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Original Article

Production and economics of Gangetic mystus (*Mystus cavasius*) farming under different feed restriction periods in cages of floodplain ecosystem

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Abstract
High feed cost is a major problem for the promotion of a nutrient rich fish like Gangetic mystus (*Mystus cavasius*) in cages under floodplain ecosystem. To address this problem, production and economics of cage farming of Gangetic mystus were evaluated under different feed restriction periods in Atrai River of Chalan Beel. Four feed restriction periods were tested in floating cages under four different treatments (T_1-0 day i.e., regular feeding, T_2-1 day, T_3-2 days, and T_4-3 days feed restriction per week). Fish were fed twice daily with commercial floating pellet containing 32% protein. Water quality parameters (water temperature, dissolved oxygen, pH and ammonia-nitrogen) were within the suitable range for fish culture. Final weight, weight gain, % weight gain, average daily gain, specific growth rate and survival rate were found significantly higher at treatment T_1 whereas a better feed conversion ratio was observed in T_2. Significantly higher fish production and benefit were also obtained from treatment T_2. The present study concluded that Gangetic mystus with a stocking density of 50 fish m^{-3} fed with 32% protein containing feed maintaining 1 day feeding restriction per week are economically feasible for cage culture in running water.

Keywords: cage culture; Gangetic mystus; restricted feeding; floodplain aquaculture

1 | INTRODUCTION

Cage culture is a method that enables the intensive cultivation of fish, allowing for the application of advanced technology and resulting in increased biomass production (Jewel *et al.* 2018).The cage culture system is favoured over other aquaculture systems due to its technical simplicity, lower capital investment, intensive feeding and health monitoring and ease of harvesting (Mondal *et al.* 2010). The water bodies in Bangladesh (e.g. rivers and floodplains) present viable locations for cage culture. This practice enables small-scale farmers to utilise their limited resources effectively and incorporate high-valued species into their cages. This, in turn, allows them to generate additional income and enhance their overall livelihood. Cage culture has been used in several research studies in Bangladesh (e.g. Mondal *et al.* 2010; Begum *et al.* 2017). However, the accumulation of uneaten feed, faeces, and metabolic by-products has caused some challenges. On the contrary, cage culture in inland open water floodplain ecosystem can optimises the utilisation of natural resources and creates a conducive environment for the rearing of aquatic organisms (Upadhyay *et al.* 2022).

Using proper stocking densities and feeding procedures are two of the cornerstones to sustainability in aquaculture operations (Abd El-Hack *et al.* 2022; Hossain *et al.* 2022). A shortage of nutritionally acceptable and low-cost feeding has long been a hurdle to the fruitful exercise of cage fish rearing in many developing countries (Otubusin 1987; Umaru *et al.* 2016; Munguti *et al.* 2021). Feed represents the most expensive cost item in aquaculture production and contributes 40 – 70% of the variable cost depending on intensity (Gandotra *et al.* 2015; Obiri-korang *et al.* 2015). Feed contributes significantly to commercial fish production and is the determining factor between profitable and unprofitable aquaculture business (Bolivar *et al.* 2006).

Starving fish for some days within culture period is a common practice for farmers to reduce feed cost and to increase profit margin (Gaylord and Gatlin 2000). Starving fish are now a familiar strategy applied by fish farmer to reduce feed cost in aquaculture as because being an important factor in commercial fish farming feed cost accounts for 40 – 60% of the production cost in fish culture (Rahman and Marimuthu 2010). However, restoration of adequate feeding can overcome the effect of starvation and was also known to give faster growth than the continuously fed fish, commonly called growth compensation. But it is always not the case as because compensatory growth may sometimes cause developmental abnormalities due to faster growth and can reduce immune-competence and disease resistance. Therefore, it is necessary to know how many days a fish can be starved and what will be the optimal feeding rate to increase feed efficiency, growth performance of fish, maintain water quality and finally to increase profit of fish production (Dwyer *et al.* 2002). Although culture of Gangetic mystus was reported in ponds (Hosen *et al.* 2017), no such research effort considering the restriction feeding strategy is taken for cage farming of this species in floodplain ecosystem. Therefore, the present study aimed at evaluating the production and economics of Gangetic mystus farming in cages under different feed restrictions in floodplain ecosystem. The specific objectives included in this study were to monitor the water quality, growth and yield of Gangetic mystus under different feed restrictions; evaluate the economics of cage fish farming; and finally, to recommend suitable feeding strategy of Gangetic mystus for cage farming in floodplain. The findings of this study might be helpful in formulating sustainable feeding strategy for cage culture of Gangetic mystus in floodplain ecosystem.

