh from March to July, 2018. Average area of the pond was 400 m^2 and depth of water was 0.8−1.6 m each. The experiment was conducted following randomized block design (RBD) with three treatments *viz.*, T_1, T_2 and T_3 and each treatment was comprised with three replicates. Shrimp post larvae and tilapia fingerlings were stocked at a ratio of 3:1 (numbers/m^2), 3:2 (numbers/m^2) and 3:3 (numbers/m^2) in T_1, T_2 and T_3, respectively.

Pond preparation and management

Before the start of the experimental trial, ponds were treated with agricultural lime ($CaCO_3$) at a rate of 250 kg/ha based on soil pH. Ponds were then filled with tidal water gradually up to a depth of 0.9 m from the nearby tidal canal through screen net. All unwanted organisms were eliminated using rotenone at a rate of 3 ppm and then lime was applied at a rate of 125 kg/ha for neutralizing its action. After 5 days of cleaning, ponds were fertilized with urea and TSP (Triple Super Phosphate) at a rate of 50 and 100 kg/ha, respectively. Fine mesh sized nylon net was used as fence on the dikes around the ponds to prohibit the potential disease carriers such as snail, snake and others.

Stocking and feed management

The shrimp PL (PCR tested) were stocked in all ponds at a rate of 3/m^2 but the stocking of tilapia fry was 1, 2 and 3/m^2 in T_1, T_2 and T_3, respectively. After 25 days of shrimp PL stocking, tilapia was stocked. Commercial pellet shrimp feed (32.0% protein, 11.0% moisture, 4.0% crude lipid and 8.0% crude fiber) was used at a rate of 10% of shrimp biomass for first month, 6% for 2nd month and gradually decreased up to 3% until the end of the study. In par, tilapia were fed with farm made feed (40% rice bran, 20% wheat flour, 15% corn flour, 20% fish meal and 5% mustard oil cake) thrice a day at a rate of 10% of the total biomass for first two months and 5−3% of body weight at the end of the culture period. Tilapia feed was used before 30−45 minutes of shrimp feed applying owing to proper utilization of feed and to minimize feed competition among cultured species. Weights of minimum 10−15% of initially stocked shrimp and tilapia in numbers were recorded fortnightly to estimate the biomass and to manage the feeding ration and also to observe the health conditions of the species. For sampling purposes cast net was used regularly. During the culture, lime was applied to all ponds at monthly intervals at the rate of 50.0−75.0 kg/ha based on water depth for maintaining good water quality.

Water quality monitoring

Ten-day intervals water quality parameters of the ponds like as temperature, salinity, transparency, dissolved oxygen (DO) concentration, pH, total alkalinity and ammonia were measured between 9.00 and 10.00 am. Salinity of water was measured using a portable refractometer (ATAGO, Hand Refractometer). Surface water temperature was determined *in situ* using a standard centigrade thermometer. Transparency was recorded using Secchi disc. Dissolved oxygen was determined using a portable DO meter (YSI 58 digital DO meter, HANNA, Yellow Springs, Ohio 45387 USA). pH of water was recorded using pH meter (HANNA, USA). Total alkalinity was measured by titrimetric method (APHA, 2000). Ammonia nitrogen was measured using ammonia test kit (Biosol, A.A. Biotech PVT LTD., Fishtech BD LTD).

Harvesting and production parameters

After 120 days of culture, bamboo poles and leaves were removed, water was drained out of ponds, shrimp and tilapia were harvested by repeated netting (cast net and surrounding net). Harvested all shrimp and tilapia from each pond were counted, measured and weighed individually to determine survival rate, growth and yield. Specific growth rate (SGR), feed conversion ratio (FCR), survival rate (%) and yield were calculated following the equation as:

Specific growth rate (SGR) (%/day) = {Ln (final body weight) – Ln (initial body weight) × 100}/cultured period (days).
Feed conversion ratio (FCR) = Feed consumed (g dry weight)/live weight gain (g wet weight) of shrimp/fish
Survival rate (%) = (Number of shrimp/fish harvested ÷ total number of shrimp/fish stocked) × 100
Yield of shrimp/fish = No. of shrimp/fish caught × (average final weight of shrimp/fish − average initial weight of shrimp/fish)

Economic analyses

A simple algebraic economic analysis was carried out to determine the net return and benefit cost ratio of shrimp and fish culture in different treatments. The following equation was used to quantify the profitability of shrimp and tilapia culture in pond systems: NR=TR− (FC + VC + Ii).

