Indian J. Fish., 62(3) : 118-123, 2015

Note

Influence of periphyton based culture systems on growth performance of fringe-lipped carp *Labeo fimbriatus* (Bloch, 1795) during fry to fingerling rearing

B. GANGADHAR, N. SRIDHAR, S. SAURABH, C. H. RAGHAVENDRA, M. R. RAGHUNATH AND HEMAPRASANTH

Regional Research Centre, ICAR-Central Institute of Freshwater Aquaculture, Hesaraghatta Lake P.O. Bangalore - 560 089, Karnataka, India
e-mail: gbarlaya@yahoo.co.in

ABSTRACT

A 90 days experiment was conducted in outdoor circular cement tanks to evaluate the growth and survival of *Labeo fimbriatus* fry when provided with sugarcane bagasse as a periphyton substrate. In all, there were six treatments *viz.,* feed (T1), substrate (T2), substrate + feed (T3), substrate in tank bottom + feed (T4) and substrate + feed + double stocking density (T5). Sugarcane bagasse was hung vertically at 2 t ha^{-1}, except in T3, where it was applied at the tank bottom. *L. fimbriatus* fry were stocked @ 30 nos. m^{-3} in all tanks, except in T5 which received double stocking density of 60 fry m^{-3}. No significant variation was observed between the different treatments with respect to water quality parameters monitored *viz*., pH, temperature, dissolved oxygen, total alkalinity and secchi disc visibility. On termination of the experiment, in treatment T4, significantly higher ($p< 0.05$) growth in terms of length and weight, specific growth rate (SGR) and percent weight gain were recorded as compared to the other treatments. Provision of substrate in the water column or at the tank bottom in addition to feed, significantly ($p<0.05$) enhanced weight, specific growth rate (SGR) and percent weight gain. Survival was lower when the substrate was provided at the tank bottom. The results indicated that stocking density can be doubled in tanks provided with substrates, without compromising growth and survival of *L. fimbriatus* fry.

Keywords: Fringe-lipped carp, *Labeo fimbriatus*, Periphyton, Seed rearing, Substrates

Species diversification is considered as one of the important management practices for sustainable aquaculture (NACA/FAO, 2000). In recent years, freshwater aquaculture sector of many south-east Asian countries witnessed inclusion of several new species into the culture systems. In India too, attempts have been made for species diversification in carp polyculture system by inclusion of new candidate species such as *Labeo fimbriatus***,** which is a 'medium carp', commonly called "fringe-lipped carp". It is widely distributed throughout central and peninsular India. Though slow growing, this medium sized carp is in good demand due to its excellent meat quality (Basavaraju *et al.,* 1995). It is reported to graze on algae, protozoa, rotifers and diatoms that grow on submerged rocks and twigs (Talwar and Jhingran, 1991; Das, 2011). Jena *et al*. (2011b) demonstrated compatibility of this species with major carps in polyculture system. Culture of *L. fimbriatus* along with Indian major carps is now being taken up by farmers. However, for taking up large scale farming of the species, there is a need for mass scale production of fingerlings for stocking.

Information on seed rearing of *L. fimbriatus* is limited. Pawar *et al.* (2009) evaluated the growth performance of fringe-lipped carp seed along with catla (*Catla catla*), rohu (*Labeo rohita*) and olive barb (*Puntius sarana*) in concrete tanks at a combined density of 50 nos. m^{-2} with provision of 4 – 12 h aeration. Over 90 days, fringe-lipped carp attained 5.0–5.5 g with a survival of 62–84% in aerated treatments as against 4.5 g and 28% respectively of the control. In another study (CIFA, 2008), fringe-lipped carp fry reared with rohu in concrete tanks at a combined density of 20 nos. m^{-2} at varied species ratios, attained 4.26–5.66 g weight with 82.8–89.2% survival after two months of rearing.

