



## Comparative efficacy of stocking density on growth and survival of fry of *Mystus vittatus* in nursery ponds

\* Maliha Hossain Mou, Khondaker Rashidul Hasan, Saokat Ahamed

Bangladesh Fisheries Research Institute, Freshwater Sub-Station, Saidpur, Nilphamari, Bangladesh

### Abstract

Efficacy of different stocking density on the growth and survival of striped dwarf catfish, *Mystus vittatus* fingerlings in nursery ponds has been evaluated with three stocking density treatments (T) viz., T<sub>1</sub> - 8,000 fry dec<sup>-1</sup>, T<sub>2</sub> - 12,000 fry dec<sup>-1</sup> and T<sub>3</sub> - 16,000 fry dec<sup>-1</sup>. After seven weeks of rearing, survival of fingerlings was the highest (65.50±0.49%) in T<sub>1</sub> which was significantly higher than those of T<sub>2</sub> (55.50±0.21%) and T<sub>3</sub> (49.00±0.70%) and also significant difference in final length (3.34-6.89cm) and final weight (3.32-7.92g) among the three treatments were observed. Physico-chemical variables of water and plankton abundance of different treatments were recorded and discussed.

**Keywords:** *Mystus gulosus*, fingerling, stocking density, survival, growth

### Introduction

*Mystus vittatus* (Striped dwarf catfish), locally known as 'Tengra' is a bottom feeder catfish commonly occurring in freshwater bodies; in flooded canals, beels, paddy and jute fields, streams, haors, oxbow lakes and rivers in swarms during rainy season in Bangladesh (Bhuiyan, 1964; Shafi and Quddus, 2001) [1, 28]. *M. vittatus* is commercially important species due to its delicious test, providing food and nutrition, subsistence and supplemental income source of the great majority of rural people in the country. It has considerable demand both in rural and urban markets, particularly to the poor and disadvantaged group. It naturally breeds during monsoons in flooded rivers and ponds (Bhuiyan, 1964; Shafi and Quddus, 2001) [1, 28]. Though it is delicious and demandable species, it is not cultured in our country and not much research work has been done on it. The production of the candidate fish is gradually declining; as a result, it has also been listed as a threatened fish (IUCN, 2010) [10]. As the production is gradually declining, the development of management and conservation are urgently required. Culture practice of this species has not yet been developed. Expansion of aquaculture of any fish is greatly dependent on its ensured supply of seed for grow-out pond. Nursing of yolk-absorbed

hatchlings in the nursery pond seems to be very sensitive, as they pass through a critical period of switching over from planktonic feed to other feed and also need to adjust with new environment from indoor hatchery to outdoor earthen pond. Short term nursing of delicate spawn in nursery ponds is a prerequisite to ensure the reliable and regular supply of quality fry for stocking in grow out ponds at farmers' level. Thus, to obtain the optimum survival and growth rate of any fish fries in nursery ponds, it is of utmost importance to maintain stocking densities. No detailed information is available in Bangladesh on the relative effect of various stocking densities on the growth and survival of striped dwarf catfish fries in nursery ponds. In view of the above, the present study was undertaken to evaluate the effect of stocking density on the growth and survival of striped dwarf catfish, *M. vittatus* fries in nursery ponds.

### Materials and methods

Effect of stocking density on the growth and production of striped dwarf catfish, *Mystus vittatus* was carried out in nine nursery ponds following the experimental design as given Table 1.