2 | METHODOLOGY

2.1 Selection of study location

This study was conducted in the stretch of Atrai River (24030′18.75″N 89008′19.15″E) that flows through the Chalan Beel in Singra Upazila of Natore district, Bangladesh (Figure 1). The study was conducted for a period of four months from 1 July to 28 October 2020.

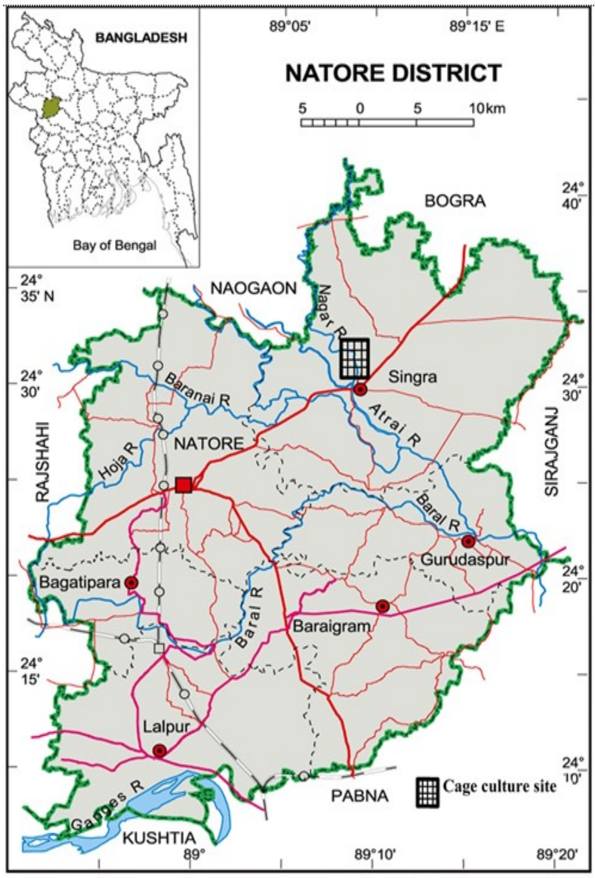

FIGURE 1 Cage fish farming experimental site in the Atrai River of Chalan Beel, Bangladesh (modified from Google map).

2.2 Description of cages

Medium sized cage (6 m × 3 m × 2 m) was used for this trial. Stainless steel metals and plastic barrels were used as frame and float respectively. The entire frame was wrapped with a net of 0.5 cm mesh size which was again covered with a net of 1 cm mesh size. The distance between the two different meshed net was 12.7 cm to save the inner net from the attack of potential attackers such as crab. A total of 12 cages were installed in a row for this experiment. The cages were maintained in a buoyant state within a body of water, positioned approximately 3 meters above the sediment at the bottom. The cages were securely fastened to blocks in the water, with three blocks per cage, to prevent them from drifting away.

2.3 Experimental design

A total of four different supplementary feed restrictions like no feed restriction (i.e. regular feeding or feeding throughout the week), 1 day feed restriction per week, 2 days feed restriction per week and 3 days feed restriction per week were tested under four treatments as T_1, T_2, T_3

and T_4 respectively. Each treatment had three replications.