Supplemental feeding is an important management measure in the intensification of aquaculture for enhancing fish production (De Silva and Anderson, 1995). High feed costs discourage subsistence farmers from adopting this practice. An alternative approach is to provide ponds with substrates for the growth of periphyton that can be eaten by herbivorous or planktivorous fish. The feasibility of using periphyton based systems has been explored and found to enhance primary production, food availability and fish production as compared to the traditional system of fish culture (Azim *et al*., 2002; Keshavanath *et al*., 2002; Azim *et al*., 2004). Specialist (macro) herbivores, more general detritus and benthos feeders can also thrive on periphyton (van Dam *et al.,* 2002). Higher survival of carps was recorded in periphyton based growth trials (Wahab *et al*., 1999a; b; Keshavanath *et al*., 2001a; 2002). Grow-out studies by Keshavanath *et al*. (2002) and Mridula *et al*. (2003) have revealed that *L. fimbriatus* is a good periphyton grazer. Sugarcane bagasse has been reported to be a good periphyton substrate (Keshavanath *et al*., 2001a; Mridula *et al*., 2003; Gangadhar and Keshavanath, 2008) that enhances fish growth (Ramesh *et al*., 1999; Keshavanath *et al*., 2001b; Gangadhar and Keshavanath, 2012). Periphyton based systems can be considered suitable for fry and fingerling production (Keshavanath *et al*., 2002). The present study evaluated the performance of *L. fimbriatus* in periphyton enhanced culture systems during fry to fingerling rearing.

This experiment of 90 days duration was carried out in 1000 l outdoor circular cement tanks with 5 cm soil base, at the Regional Research Centre of ICAR-Central Institute of Freshwater Aquaculture, Bangalore, India. Sugarcane bagasse was used as substrate for periphyton growth. Fresh bagasse procured from local sugarcane juice vending shops was soaked in water for 2 days to get rid of the sugar present and was then sun dried for a week to remove all the moisture. Water from a nearby bore well was filled in the tanks to maintain a water column of 70 cm. The evaporation loss, which was very meager, was compensated fortnightly. Total volume of water in each tank was 0.886 m^3. Initial fertilization was done with cattle dung @ 4 t ha^{-1} (0.35 kg $tank^{-1}$) followed by urea and single super phosphate (SSP) at 10 and 15 kg ha^{-1} respectively (0.90 and 1.3 g $tank^{-1}$, respectively). Triplicate tanks were allotted for the 5 different treatment combinations *viz*., feed (T1), substrate (T2), substrate+feed (T3), substrate in pond bottom+feed (T4) and substrate+feed+double stocking density (T5). Sugarcane bagasse was hung vertically at 2 t ha^{-1} (0.18 kg $tank^{-1}$) (Keshavanath *et al*., 2001b) in all the treatments, except in the treatment T4, where it was applied to tank bottom**,** maintaining uniform distance between bagasse and tank inner surface. After 10 days, *L. fimbriatus* fry (average length 2.68$\pm$0.43 cm, average weight 0.21$\pm$0.10 g) were stocked @ 3 lakh ha^{-1} (27 $tank^{-1}$) (Jena *et al*., 2005) in all the tanks**,** except in T5, which received double stocking density of 54 fry $tank^{-1}$ (6 lakh ha^{-1}). Subsequent fertilisation was done at fortnightly intervals with cattle dung @ 0.5 t ha^{-1}; urea at 10 kg ha^{-1} and and SSP at 15kg ha^{-1}. Powdered mixture of rice bran and groundnut oil cake at 1:1 ratio is the most commonly used supplementary feed in carp seed rearing (Jena *et al*., 1996). In order to increase the integrity of the feed, the feed was made into pellets using finger millet (Ragi) flour at 10% as the binder (Table 1). Fish in all the treatments, except T2, were fed at 10% of body weight (considering 27 fish $tank^{-1}$) during the first month, followed by 7% and 5% during the second and third months, respectively (Jena *et al*., 2005). Feed was provided in two split doses at 09.00 and 15.00 hrs. The pelleted feed was made into smaller particles (around 1 mm) before feeding, to suite the mouth size of the fish. Water samples were collected at fortnightly intervals, between 09.00 and 10.00 hrs from all the tanks and analysed for pH, temperature, dissolved oxygen, total alkalinity and secchi disc visibility following standard methods (APHA, 1998).