Where NR=net return, TR=total revenue from shrimp and tilapia sales, FC=fixed/common costs, VC=variable costs and Ii=interest on inputs. The benefit cost ratio (BCR) was determined as total net return/total input cost. The prices of different kinds of inputs, shrimp and tilapia correspond to the Bagerhat wholesale market prices in 2018.

Shrimp and tilapia were sold at a rate of BDT 530.00−560.00 and BDT 110.00−130.00, respectively.

Statistical analysis

Growth, production, net returns and benefit cost ratio were analyzed using one way ANOVA to compare the treatments means. The ANOVA was followed by DMRT (Duncan's Multiple Range Test), when necessary. All ANOVA were tested at 5% level of significance using SPSS (Statistical Package for Social Science) version 20

RESULTS AND DISCUSSION

Growth and survival of shrimp and tilapia

The results of growth and production performance of shrimp and monosex tilapia are presented in Table 1. Although similar sized shrimp juveniles were stocked in all treatment ponds, the individual final weight of shrimp was higher in T_2 (29.17 g) followed by T_1 (28.41 g) and T_3 (26.38 g). In case of tilapia, the highest final weight was recorded in T_1 (135.62 g) than that of T_2 (121.10 g) and T_3 (95.92 g). Islam *et al.* (2016) recorded mean final weight of prawn and tilapia as 58−63 and 149−199 g, respectively in prawn and tilapia mixed culture for 150 days in farmers' shrimp ponds of Bagerhat.

Specific growth rate (SGR) of shrimp (7.00−7.07%) was not significantly different among treatments. The highest SGR of tilapia was found in T_1 (4.09%) and T_2 (4.00%), which was significantly ($p<0.05$) different from that of T_3 (3.80%). Similar, SGR of tilapia ranged between 3.98−4.13 and 3.07−3.34%, respectively reported by Islam *et al.* (2016) and Islam and Mahmud (2011). However, Shofiquzzoha and Alam (2008) observed that the SGR of shrimp and tilapia as 6.94 and 4.26%, respectively for 120 days at Brackishwater Station (BS) pond complex, BFRI (Bangladesh Fisheries Research Institute), Khulna, which is lower than the findings of the present study.

Feed conversion ratio (FCR) of shrimp and tilapia was significantly lower in T_2 (2.4) than that of T_1 (3.0) and T_3 (3.45). Chanratchakool *et al.* (1995) stated that the FCR varies with the stocking density, quality of feed and the size at which the shrimps were harvested and also depends on the production cycle and between populations. Sedgwick (1979) reported FCR increased with the level of rations fed and with the mean weight of prawn as they grew. In this study, lowest FCR was recorded in $T_{2,}$ which seems to be due to efficient utilization of maximum ration by the shrimp and tilapia.

Survival rate of shrimp was significantly higher in T_1 (78.00%), followed by T_2 (72.00%) and T_3 (61.33%). Islam and Mahmud (2012) reported the survival of prawn ranged between 62−70% in polyculture system of prawn and tilapia, which was slightly lower than the present findings. It was observed that growth rate and survival of shrimp decreases with the increase of stocking density of tilapia. Survival rate and growth were also associated with water depth and space in ponds. The present study observed, significantly lower SGR and survival of shrimp in T_3, it could be due to intra and inter-specific competition among the animals stocked. Garcia-Perez *et al.* (2000) stated that there are many factors that affect the survival of prawn/shrimp like as environmental stress, water level, required amount of feed, stocking ratio, cannibalism, bird predation, predator fish, etc. Cannibalism during moulting period is a common phenomenon and may be responsible for a monthly mortality of 4% (AQUACOP, 1990). During the study, survival rate of monosex tilapia ranged between 51.00 and 68.00%. Higher survival of tilapia was found in T_1 (68.00%) and lower in T_3 (51.00%). Islam and Mahmud (2011) obtained the survival rate of prawn and tilapia from 58−65% and 66−73%, respectively. These findings are almost similar with the findings of the present work.