**Table 1:** Experimental design of nursery rearing of *M. vittatus*

Treatments (T)	Stocking density (fry dec <sup>-1</sup> )	Feeding/culture period
T <sub>1</sub>	8,000	Locally available commercial nursery feed (containing 35% protein) three times daily. Culture period: 49 days
T <sub>2</sub>	12,000	
T <sub>3</sub>	16,000	

The ponds (2.5 decimal each with an average depth of 1.0 m) were prepared by sun drying followed by liming soil with CaO @ 1 kg dec<sup>-1</sup> and then filled with underground water up to 100 cm depth and enclosed by fine nylon mosquito net. Water of the ponds was treated with rotenone @ 1.5 ppm to kill unwanted fishes. After 5 days, particular pond was fertilized with Urea @ 100 g dec<sup>-1</sup>, TSP @ 75g dec<sup>-1</sup> and Cattle dung @ 6 kg dec<sup>-1</sup>. Five days after fertilization, the nursery

ponds were sprayed with sumitheone 10 ml dec<sup>-1</sup> to kill harmful insects and predatory zooplankton. After twenty four hours of spreading of sumitheone, seven days old hatchlings (average length 0.83 cm) of *M. vittatus* were stocked as given in the experimental design (Table 1) in all ponds. From the second day of stocking, fish hatchlings were fed thrice daily with maintaining following (Table 2) feeding schedule for about 10,000 hatchlings.

**Table 2:** Feeding schedule for about 10,000 hatchlings of *M. vittatus*

Age of hatchling (Days)	Types of feed	Feeding rate	Feeding time/Day
1-3	Boiled egg yolk	2 piece	3 times
4-7	Flour solution	50 g	3 times
8-15	Nursery feed (containing 35% protein)	100 g	3 times
16-23	Nursery feed (containing 35% protein)	150 g	3 times
24-30	Nursery feed (containing 35% protein)	300 g	3 times
31-45	Nursery feed (containing 35% protein)	450 g	3 times
46-56	Nursery feed (containing 35% protein)	600 g	3 times

Growth and well being of the fries were checked at weekly interval. Physicochemical parameters of water *viz.*, water temperature (°C), transparency (cm), dissolved oxygen (DO) (mg<sup>l</sup><sup>-1</sup>), pH, total alkalinity (mg<sup>l</sup><sup>-1</sup>) and ammonia (NH<sub>3</sub>) (mg<sup>l</sup><sup>-1</sup>) were weekly determined by using a Celsius thermometer, a Secchi-disk, a portable dissolved oxygen meter (HI 9142, Hanna Instruments, Portugal), a portable pH meter (HI 8424, Hanna Instruments, Portugal) and a portable ammonia test kit (Hanna), respectively. Total alkalinity was determined following the titrimetric method according to the standard procedure and methods (Clesceri *et al.*, 1992) [4]. Plankton from the nursery ponds were collected in every week for quantitative and qualitative estimation. Ten liters water samples was collected from each replicate experimental ponds and then filtered through bolting silk plankton net (25 µm) to obtain a 50 ml sample. The collected samples were preserved immediately with 5% buffered formalin. Plankton was expressed as cells per liter of water of each pond. The quantitative and qualitative analysis of phytoplankton and zooplankton were done according to Stirling (1985) [27] and Needham (1963) [18], respectively. After 7 weeks of nursing, fish fries were harvested first by repeated netting, followed by draining the ponds with consequent growth and production parameters *viz.*, specific growth rate (SGR), feed conversion ratio (FCR) and survival of fingerlings were estimated. Specific growth rate (SGR %day) and feed utilization efficiency were calculated according to Ricker (1975) [19] respectively as follows:

$$\text{SGR (\%/day)} = \frac{\ln [W.\text{sub.2}] - \ln[W.\text{sub.1}]/[T.\text{sub.2}] - [T.\text{sub.1}] \times 100}{[T.\text{sub.1}] \times 100}$$