2.4 Cage management

Hatchery produced seeds (7.90 – 8.10 g) of Gangetic mystus were stocked at 50 fish m^{-3} in experimental cages. The stocking density of Gangetic mystus in each cage was maintained according to Ara *et al.* (2020). The fish were fed with commercial feed containing 32% protein and feeding was done at the rate of 5% of body weight. Fish were fed two times in a day (40% in morning and 60% at night).

2.5 Monitoring of water quality parameters

During the experimental period, water quality parameters were monitored every week. The water temperature was measured using a thermometer at a depth of 20 cm; the dissolved oxygen concentration was determined using an oxygen meter (YSL, Norwich, UK), and the pH was evaluated using a pH meter (Orion, USA). NH_3-N, unionised ammonia–nitrogen was measured using HACH kits (FF2, USA).

2.6 Fish growth monitoring

After the experimental period, the mean final body weight (FBW, g $fish^{-1}$) was determined for 100 fish sampled from each cage. The growth performance was measured using the following formulae:

Weight gain (g) = Mean final weight (g) – Mean initial weight (g);
Average daily gain (ADG) (g) = body weight gain (g) / number of days;
Yield (kg $cage^{-1}$) = Fish biomass at harvest – Fish biomass at stocking
Percent weight gain (%) = $\frac{\text{Final weight (g)} - \text{Initial weight (g)}}{\text{Initial weight (g)}} \times 100$;
SGR (%/day) = $\frac{\ln[\text{Final weight} - \ln[\text{Initial weight}]}{\text{Culture period}} \times 100$;
Survival rate (%) = $\frac{\text{No. of fish harvested}}{\text{No. of fish stocked}} \times 100$;
Food conversion ratio = $\frac{\text{Weight of feed fed}}{\text{Fish weight gain}}$
Total production (kg $cage^{-1}$) = Fish biomass at harvest
Net production (kg $cage^{-1}$) = Fish biomass at harvest – Fish biomass at stocking

2.7 Economic analysis

The prices are stated in Bangladesh Taka (BDT), the currency of Bangladesh (~84 BDT = 1 USD$). Economic analysis was performed using the following equation: R = I – (FC + VC + Ii) (Asaduzzaman *et al.* 2010). Where, R = net return, I = income from fish sale, FC = fixed / common costs, VC = variable costs and Ii = interest on inputs. The cost-benefit ratio (CBR) was also calculated using the following formula: CBR = Net benefit / Total cost.

2.8 Data analysis

Data on water quality, fish growth, yield and economics of caged fish farming under different treatments were subjected to one-way ANOVA (analysis of variance). When a mean effect was significant, the ANOVA was followed by Duncan New Multiple Range Test (DMRT) at 5% level of significance (Gomez and Gomez 1984). The percentages and ratio data were analysed using arcsine transformed data. All analyses were performed using SPSS (Statistical Package for Social Science) version 22.0 (IBM Corporation, Armonk, NY, USA).

3 | RESULTS AND DISCUSSION

There was no significant difference ($p > 0.05$) in the mean values of water quality parameters among the treatments (Table 1). Comparatively higher DO content was recorded in treatment T_2.

TABLE 1 Water quality in cages at different treatments of feed restrictions. T_1–T_4 indicates experimental groups.

Parameters	T_1	T_2	T_3	T_4
Temperature (°C)	30.35 ± 1.57	30.02 ± 1.96	29.90 ± 1.67	29.94 ± 1.20
pH	7.08 ± 0.21	7.10 ± 0.26	7.05 ± 0.20	7.04 ± 0.33
DO (mg L^{-1})	5.58 ± 0.44	5.61 ± 0.52	5.54 ± 0.47	5.56 ± 0.41
NH_3-N (mg L^{-1})	0.03 ± 0.01	0.04 ± 0.02	0.03 ± 0.01	0.03 ± 0.02

No significant ($p > 0.05$) differences were determined across treatment groups for all parameters. $N = 12$.