Production performance of shrimp and tilapia

Highest production of shrimp (664.79 kg/ha/120 days) was recorded in T_1, which was significantly different ($p<0.05$) from T_3 (485.37 kg/ha/120 days) but not significantly different from T_2 (630.07 kg/ha/120 days). Significantly higher production of tilapia was found in T_2 (1,509.63 kg/ha/120 days) and T_3 (1,467.58 kg/ha/120 days) than that of T_1 (922.22 kg/ha/120 days). Production of tilapia increased with increasing density but individual weight gradually decreased. Islam and Mahmud (2011) recorded the net yield of prawn of 1,045.8 kg/ha/180 days in polyculture system with tilapia and 1,105 kg/ha/180 days in monoculture system in brackishwater ponds, which was higher than the results of present study. Whereas the production of shrimp recorded by Islam and Mahmud (2010) and Shofiquzzoha and Alam (2008) was 416.9−641.7 kg/ha and 284.05 kg/ha, respectively, which were lower than the production obtained in the present study. Total production of present study was high than Islam and Mahmud (2010) due to might be associated with double species stocked, higher protein percentage of supplied feed, PCR tested quality shrimp PL, better size of tilapia fry and good management of water quality. Significantly higher ($p<0.05$) combined production (2,139.70 kg/ha) of shrimp and tilapia was achieved from T_2 than that of T_3 (1,952.95 kg/ha) and T_1 (1,587.01 kg/ha). The observed production was lower than the findings of Islam *et al.* (2016), who recorded the combined production of prawn and tilapia as 2491.80−2510.60 kg/ha/150 days. The combined yield of prawn and tilapia reported by Asaduzzaman *et al.* (2009) was 1,763.0 kg/ha/120 days which was lower than the present findings. The highest combined production obtained by Uddin *et al.* (2006) in ponds stocked with 75% tilapia and 25% prawn was 1,691 kg/ha which was also less than the present study.

Cost-benefit of shrimp and tilapia farming

Cost and profit of shrimp and tilapia farming was presented in Figure 1. Total net profit was significantly higher in T_2 (BDT 211,209.13/ha) than in T_3 (BDT 161,731.49/ha) and T_1 (BDT 159,445.90/ha). The observed profit was slightly lower than the findings of Islam *et al.* (2016), who recorded the profit of prawn and tilapia farming as BDT 147819.00−238923.00/ha in farmers' ponds. Islam and Mahmud (2011) recorded the profit of prawn and tilapia culture ranges from BDT 137021.00 to 236797.00/ha, which is consistent with the findings of the present study. Islam and Mahmud (2010) found the net profit of shrimp farming as BDT 45086.33−181182.35 at in 120 days culture period and used commercial and Bangladesh Fisheries Research Institute (BFRI) feeds, which is lower than the findings of the present study.

Benefit cost ratio (BCR) was significantly higher ($p<0.05$) in T_2 (1.67) than T_3 (1.58) and T_1 (1.50). Results of the study indicated that stocking ratio of tilapia affected the economic return positively. There was no adverse change in water quality due to different density of tilapia. Further, inclusion of tilapia did not hamper the growth and production of shrimp.

Water quality parameters

Water quality parameters of pond water such as temperature, transparency, dissolved oxygen, salinity, pH, alkalinity and ammonia were measured. Water temperature varied from 26.39−32.97°C in all treatments and found similar with recorded temperature (28.0−32.0°C) by Islam and Mahmud (2010). Salinity fluctuated from 3.50 to 6.14 ppt. Islam and Mahmud (2011) reported the salinity was 3.0−10.3 ppt, in farmers' shrimp ponds of Bagerhat, which are slightly higher than the present findings. Dissolved oxygen (DO) recorded to range from 4.30–5.36 mg/l, which is consistent with the findings of Islam *et al.* (2016), who found the DO ranges from 4.0 to 5.1 mg/l in farmers' shrimp culture ponds of Bagerhat. Whereas, pH values varied from 6.68 to 7.35 which is almost similar to the findings of Islam *et al.* (2016), who found the water pH ranges from 7.1 to 7.7 in shrimp ponds. Water transparency was ranged from 29.11 to 36.83 cm which was lower than the findings of Islam and Mahmud (2011), who recorded transparency ranged from 35.0 to 60.5 cm. Total alkalinity ranged from 90.51 to 103.34 mg/l. Alam *et al.* (2008) recorded the total alkalinity ranges from 153.78 to 156.39 mg/l at BS pond complex, which is higher than the present findings. The concentrations of ammonia nitrogen were varied between 0.004−0.092 mg/l, which was within the acceptable level (>0.012 mg/l) made by Meade (1985). However, no significant difference ($p>0.05$) in water quality was observed among the treatments.

