Fishery Technology 54 (2017) : 1 - 7

Evaluation of Bamboo, Coconut Shell Substrates and Supplemental Feeding on the Growth of Pearlspot, *Etroplus suratensis* (Bloch) Fry in Low Volume Cages

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Abstract

The 90 days experiment aimed at understanding the scope of utilising periphyton substrates for cage culture of pearlspot fry. The experiment evaluated coconut shells relative to bamboo as periphyton substrates for pearlspot culture. The experiment constituted six floating cages (1x0.75x1 m^3) each partitioned into two to get 12 experimental units into which 360 pearlspot fry (avg. wt. 3.55±0.17 g) were equally distributed. The experiment constituted of four treatment; T_B: substrate (bamboo-strip mats), T_C: substrate (coconut shells), T_{B+F}: substrate (bamboo-strip mats) + supplementary feed, T_F: supplementary feed, in triplicates. The substrates provided a surface area of ~ 1.9m^2 $unit^{-1}$. Feeding in T_{B+F} and T_F was done using commercial carp feed (crude protein- 32%; crude lipid- 5%) twice daily approximately at 10% of the body weight initially upto 30 days and subsequently the feeding rate was reduced to 9 and 8% of body weight after 30 and 60 days respectively. Sampling was conducted every 15 days to assess fish growth and survival. Relatively higher specific growth rate (SGR) recorded in T_{B+F} over T_F during the initial phase of the experiment indicated the ability of pearlspot to utilise periphyton efficiently in the early stages. Final SGR of 1.2 and 1.5% day^{-1} in T_C and T_B respectively indicates that periphyton can support the growth of pearlspot. Higher SGR and percentage weight gain in T_B (1.50±0.07% day^{-1}; 288.10±26.69%) relative to T_C (1.26±0.12% day^{-1}; 215.90±36.37%) shows that bamboo is superior periphyton substrate for pearlspot culture. Lower yet statistically similar growth rates of pearlspot in Tc relative to T_B together with low cost and easy availability of coconut shell substrates indicates that these could be used as alternative periphyton substrates for fish culture.

Keywords: Periphyton, substrate, cage culture, *Etroplus suratensis*

Introduction

In order to increase the production from aquaculture and create livelihood options for the resource poor sections of the society, it is important to develop sustainable, green and low cost technologies. When planned according to local needs and resources cage culture can be a successful tool for livelihood generation and poverty alleviation (Huchette & Beveridge, 2003). Cage culture is also a means to utilise untapped water bodies for fish culture. In aquaculture, feeds account for over 50% of the production costs (FAO, 2009). Both the quality of feed and the ration used can influence the quantity of nutrients added by aquaculture into water resources affecting environmental pollution (Sugiura & Hardy, 2000). Enhancing endogenous food production can help reduce dependence on the artificial feeds especially in small scale aquaculture systems. Exploiting the use of periphyton in aquaculture has been suggested as one of the means to utilise the natural food production. In comparison to phytoplankton, many truly herbivorous fish specialise in feeding on larger benthic, epiphilic or periphytic algae which require hard substrates for attachment (Horn, 1989; Keshavanath et al., 2001).

Received 20 September 2016; Revised 17 December 2016; Accepted 17 December 2016

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According to van Dam et al. (2002) fish yields from extensive and semi-intensive ponds could be upto ten times higher if primary productivity could be harvested directly by the fish. Successful attempts have been made to utilise primary production more efficiently by introducing periphyton substrates in the culture of herbivorous species like calbaush *Labeo calbasu* (Wahab et al., 1999); Mahseer, *Tor khudree* (Keshavanath et al., 2001; Keshvanath et al., 2002); rohu, *Labeo rohita* (Azim et al., 2001; Bala et al., 2015); *Labeo fimbriatus* (Keshavanath et al., 2002); Nile tilapia, *Oreochromis niloticus* and pearlspot *Etroplus suratensis* (Garg et al., 2007); common carp *Cyprinus carpio,* catla *Catla catla* and mrigal *Cirrhinus mrigala* (Bala et al., 2015) in tank or pond systems. It is worth noting that these studies have been mostly conducted in freshwater environments and more studies on periphyton based fish culture in saline environments have been advocated (van Dam et al., 2002).

Pearlspot is an omnivorous fish feeding predominantly on filamentous algae (Bindu & Padmakumar, 2008). Padmakumar et al. (2009) described the fish as an algal grazer and observed that the net cages for culture of pearlspot would be devoid of mesh clogging algae consequent to the browsing and scraping behaviour of the fish. Pearlspot is highly relished and commands a good market price in the southern state of Kerala where the fish has been declared the state fishand the year 2010-11 declared 'The year of Pearlspot'. All these steps have encouraged promotion of aquaculture of the species including small scale cage culture. Low growth rate was observed in the initial phase of culture of pearlspot. The growth rate was found to increase rapidly after 100-110 mm (Costa, 1983). The present experiment aimed at understanding the scope of using periphyton substrates for improving growth of pearlspot fry cultured in small cages. The results of many of the previous studies have proven that bamboo is a relatively efficient substrate for periphyton development and supporting fish growth (Wahab et al., 1999; Keshavanath et al., 2001; Garg et al., 2007). This experiment also aims at assessing the performance of coconut shells relative to bamboo for use as periphyton substrate for supporting growth of pearlspot.