There was no significant difference in the mean value of water quality parameters among the treatments. This was because the cage culture was performed in running water system. Hence, the pollutant in terms of NH_3-N was mainly washed out by the river water. In the present study, water temperature varied from 29.90 – 30.35°C in the treatment. Highest temperature (30.35°C) was recorded in the T_1 while the lowest was found in T_3. pH ranged between 7.04 and 7.10 in the treatment. Maximum pH (7.10) was documented in T_1 and the minimum (7.04) was reported in T_4. The DO fluctuated between 5.54 mg L^{-1} (in T_3) to 5.61 mg L^{-1} (in T_2) among the treatments. The maximum NH_3-N was recorded in T_2 whereas 0.03 mg L^{-1} was reported in T_1, T_3 and T_4. In another study of cage aquaculture, average values for water temperature, conductivity, TDS and transparency were measured in the floodplains of the Ratargul Swamp Forest and found within the acceptable range without any appreciable change (Kunda *et al.* 2022). Ara *et al.* (2020) recorded water temperature, pH, DO and NH_3-N as 21.11 ± 0.33 – 21.11 ± 0.33°C, 7.41 ± 0.02 – 7.54 ± 0.13, 7.09 ± 0.08 – 7.19 ± 0.11 mg L^{-1} and 0.001 ± 0.001 – 0.002 ± 0.000 mg L^{-1} respectively in a study on cage culture in a floodplain ecosystem. However, the water quality parameters are found within the suitable range (Boyd 1998).

Significant difference ($p < 0.05$) was observed in growth and production among the different treatments. Treatment T_2 varied more significantly than others for fish growth and production (Table 2). During the study period, the highest final weight was obtained from the fish stocked at T_1. Followed by final weight, weight gain, % weight gain, average daily gain (ADG), specific growth rate (SGR) was significantly higher in T_1 compared to the other treatments. These results agree with those obtained by Limbu and Jumanne (2014) who reported increased growth performance of fish feeding with 1 day restriction per week. This is encountering abundant food following a period of food deprivation (Zhu *et al.* 2001). Complete compensation in growth of hybrid tilapia (*O. niloticus* × *O. aureus*), Nile tilapia and *Lates calcarifer* was also observed by researchers (e.g. Abdel-Hakim *et al.* 2009; Tian and Qin 2003) in which fishes were exposed to different feeding restriction and re-feeding period. Increased restriction time caused a reduction in the growth parameters might be due to the factors associated with interspecific competition for food and stress. Therefore, the lowest growth performance was observed in T_4. Regular feeding of fish also caused higher survivability in T_1. On the other hand, 3-day feeding restriction in T_4 resulted in increased stress condition and lower survivability of fish. Although lower amount of feed was needed in T_3, reduction in growth resulted in lower FCR. Better performance of FCR for fishes fed with 1-day restricted feeding at treatment T_3 might be due to optimum consumption of the diets and efficiency utilisation of the nutrients contained in the diets (Aderolu *et al.* 2017). Evidence of cyclic starvation and re-feeding effect on feed utilisation was also proved by Tian *et al.* (2010), Urbinati *et al.* (2014) and Zaldua and Naya (2014) in fishes. During fasting period, hyperphagia (an increase in appetite) can be occurred which might cause rapid food consumption and improved growth efficiency (Limbu and Jumanne 2014; Zhu *et al.* 2001). Therefore, nutrients contained in the diet in treatment T_2 were efficiently converted by fish into growth, which was responsible for better performance of FCR in this treatment. However, continuous feeding in treatment T_1 significantly reduced the performance of FCR.

At the end of the study period, significantly higher total and net production were obtained from T_1 (126.14 ± 4.48 and 98.32 ± 4.24 kg respectively) and T_2 (126.23 ± 4.52 and 98.50 ± 4.76 kg respectively) than others treatment. On the other hand, higher net income and CBR were obtained from T_2, which received one day feed restriction per week. Economic analysis revealed higher total and net income and better CBR in T_2 (Table 3).

TABLE 2 Fish growth and yield in cages at different treatments of feed restrictions. T_1–T_4 indicates experimental feeding groups.