Table 1. Ingredient proportion and proximate composition (Mean$\pm$SE) of the experimental diets

Ingredient proportion	(%)	Proximate composition	(%)
Groundnut oil cake	45.0	Dry matter	85.5
Rice bran	20.0	Crude protein	26.7
De-oiled rice bran	25.0	Fat	03.8
Ragi flour	10.0	Crude fibre	12.7
Ash	10.1	NFE	32.2

On termination of the experiment, fingerlings were harvested by draining the tanks. All surviving fish were counted, length and weight measured (using digital balance of 0.1 mg sensitivity). The specific growth rate, percent weight gain and biomass were calculated (Gangadhar *et al.,* 2014). Comparison between treatments for fish growth, survival and water quality parameters was done by one-way analysis of variance (ANOVA) procedure of SAS version 6.12 (SAS Institute Inc., Cary NC 27513, USA), followed by Duncan's multiple range test at $p<0.05$ (Duncan, 1955; Snedecor and Cochran, 1968).

The mean water quality parameters recorded in the different treatment tanks during the experimental duration did not vary significantly ($p>0.05$) (Table 2). The water temperature was generally low (mean 21.52°C). Dissolved oxygen (DO) content ranged from 4.18 to 7.84 mg l^{-1}. Total alkalinity was generally in a higher range (291.43 - 300.10 mg l^{-1}). Fig. 1 shows the variation in water quality parameters observed during the study period. There was an increasing trend in the water pH during the first 15 days of the experiment. The second half of the study period witnessed low water temperature (18.53-20.83°C) compared to the first half (22.37-23.77°C). Secchi disc was visible at water depth of 70 cm on the first sampling day and the visibility depth subsequently decreased. A sharp decline in the total alkalinity was observed between 0 and 15 days of sampling.

On termination of the experiment, mean length of *L. fimbriatus* fingerlings was almost similar in all the

Table 2. Water quality parameters (Mean ± SE) recorded during the experimental period

Treatment	pH	Temperature (°C)	Dissolved oxygen (mg l^{-1})	Total alkalinity (mg l^{-1})	Secchi disc visibility (cm)
T1	8.45 ±0.09	21.54 ± 0.76	6.44 ±1.41	291.91 ± 11.41	60.38 ± 3.78
T2	8.69 ±0.15	21.49 ± 0.75	6.60 ±1.44	291.43± 11.16	55.57 ± 3.53
T3	8.48 ±0.11	21.53 ± 0.75	6.70 ± 1.46	296.78± 0.43	59.90 ± 2.33
T4	8.51 ±0.12	21.57 ± 0.76	6.43 ±1.40	300.10± 10.67	65.57 ± 1.46
T5	8.67 ±0.14	21.49 ± 0.73	6.26 ±1.37	296.72± 10.41	55.86 ± 4.04