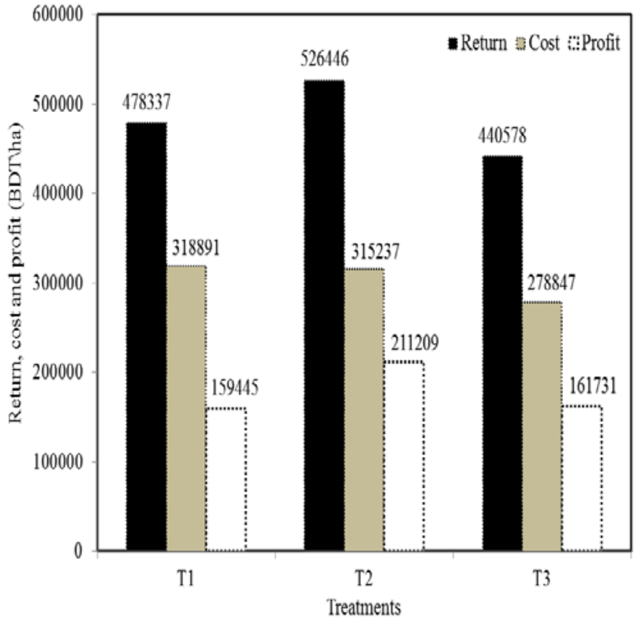

Fig. 1: Benefit cost of shrimp and tilapia farming in coastal area of Bangladesh

In summary, polyculture/mixed culture has gained much importance than monoculture around the world because it contributes to increased total production and high economic return. The results of the present study, concludes that for higher production and net profit, concurrent culture of shrimp and tilapia at a ratio of 3:2/m^2 could be suggested to adopt at end users level in coastal areas of Bangladesh.

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Table 1: Growth, survival rate and production (mean±SD) of *Penaeus monodon* and *Oreochromis niloticus* in different treatments

Species and production parameters	T_1 (3:1/m^2)	T_2 (3:2/m^2)	T_3 (3:3/m^2)
Penaeus monodon			
Average initial weight (g)	0.006 ± 0.002	0.006 ± 0.002	0.006 ± 0.001
Average final weight (g)	28.41^a ± 2.09	29.17^a ± 3.80	26.38^b ± 2.80
Survival rate (%)	78.00^a ± 2.65	72.00^a ± 3.00	61.33^b ± 3.51
Specific growth rate (%/day)	7.05^a ± 0.14	7.07^a ± 0.30	7.00^a ± 0.13
Production (kg/ha)	664.79^a ± 19.09	630.07^a ± 96.66	485.37^b ± 66.37
Oreochromis niloticus			
Average initial weight (g)	1.0 ± 0.02	1.0 ± 0.04	1.0 ± 0.03
Average final weight (g)	135.62^a ± 5.79	121.10^b ± 3.29	95.92^c ± 3.09
Survival rate (%)	68.00^a ± 3.00	62.33^b ± 1.53	51.00^c ± 2.00
Specific growth rate (%/day)	4.09^a ± 0.04	4.00^a ± 0.05	3.80^b ± 0.02
Production (kg/ha)	922.22^b ± 1.42	1509.63^a ± 19.88	1467.58^a ± 86.94
Total FCR	3.0^b±0.1	2.4^c±0.2	3.45^a±0.3
Combined production (kg/ha)	1587.01^c ± 20.51	2139.70^a ± 99.67	1952.95^b ± 152.93

Figures with different superscript in the same row differ significantly ($p>0.05$).

REFERENCE

Alam, M.J., Islam, M.L. and Tuong, T.P. 2008. Introducing tilapia (GIFT) with shrimp *(Penaeus monodon)* in brackishwater rice−shrimp system: impact on water quality and production. *Bangladesh J. Fisheries Res.* 12(2):187-195.