Parameters	T_1	T_2	T_3	T_4
Initial weight (g)	7.90 ± 0.43^a	7.98 ± 0.28^a	8.11 ± 0.40^a	8.02±0.30^a
Final weight (g)	38.27±1.07^a	38.20±1.14^a	31.14±2.41^b	25.54±2.35^c
Weight gain (g)	30.37±1.16^a	30.23±1.06^a	23.03±2.46^b	17.53±2.28^c
% weight gain	385.89±31.00^a	379.35±16.79^a	284.71±36.19^b	218.72±27.64^c
ADG (G)	1.32±0.05^a	1.30±0.03^a	1.12±0.08^b	0.96±0.08^c
SGR (%/day)	0.25±0.01^a	0.24±0.01^a	0.19±0.02^b	0.15±0.02^c
Survival rate (%)	94.17±1.44^a	94.39±1.29^a	89.33±2.83^b	83.06±5.87^c
FCR	1.69±0.14^{ab}	1.45±0.07^b	1.78±0.24^a	1.64±0.38a^b
Total yield (kg)	126.14±4.48^a	126.23±4.52^a	97.36±8.18^b	74.19±7.82^c
Net yield (kg)	98.32±4.24^a	98.50±4.76^a	68.97±8.46^b	46.13±7.82^c

Values in a row having different superscripts are significantly different ($p < 0.05$)

TABLE 3 Economic performance of cage culture at different treatments of feed restrictions. T_1–T_4 indicates experimental feeding groups.

Parameters	T_1	T_2	T_3	T_4
Feed cost (BDT cage^{-1})	10613.1 ± 572.4^a	9111.3 ± 314.3^b	7723.9 ± 381.0^c	4668.9 ± 176.0^d
Seed cost (BDT cage^{-1})	7000.0	7000.0	7000.0	7000.0
Cage cost (BDT cage^{-1})	2000.0	2000.0	2000.0	2000.0
Labour cost (BDT cage^{-1})	1600.0	1600.0	1600.0	1600.0
Total cost (BDT cage^{-1})	21213.1 ± 572.4^a	19711.3 ± 314.3^b	18323.9 ± 381.0^c	15268.9 ± 176.0^d
Total income (BDT cage^{-1})	56763.3 ± 2015.0^a	56803.5 ± 2032.2^a	38946.4 ± 3274.1^b	25967.7 ± 2738.4^c
Net income (BDT cage^{-1})	35550.2 ± 2108.9^a	37092.2 ± 1934.6^a	20622.5 ± 3339.7^b	10698.5 ± 2732.3^c
CBR	1.68 ± 0.12^b	1.88 ± 0.10^a	1.13 ± 0.19^c	0.70 ± 0.18^d

Values in a row having different superscripts are significantly different ($p < 0.05$). 1 USD = 84.72 BDT in October 2020.

Effecting feeding strategy is considered very important for any intensive or high stocking density-based fish farming which improves water quality and fish production; reduces feed cost; and thereby increases the net benefit. At the end of the study period, significantly higher total and net production were obtained in T_2. Result demonstrated the best performance of total income, net income and CBR in treatment T_2, where the restriction of feeding was 1 day per week. Improved water quality (comparatively higher DO content) was also recorded in treatment T_2. Almost similar observations were noted by Islam *et al.* (2021) who reported improved water quality, fish production and net benefit in case of carp fattening and catfish farming under one-day feed restriction per week. Findings also agreed with Al-Shammari *et al.* (2019) encouraging caged fish farming as a profitable business.

4 | CONCLUSIONS

The present study describes the effect of cyclic starving and re-feeding period on growth, feed utilisation and economics from cage farming of Gangetic mystus in open water floodplain ecosystem in Bangladesh. Significantly lowest FCR and highest CBR were obtained from treatment T_2 which received one day feed restriction per week. Therefore, appropriate feed restriction is a potential strategy to reduce the feed cost. This study used only one type of feed (factory feed with 32% protein content). Further studies are also required with focus on dietary protein level optimisation and feed formulation using locally available ingredients.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHORS' CONTRIBUTION

Jesmin Ara collected the data, organised the data and prepared the manuscript; Md. Ayenuddin Haque carried out the data analysis; Md. Akhtar Hossain supervised the research work and critically reviewed the manuscript; Md. Abu Sayed Jewel co-supervised the research work and critically reviewed the manuscript.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request to the corresponding author.