Materials and Methods

The ninety day experiment was conducted at the Muttukadu experimental station of Central Institute of Brackishwater Aquaculture (ICAR), Chennai, India. The experiment constituted of six floating cages (1x 0.75x 1 m^3) constructed from 25 mm PVC pipes and mesh screens (0.7 mm) supported by rectangular floats. Each cage was partitioned into two in order to get 12 experimental units. The cages were placed in the secondary discharge pond of fish hatchery where constant water flow was available.

The experiment constituted of four treatments *viz.,* T_B: substrate (bamboo strips), T_C: substrate (coconut shells), T_{B+F}: substrate (bamboo strips)+ supplementary feed,T_F: supplementary feed. The treatments tested in triplicates, were randomly allotted to each of the experimental units. Fish in each of the experimental units were counted and weighed at every 15 day interval to assess survival and growth. Four bamboo-strip mats per unit were suspended in T_B and T_{B+F} treatment while split coconut shells were suspended from nylon twines after drilling holes in each half of the coconut shell in T_C providing an approximately equal surface area of 1.9 m^2 $unit^{-1}$ in each case. The bamboo-strip mats were suspended at a distance of 20 cms from each other. Similarly 5 numbers of coconut shells were suspended per twine and a total of 8 such twines were suspended in 2 rows. Substrate submersion time of over 4 weeks was allowed as recommended by Richard et al. (2009) for optimum colonisation of periphyton in saline environments.

The pearlspot fry were procured from Ponnani, Kerala from farmers' pond and maintained in rectangular cages (2x1x1 m) within the same pond for two weeks till the beginning of the experiment. The fish were maintained on fish feeds and regular water exchange was provided during this period. Stocking of pearlspot fry (avg. wt. 3.55± 0.17 g) was done at 30 fish $unit^{-1}$. In absence of a standard feed for pearlspot, feeding in T_{B+F} and T_F was done using commercial fish feed (crude protein-32%; crude lipid-5%) twice daily (08:00 and 17.00 h) approximately at 10% of the body weight initially upto thirty days and subsequently at 9 and 8% of body weight after 30 and 60 days, respectively. Feed was not provided one day prior to the day of sampling.

The water quality parameters were monitored and recorded every 15 days during the experimental period. Salinity and temperature was measured using digital probe (Digital probe, HANNA, Woonsocket, USA) while pH was measured using a digital pH meter (Lab India). Dissolved oxygen, total ammonia-N, nitrite, alkalinity were estimated using standard methods of APHA (1998). During the experimental period, the salinity, water temperature, pH, alkalinity, dissolved oxygen, ammonia, nitrite were found in the normal range of 23.5 - 28.6 ppt, 25.8- 29.8°C, 7.5-8.2, 140-148.7 mgL^{-1}, 5-6.3 mgL^{-1}, 0.05-0.2 mgL^{-1}, 0.001-0.03 mgL^{-1} respectively.

Sampling (30% fish) was conducted at 15 day interval to assess survival and growth of fish. Weight gain (%) was calculated as [(final weight-initial weight)*100/initial weight]. Survival rate (%) was calculated as [100-(number of fish stocked-number of fish harvested) x 100/ number of fish stocked)]. SGR (% day^{-1}) was calculated as [ln (final weight of fish)-ln (intial weight of fish) x 100]/ days of culture.

Data were analyzed by one-way ANOVA at 5% level of significance and the difference between two means was analyzed by Duncan's Multiple Range Test (DMRT) using SPSS 14.0.