Anggawa, A. 1999. Polyculture of shrimp and tilapia in east Java. American Soybean Association (ASA) Technical Bulletin. *Aquaculture,* 47.

AQUACOP. 1990. Freshwater prawns. In Norton M, (Ed.). Aquaculture. Bookcraft Limited, London, UK, 501−528.

Asaduzzaman, M., Wahab, M.A., Verdegem, M.C.J., Benerjee, S., Akter, T., Hasan, M.M. and Azim, M.E. 2009. Effects of addition of tilapia *Oreochromis niloticus* and substrates for periphyton developments on pond ecology and production in C/N−controlled freshwater prawn *Macrobrachium rosenbergii* farming systems. *Aquaculture*, 287: 371−380.

Chanratchakool, P.J.F., Turnbul, S., Fung, S. and Wan, C.L. 1995. Health Management in shrimp ponds’’ 2nd edition. Published by Aquatic Animal Health Research Institute. Dept. of fisheries. Kasetsart University Campus, Jatujak, Bankok 10900, Thailand. p. 111.

DoF (Department of Fisheries). 2018. National Fish Week Compendium (In Bangla). Ministry of Fisheries and Livestock, Dhaka, Bangladesh. p. 160.

Garcia-Perez, A., Alston, D.E. and Cortees Maldonado, R. 2000. Growth, survival, yield and size distributions of freshwater prawn *Macrobrachium rosenbergii* and tilapia *Oreochromis niloticus* in polyculture and monoculture systems in Puerto Rico. *J. World Aquaculture Society,* 31(3): 446−451.

Islam, M.S. and Mahmud, Y. 2010. Impact of different feeds on production and economic return of tiger shrimp (*Penaeus monodon*) in coastal aquaculture farm. *Bangladesh Journal Agriculture*, 35(1): 119−126.

Islam, M.S. and Mahmud, Y. 2011. Performance of fresh water prawn with tilapia and rui in brakishwater pond. *SAARC J. Agri.,* 9(1): 107−121.

Islam, M.S. and Mahmud, Y. 2012. Impact of stocking density of freshwater prawn *(Macrobrachium rosenbergii)* and monosex tilapia *(Oreochromis niloticus)* on production and economic return under polyculture systems in brackishwater ponds. *Eco−friendly Agril. J.,* 5(12): 257−263.

Islam, M.S., Mahmud, Y. and Begum, N. 2016. Systems in the Ponds of Coastal Region: Impact of stocking density of tilapia on production and profitability. *American Journal of Experimental Agriculture,* 13(3): 1−9.

Liao, C. 1987. Prawn culture from Taiwan’s experience. Round Table Panel, 18th annual meeting of World Aquaculture Society, Contrib. B−52 Tungkang Marine Laboratory. Guayaquil, Ecuador. p. 24.

Meade, J.W. 1985. Allowable Ammonia for Fish Culture. *Prog. Fish culture,* 47**:** 135−145.

Rouse, D.B. and Stickney, R.R. 1982. Evaluation of the production potential of *Macrobrachium rosenbergii* in monoculture and polyculture with *Tilapia aurea*. *J. World Mariculture Society,* 13: 73−85.

Sedgwick. 1979. Effect of ration size and feeding frequency on the growth and food conversion of juvenile *Penaeus mergulensis. Aquaculture,* 16: 279−298.

Shofiquzzoha, A.F.M. and Alam, M.J. 2008. Culture feasibility of silver barb (*Barbodes gonionotus* Bleeker) and GIFT with shrimp (*Penaeus monodon* Feb.) in brackishwater pond. *Bangladesh Journal of Fisheries Research,* 12(1): 69−74.

Uddin, M.S., Azim, M.E., Wahab, M.A. and Verdegem, M.C.J. 2006. The potential of mixed culture of genetically improved farmed tilapia (*Oreochromis niloticus*) and freshwater giant prawn (*Macrobrachium rosenbergii*) in periphyton based systems. *Aquaculture Research,* 37: 241−247.

Yuan, D., Yi Y., Yakupitiyage, A., Fitzimmons, K. and Diana, J.S. 2010. Effects of addition of red tilapia (*Oreochromis* spp.) at different densities and sizes on production, water quality and nutrient recovery of intensive culture of white shrimp (*Litopenaeus vannamei)* in cement tanks. *Aquaculture,* 298: 226−238.