**Table 3:** Water quality parameter of nursery rearing of *M. vittatus*

Parameters	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>
Water temperature (°C)	30.93±1.25 <sup>a</sup>	29.12±1.37 <sup>a</sup>	31.17±0.84 <sup>a</sup>
Transparency (cm)	36.1±2.70 <sup>a</sup>	44.5±.03 <sup>b</sup>	51.3±5.01 <sup>c</sup>
Water pH	7.50±0.22 <sup>a</sup>	8.20±0.26 <sup>a</sup>	8.28±0.39 <sup>a</sup>
DO (mg <sup>l</sup> <sup>-1</sup> )	5.3±0.57 <sup>a</sup>	4.8±0.53 <sup>b</sup>	4.1±0.51 <sup>c</sup>
Total alkalinity (mg <sup>l</sup> <sup>-1</sup> )	145.9±24.75 <sup>a</sup>	146.4±28.04 <sup>a</sup>	157.5±22.85 <sup>a</sup>
NH <sub>3</sub> (mg <sup>l</sup> <sup>-1</sup> )	0.17±0.18 <sup>a</sup>	0.21±.22 <sup>a</sup>	0.30±0.26 <sup>a</sup>

Different superscript letters within one row indicated statistically significant differences at p<0.05.

Dissolved oxygen (DO) content was varied from 5.3±0.57 to 4.1±0.51 mg<sup>l</sup><sup>-1</sup> among the treatments. In all the experimental pond water, comparatively lower level of dissolved oxygen was observed that might be due to sampling time which was monitored at about 900-10.00 am. Wahab *et al.* (1995) [29] reported dissolved oxygen ranging from 2.2 to 7.1 mg<sup>l</sup><sup>-1</sup> in nine ponds of BAU campus, Mymensingh. Rahman *et al.* (2013) was found dissolved oxygen 4.13 to 4.71 mg<sup>l</sup><sup>-1</sup>, while

Where,

[W.sub.1] = initial live body weight (g) at time [T.sub.1] (day)

[W.sub.2] = final live body weight (g) at time [T.sub.2] (day).

**Feed Conversion Ratio (FCR)** = Dry weight (g) of feed supplied /Live weight (g) of fish gained

## Results and discussion

### Physico-chemicals properties

The results of physico-chemicals parameters in three treatments are presented in Table 3. The physico-chemicals parameters measured in different treatments throughout the experimental period were found within the acceptable range for fish culture. The mean water temperature was measured 30.93±1.25, 29.12±1.37 and 31.17±0.84° C in T<sub>1</sub>, T<sub>2</sub> and T<sub>3</sub>, respectively. However, there was no significant (*P*<0.05) variation among the treatments. Monir and Rahman (2015) [17] also observed temperature ranged of 28 to 32° C in the nursery ponds of Shing (*H. fossilis*). Rahman *et al.* (2008) observed almost similar types of temperature variation in nursery rearing of *Ompok pabda* fingerlings. The present findings agree with the finding of Mollah and Haque (1978) [16], Wahab *et al.* (1995) [29] and Kohinoor *et al.* (1998).

The mean values of water pH of the different treatments were 7.50±0.22 (T<sub>1</sub>), 8.20±0.26 (T<sub>2</sub>) and 8.28±0.39 (T<sub>3</sub>) which were not statistically significant (*P*<0.05). According to Swingle (1969) [26], pH range from 6.5 to 9.0 is suitable for pond culture. However, the pH range was found to be suitable for fish culture that agrees well with the findings of Rahman *et al.* (2005) and Kohinoor *et al.* (2012).

Kohinoor *et al.* (2012) measured dissolved oxygen 4.23 to 5.32 mg<sup>l</sup><sup>-1</sup> in *H. fossilis* cultured ponds. However, the DO levels are within the acceptable ranges in all the experimental nursery ponds.

Total alkalinity values depend on the location, season, plankton population, nature of bottom deposits etc. Total alkalinity was significantly (*P*<0.05) highest in T<sub>3</sub> (157.5±22.85) followed by T<sub>2</sub> (146.4±28.04) and lowest in T<sub>1</sub>

(145.9±24.75mg<sup>l</sup><sup>-1</sup>). Boyd (1982) [3] advocated that the total alkalinity should be more than 20 mg<sup>l</sup><sup>-1</sup> in fertilized ponds as production increases with the increase in total alkalinity. The variations of total alkalinity in all the treatments were within the productive range for aquaculture ponds (Wahab *et al.*, 1995; Kohinoor *et al.*, 1998) [29].