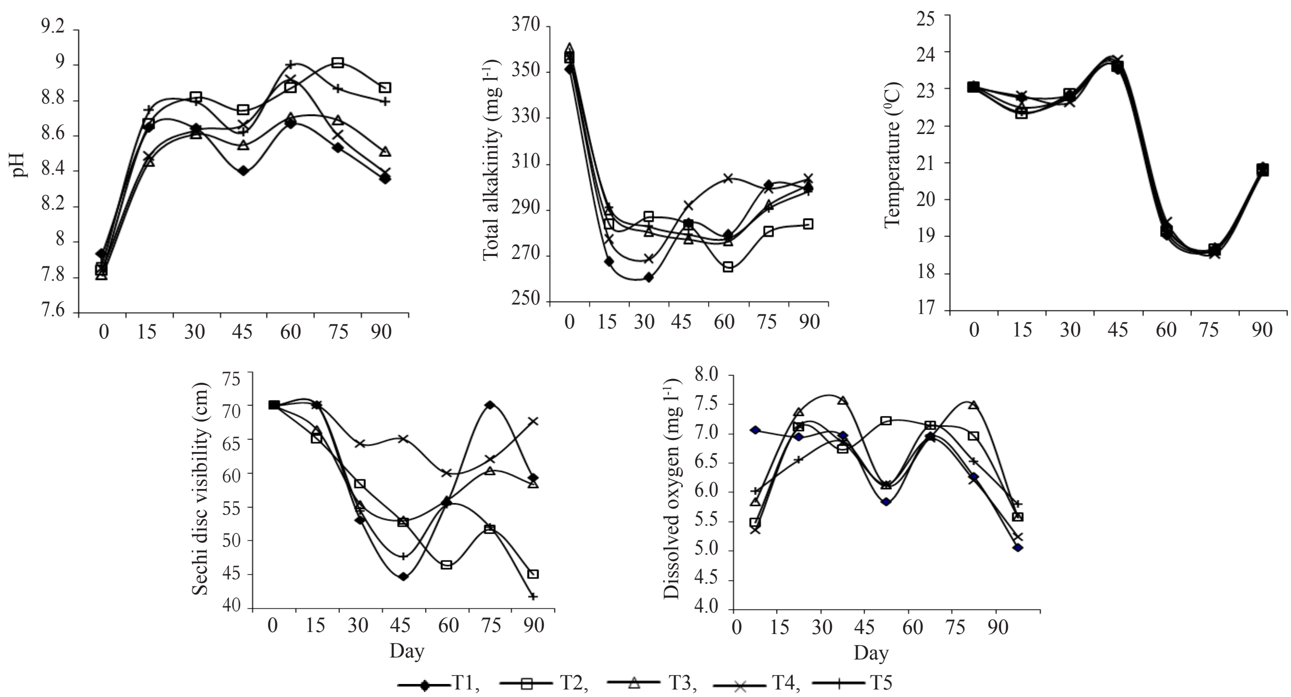

Fig. 1. Variation in water quality parameters recorded in the experimental tanks during the study period

treatments (6.03 cm - 6.48 cm), except in T4, where it was significantly ($p<0.05$) higher (7.88 cm) (Table 3). Treatments having feed and substrate were comparable in terms of mean weight, specific growth rate (SGR), percent weight gain, survival and fish biomass. Provision of substrate in addition to feed increased the mean weight, SGR, percent weight gain and fish biomass; with out affecting survival. Highest fish biomass production was recorded in T5 which received double stocking density along with feed and substrate. Fish at harvest in treatment T5 was comparable with T1 (feed treatment) in terms of length, T2 (substrate treatment) in terms of weight as well as percent weight gain, while survival in T5 was comparable with that of both T1 and T2.

Water quality parameters were within acceptable limits for the seed rearing of carps (Jena *et al*., 2011a). pH was in the alkaline range throughout the experimental duration, indicating favourable conditions for biological production. Wide fluctuation in temperature can affect fish metabolism and growth. With a mean temperature of 21.52°C, variation between treatments was marginal and hence would not have affected growth differently. Jhingran (1991) observed that carps thrive well in the temperature range of 18.3 to 37.8°C. In a 90 days polyculture of fry to fingerling rearing, Jena *et al*. (2011a) recorded a mean harvest weight of 5.31 g, length of 8.26 cm and survival of 92.1% with *L. fimbriatus* stocked at the same density **(**3 lakh ha^{-1}**)** at a water temperature of 24.7-28.1°C. The lower values recorded in the present study may be attributed to the lower water temperature that prevailed during the study period (18.53 - 23.76°C). In 90 days carp seed rearing experiments, Pawar *et al*. (2009) and Jena *et al.* (2011a) observed that dissolved oxygen reduced to below 4 mg l^{-1} after 45 days. They attributed this to increased demand for respiration and mineralisation of accumulated feed and faecal residue with the progress of the culture period (Boyd, 1990). However, no such trend was observed in the present study. Periphyton is

Table 3. Growth parameters (Mean ± S.E) of *L. fimbriatus* at harvest

Treatment	Length* (cm)	Weight* (g)	Specific growth rate (%)	Percent weight gain	Survival (%)	Biomass (g tank^{-1})
T1	6.48±0.02[a]	3.07±0.06[b]	2.98±0.02[b]	1363.49±28.88[b]	72.84±6.17[ab]	60.43±1.19[a]
T2	6.06±0.09[a]	2.77±0.08[ab]	2.87±0.03[b]	1222.22±40.53[ab]	70.37±9.32[ab]	52.76±1.62[a]
T3	6.47±0.27[a]	3.63±0.01[c]	3.16±0.03[c]	1626.98±57.95[c]	88.88±2.14[b]	87.03±2.92[b]
T4	7.88±0.09[b]	5.68±0.25[d]	3.66±0.05[d]	2604.76±119.05[d]	59.32±3.18[a]	90.99±4.00[b]
T5	6.03±0.06[a]	2.41±0.09[a]	2.71±0.04[a]	1047.62±43.98[a]	79.63±4.66[b]	103.63±3.97[c]