REFERENCES

Abd El-Hack ME, El-Saadony MT, Nader MM, Salem HA, ... Khafaga AF (2022) Effect of environmental factors on growth performance of Nile tilapia (*Oreochromis niloticus*). International Journal of Biometeorology, 66: 2183–2194.

Abdel-Hakim NF, Abo State HA, Al-Azab AA, El Kholy FK (2009) Effect of feeding regimes on growth performance of juvenile hybrid tilapia (*Oreochromis niloticus* × *Oreochromis aureus*). World Journal of Agricultural Science 5(1): 49–54.

Aderolu AZ, Lawal MO, Eziefula PN, Ahaiwe EE (2017) Feeding frequency and feeding regime in catfish: effects on nutrient utilization, growth, biochemical and haematological parameters. Journal of Agricultural Sciences (Belgrade) 62(4): 395–410.

Al-Shammari ST, Al-Jumaily JS, Al-Satorei KK (2019) Financial & economical evaluation of cage floating fish culture projects in Babylon province for the production seasons (2015-2016). Tikrit Journal for Agricultural Sciences 18(3): 146–156.

Ara J, Jewel AS, Hossain A, Ayenuddin M (2020) Determination of suitable species for cage fish farming in Chalan Beel, Bangladesh. International Journal of Fisheries and Aquatic Studies 8(2): 315–320.

Asaduzzaman M, Wahab MA, Verdegem MCJ, Adhikary RK, Rahman SMS (2010) Effects of carbohydrate source for maintaining a high C: N ratio and fish driven re-suspension on pond ecology and production in periphyton-based freshwater prawn culture systems. Aquaculture 301: 37–46.

Begum N, Islam MS, Haque AKMF, Suravi IN (2017) Growth and yield of monosex tilapia *Oreochromis niloticus* in floating cages fed commercial diet supplemented with probiotics in freshwater pond, Sylhet. Bangladesh Journal of Zoology 45(1): 27–36.

Bolivar RB, Jimenez EBT, Christopher LB (2006) Alternate-day feeding strategy for Nile tilapia grow out in the Philippines: marginal cost–revenue analyses. North American Journal of Aquaculture 68: 192–197.

Boyd CE (1998) Water quality for fish pond. Aquaculture Research and Development Series No. 43. Auburn University, Alabama, USA. 37 pp.

Dwyer KS, Brown JA, Parrish C, Lall SP (2002) Feeding frequency affects food consumption, feeding pattern and growth of juvenile yellowtail flounder (*Limanda ferruginea*). Aquaculture 213: 279–292.

Gandotra R, Kumari R, Parihar DS (2015) Impact of varied dietary protein on the growth performance of the juveniles of *Labeo rohita*. Journal of Environmental Biology 2(3): 652–655.

Gaylord IG, Gatlin III DM (2000) Assessment of compensatory growth in channel catfish *Ictalurus punctatus* R. and associated changes in body condition indices. Journal of the world Aquaculture Society 31(3): 326–336.

Gomez KA, Gomez AA (1984) Statistical procedure for agricultural research 2nd edition. John Wiley & Sons, New York. 697 pp.

Hosen MHA, Pervin R, Shahriar SIM (2017) Changes in growth performances, survival rate and water quality parameter of pond on different stocking density of Gulsha Tengra (*Mystus cavasius*) in a monoculture system. International Journal of Fisheries and Aquatic Studies 5(6): 52–56.

Hossain MA, Haque MA, Mondol MMR, Harun-Ur-Rashid M, Das SK (2022) Determination of suitable stocking density for good aquaculture practice-based carp fattening in ponds under drought-prone areas of Bangladesh. Aquaculture 547: 737485.