The mean transparency level was significantly (P<0.05) higher in T<sub>3</sub> and consistently lower in T<sub>1</sub>, which might be due to the reduction of the plankton population by higher density of fish (Rahman *et al.*, 2005; Rahman *et al.*, 2013). Boyd (1982) [3] reported that the range of transparency from 15-40 cm is suitable for fish culture. From the above findings, it can be concluded that the transparency content in the experimental ponds were within the good productive range.

The mean values of ammonia-nitrogen (NH<sub>4</sub>-N) contents in the present study were significantly (P<0.05) higher in T<sub>3</sub> (0.30±0.26) followed by T<sub>2</sub> (0.21±.22) and T<sub>1</sub> (0.17±0.18 mg<sup>l</sup><sup>-1</sup>). Kohinoor *et al.* (2001) found the ammonia-nitrogen ranged from 0.01-1.55 mg<sup>l</sup><sup>-1</sup> in monoculture ponds. Boyd (1982) [3] reported that the suitable range of ammonia-nitrogen in fish culture less than 0.1 mg<sup>l</sup><sup>-1</sup>. Ammonia-nitrogen contents in T<sub>2</sub> and T<sub>3</sub> were higher than T<sub>1</sub> that might be due to higher stocking density of Tengra fry and the higher rate of dropping of the fish in T<sub>2</sub> and T<sub>3</sub> may increase ammonia in respective

ponds. However, the present level of ammonia-nitrogen content in the experimental ponds is not lethal to the fish (Kohinoor *et al.*, 1998; Kohinoor *et al.*, 2001).

**Plankton population**

Four groups of phytoplankton population was mainly found in the experimental nursery ponds- Bacillariophyceae, Chlorophyceae, Cyanophyceae and Euglenophyceae whereas the zooplankton population was composed only of two groups- Crustacea and Rotifera (Table 4). Phytoplankton of Chlorophyceae group was the most dominant and Euglenophyceae group was the least abundant as observed during the study period. Zooplankton of Rotifera group was the most dominant in terms of both numbers and genera compared to Crustacean group among the treatments. The total phytoplankton ranged from (6500 to 15500) X 10<sup>3</sup> units l<sup>-1</sup> with mean abundance were 13142±1406 (T<sub>1</sub>), 11178±1705 (T<sub>2</sub>) and 8714±1050 X 10<sup>3</sup> units l<sup>-1</sup> (T<sub>3</sub>), respectively and showed significant (P<0.05) difference among the treatments. The mean abundance of total zooplankton were 6642±1433, 5107±1059 and 3714±1188 X 10<sup>3</sup> units l<sup>-1</sup> in T<sub>1</sub>, T<sub>2</sub> and T<sub>3</sub>, respectively and also showed statistically significant (P<0.05) among the treatments.