*Initial length and weight of fish were 2.68±0.43 cm and 0.21±0.10 g respectively
Figures in the same column with the same superscript do not differ significantly ($p>0.05$).

known to entrap organic detritus, remove nutrients from the water column and help control the dissolved oxygen concentration and pH of the surrounding water (Azim *et al.,* 2002; Dodds, 2003; Bender *et al*., 2004).

The comparable mean length, weight parameters and survival recorded between treatments receiving feed and substrate combinations indicate that fringe-lipped carp young ones can efficiently utilise periphyton growing on the substrate as a food. Provision of substrate in addition to feed, improved the growth performance ($p<0.05$) of fish. This is attributable to the grazing of periphyton by the fish. Higher survival of carps has been recorded in periphyton based growth trials, compared with systems without substrates (Wahab *et al*., 1999a, b; Keshavanath *et al*., 2001a; 2002).

Provision of substrate at the tank bottom resulted in higher body length of fringe-lipped carp compared to the treatments where substrate was provided vertically in the water column. This species is a herbivorous bottom feeder, consuming mainly vegetable debris, decaying organic matter, algae (Chlorophyceae and Myxophyceae) and macrovegetation in adult stages and planktonic crustaceaens, protozoa, rotifer, copepod and Bacillariophyceae during fry and fingerling stages (Mohanta *et al*., 2008). Periphyton growth on substrates provided at the tank bottom would have had the advantage of benefiting from nutrients released at the water-sediment interface, as compared to periphyton growing on substrates hung in the water column. Moreover, it could also benefit from trapping suspended sediment and microphytobenthos present at the bottom of the pond (Richard *et al*., 2009). Possibly the comparatively better growth of periphyton on the bagasse substrate at the tank bottom were efficiently grazed upon by the fringe-lipped carp leading to better growth. However, due to lower survival, the total fish biomass produced in this treatment was only comparable with the treatment where bagasse was provided vertically in water column. With the available data, it is difficult to explain the reason for lower survival obtained when bagasse was provided at the tank bottom. Substrates at pond bottom are prone to faster mineralisation than those in the water column which can lead to lower oxygen availability particularly for species like fringe-lipped carp, which prefers to be in pond column and bottom, causing mortality.

It is interesting that body length and survival of fishes were comparable between T1 (feed treatment) and T5 (substrate + feed + double stocking density). Fish in the latter received the same amount of feed as that of the former. Hence, comparable performance of the fish at the double stocking density is attributable to the utilisation of periphyton as food in addition to the artificial feed. According to Dharmaraj *et al*. (2002) and Keshavanath *et al.* (2002), *L. fimbriatus* can utilise periphyton and provision of substrates can be an alternative to feeding in grow-out rearing. Results of the present study revealed that young ones of this species can also utilise periphyton as food.

It is evident from the present study that in fry to fingerling rearing of *L. fimbriatus,* provision of substrate can replace supplementary feeding and stocking density can be doubled in tanks provided with substrates, without compromising fingerling growth and survival.

Acknowledgements

The authors are grateful to the Department of Biotechnology, New Delhi for funding support to conduct this study under the project No. BT/PR5388 AAQ/3/594/2012 and the Director, ICAR-Central Institute of Freshwater Aquaculture, Bhubaneswar for the infrastructure facilities provided.

References

APHA 1998. *Standard methods for the examination of water and waste water,* 20th edn. American Public Health Association, Washington DC, USA, 1220 pp.

Azim, M. E., Verdegem, M.C. J., Khatun H., Wahab, M. A., van Dam, A. A. and Beveridge, M. C. M. 2002. A comparison of fertilisation, feeding and three periphyton substrates for increasing fish production in freshwater pond aquaculture in Bangladesh. *Aquaculture*, 212: 227-243.