Results and Discussion

Growth in terms of the final body weight of pearlspot in T_{B+F} was significantly ($p<0.05$) higher (32.87± 0.50 g) followed by T_F (29.43± 0.6 g), T_B(12.42± 0.66 g) and T_C (9.87± 0.37 g) at the end of 90 day culture period (Table 1). However, in the initial phase of the experiment, relatively higher SGR was recorded in $T_{(B+F)}$ relative to T_F indicating the ability of pearlspot to utilise periphyton efficiently in the early stages (Fig.1). Benefit of providing periphyton substrates along with feed was observed to decline as the experiment progressed with approximately same SGR being recorded in T_{B+F} and T_F after 60 days. This may possibly be due to the change in food preference of pearlspot with size; the smaller fish prefer feeding on micro-vegetation and decayed organic matter while the larger ones prefer feeding on a variety of food like decayed organic matter, macro-vegetation, filamentous algae and crustaceans (Alikunhi, 1957; Devaraj et al., 1975; Keshava et al., 1988). Results of few studies have shown that periphyton substrates will be more suitable during the early phase of fish culture. A reduction in periphyton consumption was observed in *Labeo* spp. when fish size exceeded 9-13 g (Rahamatullah et al., 2001). In Nile tilapia periphyton consumption was found to be higher in smaller size group of fish (7 g), 0.9 mg dm $g^{-1}h^{-1}$as compared to larger size group (24 g), 0.18 mg dm g^{-1} h^{-1}. In the study, an increase in periphyton consumption was also observed with increasing periphyton density in the smaller fish (Azim et al., 2003). Huchette & Beveridge (2003) have also

Table 1. Effect of periphyton substrates *viz.*, bamboo, coconut shells and supplemental feeding on fish production parameters of pearlspot, *Etroplus suratensis* grown in cages at the end of 90 days

Treatment	Substrate surface area (m^2)	Initial weight (g)	Biomass at stocking (g)	Final weight (g)	Biomass at harvest (g)	Weight gain (%)	Specific growth rate (% day^{-1})	Survival (%)
T_C: Substrate (Coconut shells)	~1.9	3.19± 0.3	95.60± 9.01	9.87^a± 0.37	249.16^a± 19.31	215.90^a± 36.37	1.26± 0.12	79.63± 11.30
T_B: Substrate (Bamboo)	~1.9	3.25± 0.37	97.5± 11.07	12.42^b± 0.66	313.41^b± 6.66	288.10^a± 26.69	1.50± 0.07	81.30± 4.06
T_{B+F}: Substrate (Bamboo)+ Supplementary Feed	~1.9	4.14± 0.35	124.30± 10.54	32.87^d± 0.50	953.81^d± 33.51	703.22^b± 58.74	2.31± 0.08	96.47± 2.06
T_F: Supplementary Feed	0	3.60± 0.16	108.10± 4.73	29.43^c± 0.6	854.02^c± 34.04	718.58^b± 23.64	2.34± 0.03	96.47± 2.06

*Values are means± standard error of three replicates. Values within the same column not sharing a common superscript are significantly different ($p<0.05$).

reported that better results were obtained during the culture of smaller sized tilapia (10.7± 1.7 g) when same biomass and substrate density was used as that in the culture of larger fish (27.0± 3.5 g) within cages.

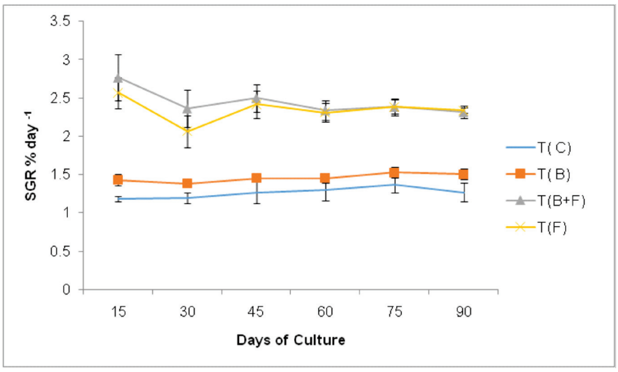

Fig. 1. Effect of periphyton substrates *viz.*, Bamboo (T_B), coconut shells (T_C) and supplemental feeding on specific growth rate (% day^{-1}) of pearlspot, *Etroplus suratensis* grown in cages.

Absence of significant benefit on providing periphyton substrates as the experiment progressed may also be attributed to the increasing fish biomass in T_{B+F}. This could have exerted high grazing pressure on the periphyton community making the periphytic population insufficient and unsustainable to significantly enhance fish growth. In the periphyton based cage culture of Nile tilapia it was observed that the grazing pressure kept the standing crop of periphyton communities on plastic bottles at levels insufficient to significantly contribute to the diet of fish (Huchette et al., 2000).

The pearlspot provided with periphyton substrates attained approximately one third the final body weight of the treatments provided with feed and this is also reflected in the final biomass of fish attained in the different treatments (Table 1). At the end of the 90 day feeding trial it was found that the periphyton substrates could support an SGR of 1.26±0.12 and 1.50±0.07% day^{-1} in T_C and T_B respectively indicating that periphyton can support the growth of pearlspot. Keshvanath et al. (2002) observed that the enhancement in fish production by 41- 75% by providing periphyton substrates was comparable to a production achieved by artificial feeds. In a polyculture experiment using Nile tilapia and pearlspot, higher production of pearlspot (final weight, 77 g) was observed by using bamboo poles as periphyton substrates in manured ponds in comparison to similar ponds where feed was provided (Garg et al., 2007). This underlines the scope of using periphyton substrates for pearlspot culture even during the grow-out phase especially in closed systems. Unlike in the case of cages in open water bodies, closed systems like tanks or ponds allow interventions like manuring or fertilisation which may help to significantly enhance periphyton production. Besides there is a scope to provide a greater surface area relative to the number of fish stocked allowing a sustainable population of periphyton to develop in the system. Hence the key to the development of periphyton based fish culture in cage systems may lie inidentifying or developing low cost substrates capable of sustaining sizeable periphytic populations for supporting the growth of fish stocked at relatively higher densities and also in developing models which can be conveniently integrated with the locally used low volume cages in brackish water bodies.