**Table 4:** Plankton abundance (units l<sup>-1</sup>) of pond water of weekly samples over the 7 weeks experiment.

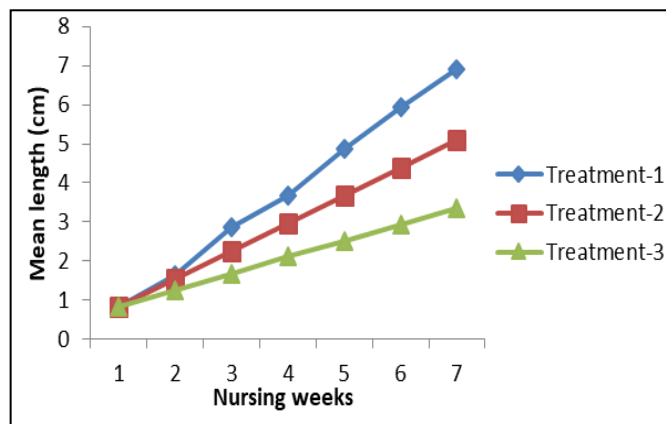
Plankton group	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>
Phytoplankton			
Bacillariophyceae	3285 ±377 <sup>a</sup> (2500-4000)	2892±560 <sup>b</sup> (1500-3500 )	2428±513 <sup>c</sup> ( 1500-3500)
Chlorophyceae	4678±799 <sup>a</sup> (3500-6000)	4035±819 <sup>b</sup> (3000-5500 )	3107±625 <sup>c</sup> (2000-4000)
Cyanophyceae	2750±545 <sup>a</sup> (2000-3500)	2428±675 <sup>b</sup> (1500-4000)	1857±456 <sup>c</sup> (1000-2500)
Euglenophyceae	2428±755 <sup>a</sup> (1500-4000)	1821±575 <sup>b</sup> (1000-3000)	1321±464 <sup>c</sup> (500-2000)
Total	13142±1406 <sup>a</sup> (11000-15500)	11178±1705 <sup>b</sup> (8500-14500 )	8714±1050 <sup>c</sup> (6500-10000)
Zooplankton			
Crustacea	3214±913 <sup>a</sup> (1500-4500)	2321±774 <sup>b</sup> (1000-3500)	1678±607 <sup>c</sup> (500-2500)
Rotifera	3428±730 <sup>a</sup> (2000- 45000)	2785±544 <sup>b</sup> (2000-4000)	2035±1008 <sup>c</sup> (1000-4500)
Total	6642±1433 <sup>a</sup> (3500-9000 )	5107±1059 <sup>b</sup> (4000-7000)	3714±1188 <sup>c</sup> (2500-6500)

The plankton abundance in the present experiment was significantly higher in T<sub>1</sub> which might be due to the lower density fry/fingerlings than those in T<sub>2</sub> and T<sub>3</sub>. It seems likely that in the nursery ponds where stocking density were high, consumption of plankton by the fry/fingerlings were also high. Rahman and Monir (2013) [23, 24] obtained phytoplankton range 8500 to 15500 x10<sup>3</sup> units l<sup>-1</sup> in nursery ponds located in Saidpur, Nilphamari. However, the plankton population in the study showed to be more or less similar with the findings of Rahman *et al.*, 2008.

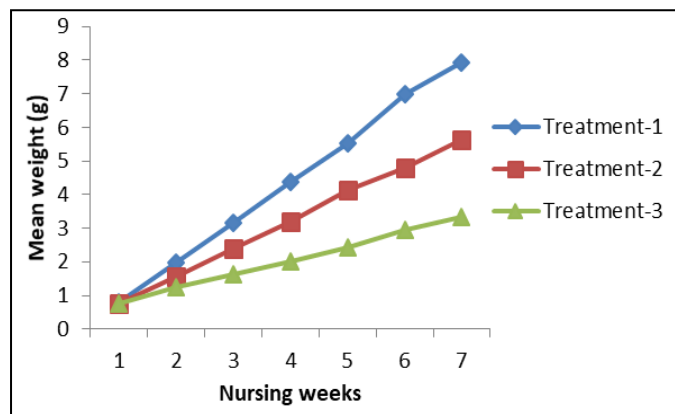
**Growth and production of *M. vittatus* fingerlings**

The length and weight of *M. vittatus* fingerlings under different stocking densities at the end of the experiment in weekly sampling is shown in Fig. 1 & 2 which indicates that the improvement of length and weight were always higher in T<sub>1</sub> than T<sub>2</sub> and T<sub>3</sub>. The mean final length attained under T<sub>1</sub>, T<sub>2</sub> and T<sub>3</sub> were 6.89±0.09, 5.10±.01and 3.34±0.35cm,

respectively (Table 5).



**Fig 1:** Improvement of the length of *M. vittatus* fingerlings at different stocking densities over the nursing period of 7 weeks.