Islam MM, Hossain MA, Razzak MA, Mondol MMR, Alam MA (2021) Improvement of existing fattening technology of carp and high valued small indigenous species (SIS) through good aquaculture practices (GAP) in different agro-ecosystems. Sub-Project Completion Report, BARC, Bangladesh. 137 pp.

Jewel MAS, Husain MI, Haque MA, Sarker MAA, Khatun MS, ... Akter S (2018) Development of low cost formulated quality feed for growth performance and economics of *Labeo rohita* cultured in cage. AACL Bioflux 11(5): 1486–1494.

Kunda M, Chowdhury S, Harun-Al-Rashid A, Islam MA, Ray D, Pandit D (2022) Finding the suitable catfish species for cage aquaculture in a freshwater swamp. Egyptian Journal of Aquatic Biology and Fisheries 26(6): 1285–1299.

Limbu SM, Jumanne K (2014) Effect of restricted and refeeding regime on feeding cost, growth performance, feed utilization and survival rate of mixed sex Nile tilapia *Oreochromis niloticus* cultured in tanks. International Journal of Fisheries and Aquatic Studies 2(1): 118–123.

Mondal MN, Shahin J, Wahab MA, Asaduzzaman M, Yang Y (2010) Comparison between cage and pond production of Thai climbing perch (*Anabas testudineus*) and tilapia (*Oreochromis niloticus*) under three management systems. Journal of the Bangladesh Agricultural University 8: 313–322.

Munguti J, Odame H, Kirimi J, Obiero K, Ogello E, Liti D (2021) Fish feeds and feed management practices in the Kenyan aquaculture sector: challenges and opportunities. Aquatic Ecosystem Health & Management 24(1): 82–89.

Obirikorang KA, Amisah S, Fialor SC, Skov P V (2015) Digestibility and postprandial ammonia excretion in Nile tilapia (*Oreochromis niloticus*) fed diets containing different. Aquaculture international 23(5): 1249–1260.

Otubusin SO (1987) Effect of different levels of blood meal in pelleted feeds on tilapia, *Oreochomis niloticus*, production in floating bamboo net-cages. Aquaculture 65: 263–266.

Rahman MA, Marimuthu K (2010) Effect of different stocking density on growth, survival and production of endangered native fish climbing perch (*Anabas testudineus*, Bloch) fingerlings in nursery ponds. Advances in Environmental Biology 4(2): 178–187.

Tian X, Fang J, Dong S (2010) Effects of starvation and recovery on the growth, metabolism and energy budget of juvenile tongue sole (*Cynoglossus semilaevis*). Aquaculture 310: 122–129.

Tian X, Qin JG (2003) A single phase of food deprivation provoked compensatory growth in barramundi *Lates calcarifer*. Aquaculture 224: 169–179.

Umaru J, Auta J, Oniye SJ, Bolorunduro PI (2016) Growth and economic performance of African catfish, *Clarias gariepinus* (Burchell, 1822) juveniles to imported and local feeds in floating bamboo cages. International Journal of Fisheries and Aquatic Studies 4(2): 221–226.

Upadhyay A, Swain HS, Das BK, Ramteke MH, Kumar V, ... Das AK (2022) Stocking density matters in open water cage culture: influence on growth, digestive enzymes, haemato-immuno and stress responses of *Puntius sarana* (Ham, 1822). Aquaculture 547: 737445.

Urbinati EC, Sarmiento SJ, Takahashi LS (2014) Short-term cycles of feed deprivation and refeeding promote full compensatory growth in the Amazon fish matrinxã (*Brycon amazonicus*). Aquaculture 433: 430–433.

Zaldua N, Naya DE (2014) Digestive flexibility during fasting in fish: a review. Comparative Biochemistry and Physiology 169A: 7–14.

Zhu X, Cui Y, Ali M, Wootton RJ (2001) Comparison of compensatory growth responses of juvenile three-spined stickleback and minnow following similar food deprivation protocols. Journal of Fish Biology 58(4): 1149–1165.