Azim, M. E., Rahaman, M. M., Wahab, M. A., Asaeda, T., Little D. C. and Verdegem, M. C. J. 2004. Periphyton-based pond polyculture system: a bio-economic comparison of on-farm and on-station trials. *Aquaculture*, 242: 381-396.

Basavaraju, Y., Devaraj, K.V. and Ayyar, S. P. 1995. Comparative growth of reciprocal carp hybrids between *Catla catla* and *Labeo fimbriatus*. *Aquaculture*, 129: 187-191.

Bender, J., Lee, R., Sheppard, M., Brinkley, K., Philips, P., Yeboah, Y. and Wah, R.C. 2004. A waste effluent treatment system based on microbial mats for black seabass *Centropristis striata* recycled water mariculture. *Aquac. Eng*., 31: 73-82.

Boyd, C. E. 1990. *Water quality in ponds for aquaculture*. Alabama Agricultural Experimental Station, Auburn University, USA, 482 pp.

CIFA, 2008. Evaluation of performance of fringe-lipped carp during fingerling rearing under polyculture with rohu. *Annual Report 2007– 08*. Central Institute of Freshwater Aquaculture, Bhubaneswar, India, 120 pp.

Das, P. 2011. Diversification of freshwater aquaculture species-potential of endemic fishes, *Fishing Chimes*, 31: 21-22.

De Silva, S. S. and Anderson, T. A. 1995. *Fish nutrition in aquaculture*. Chapman and Hall, London, UK, 320 pp.

Dharmaraj, M., Manissery, J. K. and Keshavanath, P. 2002. Effects of a biodegradable substrate, sugarcane bagasse and supplementary feed on growth and production of fringe-lipped peninsular carp, *Labeo fimbriatus* (Bloch). *Acta Ichthyol. Piscat.*, 32: 137-144.

Dodds, W. K. 2003. The role of periphyton in phosphorus retention in shallow freshwater aquatic systems. *J. Phycol*., 39: 840-849.

Duncan, D. B. 1955. Multiple range and multiple F-tests. *Biometrics,* 11: 1-42.

Gangadhar, B. and Keshavanath, P. 2008. Planktonic and biochemical composition of periphyton grown on some biodegradable and non-degradable substrates. *J. Appl. Aquac.*, 20: 213-232.

Gangadhar, B. and Keshavanath, P. 2012. Growth performance of rohu, *Labeo rohita* (Ham.) in tanks provided with different levels of sugarcane bagasse as periphyton substrate. *Indian J. Fish.,* 59: 77-82.

Gangadhar, B., Sridhar, N., Saurabh, S., Raghavendra, C. H., Hemaprasanth, K. P., Raghunath, M. R. and Jayasankar, P. 2014. Growth response of *Cirrhinus mrigala* to Azolla (*Azolla pinnata*) incorporated diets during fry to fingerling rearing. *Fish. Technol.*, 51: 156-161.

Jena, J. K., Mukhopadhyay, P. K., Sarkar, S., Aravindakshan, P. K. and Muduli, H. K. 1996. Evaluation of a formulated diet for nursery rearing of Indian major carp under field condition. *J. Aquac. Trop*., 11: 299-305.

Jena, J. K., Das, P. C., Das, B. K., Mohapatra, B. C., Sarangi, N., Modayil, M. J., Vass, K. K., Ravichandran, P. and Ayyappan, S. 2005. *Aquaculture technologies for farmers*. Indian Council of Agricultural Research, Krishi Bhawan, New Delhi, India, 95 pp.

Jena, J. K., Das, P. C., Mitra, G., Patro, B., Mohanta, D. and Mishra, B. 2011a. Evaluation of growth performance of *Labeo fimbriatus* (Bloch), *Labeo gonius* (Hamilton) and *Puntius gonionotus* (Bleeker) in polyculture with *Labeo rohita* (Hamilton) during fingerling rearing at varied densities. *Aquaculture*, 319: 493-496.