**Fig 2:** Improvement of the weight of *M. vittatus* fingerlings at different stocking densities over the nursing period of 7 weeks.

The highest mean final weight was also obtained in T<sub>1</sub> (7.92±0.12 g) and lowest in T<sub>3</sub> (3.32±0.39 g). However, the mean final length and weight showed significant difference (P<0.05) in T<sub>1</sub> followed by T<sub>2</sub> and T<sub>3</sub>, when ANOVA was performed. The Specific growth rate (SGR % day) was significantly (P<0.05) higher in T<sub>1</sub> (4.73±0.01) than those obtained in T<sub>2</sub> (4.12±0.19) and T<sub>3</sub> (3.03±0.16). The highest survival rate (65.50±0.49%) was also observed in T<sub>1</sub>, where the stocking density was 8,000 fry dec<sup>-1</sup>, whereas the lowest was 49.00±0.70% in T<sub>3</sub>, where the stocking density was 16,000 fry dec<sup>-1</sup> and there were significant differences among the treatments. The Food Conversion Ratio (FCR) of T<sub>1</sub> (1.75±0.21) was found to be significantly lower than T<sub>2</sub> (2.55±0.21) and T<sub>3</sub> (3.20±0.14).

**Table 5:** Growth performance and survival of nursery rearing of *M. vittatus*

Parameters	Treatments		
	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>
Stocking density (dec <sup>-1</sup> )	8,000	12,000	16,000
Initial length (cm)	0.82±.02	0.85±.03	0.84±.00
Final length (cm)	6.89±0.09 <sup>a</sup>	5.10±.01 <sup>b</sup>	3.34±0.35 <sup>c</sup>
Initial weight (g)	0.78 ±.02	0.75±.04	0.75±.03
Final weight (g)	7.92±0.12 <sup>a</sup>	5.62±0.25 <sup>b</sup>	3.32±0.39 <sup>c</sup>
Length gain (cm)	6.10±0.11 <sup>a</sup>	4.21±0.12 <sup>b</sup>	2.49±0.34 <sup>c</sup>
Weight gain (g)	7.14±0.10 <sup>a</sup>	4.87±0.29 <sup>b</sup>	2.57±0.37 <sup>c</sup>
SGR (% day <sup>-1</sup> )	4.73±0.01 <sup>a</sup>	4.12±0.19 <sup>b</sup>	3.03±0.16 <sup>c</sup>
FCR	1.75±0.21 <sup>a</sup>	2.55±0.21 <sup>b</sup>	3.20±0.14 <sup>c</sup>
Survival (%)	65.50±0.49 <sup>a</sup>	55.50±0.21 <sup>b</sup>	49.00±0.70 <sup>c</sup>

Different superscript letters within one row indicated statistically significant differences at p<0.05.

Growth performances (final length, length gain, final weight, weight gain and specific growth rate) and survival rate of Tengra (*M. vittatus*) in nursery ponds revealed that T<sub>1</sub> was significantly higher (P<0.05) where the stocking density of fry (8,000 fry dec<sup>-1</sup>) was low compared to those of T<sub>2</sub> (12,000 fry dec<sup>-1</sup>) and T<sub>3</sub> (16,000 fry dec<sup>-1</sup>), although the same fish feed with equal ratio was applied in all the treatments. The lower growth performances were in T<sub>2</sub> and T<sub>3</sub> than T<sub>1</sub> that might be due to competition for food and habitat for higher number of fingerlings. Stocking density is known to be one of the important parameters in fish culture, since directly effects

growth and survival, and hence production (Backiel and ED, 1967) [2]. Haylor (1992) [6] revealed that the growth and survival rate of African catfish (*Clarias gariepinus*) larvae was significantly influenced by the density at which they were stocked. More or less similar results were also obtained by Rahman *et al.* (2005), Kohinoor *et al.* (2007) and Kohinoor *et al.* (2009) from their fry/fingerlings rearing experiments with various carp, barb and catfish species. However, higher stocking density with abundance of sufficient feed might produce a stressful situation if the feed is not used for growth (Haque *et al.*, 1994 and Rahman *et al.*, 2003) [7].