Jena, J. K., Das, P. C., Mitra, G., Patro, B., Mohanta, D. and Mishra, B. 2011b. *Evaluation of growth performance and compatibility of Labeo fimbriatus with major carps in polyculture system.* Abstract, 10th Agricultural Science Congress, 8-10 February, 2011. NBFGR, Lucknow, India.

Jhingran, V. G. 1991. *Fish and fisheries of India*, Hindustan Publishing Corporation, Delhi, India, 954 pp.

Keshavanath, P., Gangadhar, B., Ramesh, T. J., van Rooij, J. M., Beveridge, M. C. M., Baird, D. J., Verdegem, M. C. J. and van Dam, A. A. 2001a. Use of artificial substrates to enhance production of freshwater herbivorous fish in pond culture. *Aquac. Res*., 32: 189-197.

Keshavanath, P., Ramesh, T. J., Gangadhar, B., Beveridge, M. C. M, van Dam, A. A. and Verdegem, M. C. J. 2001b. On farm evaluation of Indian major carp production with sugarcane bagasse as substrate for periphyton. *Asian Fish. Sci.,* 14: 367-76.

Keshavanath, P., Gangadhar, T., Ramesh, B. J., van Dam, A. A., Beveridge, M. C. M. and Verdegem, M. C. J. 2002. The effect of periphyton and supplemental feeding on the production of the indigenous carps *Tor khudree* and *Labeo fimbriatus*. *Aquaculture,* 213: 207–218.

Mohanta, K. N., Subramanian, S., Komarpant, N. and Saurabh, S. 2008. Alternate carp species for diversification in freshwater aquaculture in India. *Aquac. Asia*, 13: 11-15.

Mridula, R.M., Manissary, J. K., Keshavanath, P., Shankar, K. M., Nandeesha, M. C. and Rajesh, K. M. 2003. Water quality, biofilm production and growth of fringe-lipped carp (*Labeo fimbriatus*) in tanks provided with two solid substrates. *Aquaculture*, 87: 263-267.

NACA/FAO 2000. Aquaculture development beyond 2000: The Bangkok declaration and strategy. *Proceedings of the Conference on Aquaculture in the Third Millennium, 20-25* February 2000 Bangkok, Thailand. NACA, Bangkok and FAO, Rome, 471 pp.

Pawar, N. A., Jena, J. K., Das, P. C. and Bhatnagar, D. D. 2009. Influence of duration of aeration on growth and survival of carp fingerlings during high density seed rearing. *Aquaculture*, 290: 263-268.

Ramesh, M. R., Shankar, K. M., Mohan, C. V. and Varghese, T. J. 1999. Comparison of three plant substrates for enhancing carp growth through bacterial biofilm. *Aquac. Eng.,* 19: 119-131.

Richard, M., Trottier, C., Verdegem, M. C. J. and Hussenot, J. M. E. 2009. Submersion time, depth, substrate type and sampling method as variation sources of marine periphyton. *Aquaculture,* 295: 209-217.

Snedecor, G. W. and Cochran, G. W. 1968. *Statistical methods,* Oxford and IBH Publishing Company, Calcutta, India.

Talwar, P. K. and Jhingran, A. G. 1991. *Inland fishes of India and adjacent countries*, *vol. 1.* Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi, 1158 pp.

Van Dam, A. A., Beveridge, M. C. M., Azim, M. E. and Verdegem, M. C. J. 2002. The potential of fish production based on periphyton. *Rev. Fish Biol. Fish.*, 12: 1-31.

Wahab, M. A., Azim, M. E., Ali, M. H., Beveridge, M. C. M. and Khan, S. 1999a. The potential of periphyton-based culture of the native major carp calbasu, *Labeo calbasu* (Hamilton). *Aquac. Res*., 30: 409-419.

Wahab, M. A., Manan, M. A., Huda, M. A., Azim, M. E., Tollervey, A. G. and Beveridge, M. C. M. 1999b. Effect of periphyton growth on bamboo substrates on growth and production of Indian major carp, rohu *(Labeo rohita*). *Bangladesh J. Fish Res.*, 3: 1-10.

Date of Receipt : 19.07.2013
Date of Acceptance : 22.04.2015