The Food conversion ratio (FCR) in T<sub>1</sub> during the study period was significantly lowest followed by T<sub>2</sub> and T<sub>3</sub>. In the present study, the FCR values are lower than the FCR values reported by many workers (Islam, 2002; Islam *et al.*, 2002 and Rahman and Monir, 2013) [23, 24]. The causes might be due to the smaller ration size, higher digestibility and proper utilization of feed. Reddy and Katro (1979) and Das and Ray (1989) observed increasing trends of FCR values with increasing ration size in the growth trials of air breathing catfish (*Heteropneustes fossilis*) and Indian major carp (*Labeo rohita*), respectively. However, the lower FCR value in the present study indicates better food utilization efficiency, despite the values increased with increasing stocking densities.

### Conclusion

The growth and survival of Tengra (*M. vittatus*) fingerlings were inversely related to the stocking densities of fry in the experimental nursery ponds. In all respects, 8,000 fry dec<sup>-1</sup> was the highest performances than those obtained at higher stocking rates. However, stocking density of 8,000 fry dec<sup>-1</sup> may be suggested for rearing of Tengra (*M. vittatus*) fingerlings over 7 (Seven) weeks in single stage nursing rearing system in northern region of Bangladesh and extremely helpful towards the protection of this species from extinction.

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### References

1. Bhuiyan AL. Fishes of Dacca, Asiatic Soc. Pakistan, Pub. 1, No. 13, Dacca, 1964, 30-32.
2. Backiel T, ED Le Cren. Some density relationship for fish population parameters. In: Gerking SD Editor. The Biological Basis of Freshwater Fish Production. Blackwell Scientific Publication. Oxford, 1967; 27-36:261-293.
3. Boyd CE. Water quality management for fish culture. Elsevier Science Publisher, the Netherlands, 1982, 318.

4. Clasceri LS, Greenbarg AE, Trussell RR. Standard Methods for the Examination of Water and Wastewater. American Public Health Association, American Water Works Association and Water Pollution Control Federation. Edn 18, 1015 Washington DC, USA, 1992, 10-203.
5. Das I, Ray AK. Growth performance of Indian major carps *Labeo rohita* Ham. on duckweed incorporated pelleted feed: a preliminary study. Journal of Inland Fisheries, 1989; 21:1-6.
6. Haylor GS. Controlled hatchery production of *Clarias gariepinus* Burchell: Growth and survival of larvae at high stocking density. Aquacult Fish Manage, 1992; 23(3):303-314.
7. Haque MZ, Rahman MA, Hossain MM, Raman MA. Effect of stocking densities on the growth and survival of mirror carp, *Cyprinus carpio* var. *specularis* in rearing ponds. Bangladesh Journal of Zoology, 1994; 22:109-116.
8. Islam MS. Evaluation of supplementary feeds for semi intensive pond culture of mahseer, *Tor putitora* Hamilton. Aquaculture, 2002; 212:263-276.
9. Islam MS, Dewan S, Hussain MG, Hossain MA, Mazid MA. Feed utilization and wastage in semi-intensive pond culture of mahseer, *Tor putitora* Ham. Bangladesh Journal of Fisheries Research, 2002; 6:1-9.
10. IUCN. IUCN Red List of Threatened Species. Version 2010, 4.
11. Kohinoor AHM, Islam ML, Wahab MA, Thilsted SH. Effect of mola *Amblypharyngodon mola* Ham. on the growth and production of carps in polyculture. Bangladesh Journal of Fisheries. 1998; 2(2):111-126.
12. Kohinoor AHM, Wahab MA, Islam ML, Thilsted SH () Culture potentials of mola *Amblypharyngo donmola*, chela *Chela cachius* and punti *Puntiussophore* under monoculture system. Bangladesh Journal of Fisheries Research. 2001; 5:123-134.
13. Kohinoor AHM, Islam AKMS, Jahan DA, Zaher M, Hussain MG. Monoculture of climbing perch, Thai koi, *Anabas testudineus* Bloch under different stocking densities at on-farm. Bangladesh Journal of Fisheries Research, 2007; 11:173-180.
14. Kohinoor AHM, Jahan DA, Khan MM, Ahmed SU, Hussain MG. Culture potentials of climbing perch, *Anabas testudineus* Bloch under different stocking densities at semi-intensive management. Bangladesh Journal of Fisheries Research, 2009; 13:115-120.
15. Kohinoor AHM, Khan MM, Yeasmine S, Mandol P, Islam MS. Effects of stocking density on growth and production performance of indigenous stinging catfish, *Heteropneustes fossilis* Bloch. Int. J Agril Res Innov and Tech. 2012; 2(2):9-14.
16. Mollah MFA, Haque AKMA. Studies on monthly variation of plankton in relation to the physic-chemical conditions of water and bottom soil of two ponds. II. Zooplankton. Bangladesh J Fish, 1978; 1:99-103.
17. Monir MS, Rahman S. Effect of stocking density on growth, survival and production of shing *Heteropneustes fossilis* fingerlings under nursery ponds in Northern region of Bangladesh. International Journal of Fisheries and Aquatic Studies. 2015; 2(3):81-86.
18. Needham JG, Needham PR. A guide to study of freshwater biology. Edn 5, Holden-day Inc., San Francisco, 1963, 106.
19. Ricker WE. Computation and interpretation of biological statistics of fish population. Bull Fisheries Res Board of Canada. 1975; 191:1-382.
20. Reddy SR, Katro S. Growth rate and conversion efficiency of air breathing catfish, *Heteropneustes fossilis* in relation to ration size. Aquaculture, 1979; 18:35-50.
21. Rahman MA, Rahman MR. Studies on the growth and survival of sharpunti *Puntius sarana* Ham. spawn at different stocking densities in single stage nursing. Progressive Agriculture. 2003; 14(1-2):109-116.
22. Rahman MA, Mazid MA, Rahman MR, Khan MN, Hossain MA, Hussain MG *et al.* Effect of stocking density on survival and growth of critically endangered mahseer, *Tor putitora* Hamilton in nursery ponds. Aquaculture, 2005; 249:275-284.
23. Rahman MA, Yeasmine S, Khan MM. Growth, survival and production of a threatened silurid catfish, *Ompok pabda* hamilton fingerlings in nursery ponds. Malays Appl. Biol. 2008; 37(1):47-56.
24. Rahman S, Monir MS, Khan MH. Culture potentials of climbing perch. Thai koi, *Anabas testudineus* Bloch under different stocking densities in northern regions of Bangladesh. Journal of Experimental Biology and Agricultural Sciences. 2013; 1(3):203-208.
25. Rahman S, Monir MS. Effect of stocking density on survival, growth and production of Thai *Anabas testudineus* bloch fingerlings under nursery ponds management in northern regions of Bangladesh. Journal of Experimental Biology and Agricultural Sciences, 2013; 1(6):465-472.
26. Swingle HS. Standardization of chemical analysis for waters and pond mud. FAO. Fisheries Res. 1969; 4(2):397-421.
27. Stirling HP. Chemical and biological methods of water analysis for aquaculturists. Institute of Aquaculture, University for Stirling Scotland. 4LA FK9, 1985, 119.
28. Shafi M, Quddus MMA. Bangladesher Matsho Shampad Fisheries of Bangladesh in Bengali; Kabir publication, Dhaka, Bangladesh. 2001, 186-187.
29. Wahab MA, Ahmed ZF, Haque MS, Haque MA, Biswas BK. Effect of frequency of fertilization on the pond ecology and growth of fishes. BAU Research Prog., 1995; 9:410- 419.