In the present experiment, we could visually observe a decrease in feed requirement (as observed by consistent feed wastage) in T_{B+F} unlike T_F when provided with the same ration. This suggests that feed requirement could be cut down to certain extent by providing periphyton substrates and further studies are needed to understand the possibility of feed reduction by providing periphyton substrates. Keshvanath et al. (2004) have reported lower food conversion ratio when bamboo substrates were provided for hybrid red tilapia (*Oreochromis mossambicus* X *Oreochromis niloticus*). No commercial feed is available for pearlspot and most of its culture in India is supported by commercial or farm-made fish feeds or locally available ingredients like rice bran, ground nut oil cakes, vegetable wastes etc. Presence of natural feeds in the diet of pearlspot during its culture can also help to supplement fish growth in absence of a feed based on the specific dietary nutrient requirement of the species. Local farmers believe that pearlspot cultured using natural feeds have superior organoleptic characteristics and higher market demand than the ones reared on artificial feeds alone (Sukumaran et al., 2011). Huchette & Beveridge (2005) have suggested that periphyton based cage fish production is likely to prove most profitable for rearing early fry or fingerlings. Similarly, tilapia reared in cages on low protein feeds along with periphyton substrates proved cost effective and performed better than those fed with relatively high protein feeds (Sakr et al., 2015). Gangadhar et al.

(2016) have suggested that use of sugarcane bagasse can support in reducing the cost of artificial feeds during nursery rearing of fringe-lip carp. The results of the present study also indicates that use of periphyton substrates may be especially beneficial during the rearing of pearlspot fry or fingerlings and may be used as one approach to counter the challenge of slow growth rates encountered in the initial phase of culture of the species.

The impact of using periphyton substrates on the economics of fish culture depends on the cost and efficiency of the periphyton substrate and the feed involved. In different culture experiments a variety of natural and synthetic substrates have been tested; bamboo poles, jute stick and branches of hizol tree, sugarcane bagasse, palm leaf (Keshavanath et al., 2001; Azim et al., 2002a; Azim et al., 2002b; Keshavanath et al., 2012); PVC pipes, plastic sheets, aquamats (Tidwell et al., 1998; Keshavanath et al., 2001; Bratvold & Browdy, 2001). Substrate type has a significant effect on the periphyton density due to the differences in leaching of nutrients or toxic substances and in surface roughness (van Dam et al., 2002). In the present study, higher percentage weight gain and SGR in T_B relative to T_C suggests that bamboo is superior periphyton substrate for pearlspot culture. In previous studies also bamboo wasfound to be a superior periphyton substrate compared to many other materials. Keshavanath et al. (2001) reported bamboo to be a superior substrate for the development of periphyton biomass and the growth of mahseer when tested along with PVC pipes and sugarcane bagasse bundles. Periphyton developing on bamboo has also been shown to be nutritionally superior as the protein content was found to be 50% higher than the periphyton developing on kanchi or hizol tree branches (Azim et al., 2002b). The use of bamboo as periphyton substrates was found to give 80% higher production in 120 days in experiments on *L. calbasu* (Wahab et al., 1999). Similar results were observed in case of rohu where a 77% higher production was recorded using bamboo substrate in 70 days (Azim et al., 2001). Most of the periphyton based studies in Bangladesh have utilised bamboo based substrates mainly because of its local availability (Milstein, 2005). Similarly, Bunting et al. (2005) have advocated studies on alternative substrates to reduce pressure on substrate material that may have other uses or be in short supply. The authors have also encouraged the use of on-farm resources opposed to purchase of substrates.

Although the SGR of pearlspot in T_B was consistently better than T_C throughout the experiment, there was no significant ($p>0.05$) difference between the treatments. Unlike bamboo, coconut shells are abundantly available in regions of India where pearlspot is cultured. It has restricted commercial value as raw material for activated charcoal manufacture and limited utility as household fuel or base for handicrafts manufacture. In the present study, coconut shell substrates gave a lower yet statistically similar growth and weight gain of pearlspot as bamboo substrate. Considering the cost and local availability factors, coconut shell substrates can be a good alternative as a periphyton substrate for the culture of pearlspot.

Acknowledgements

The authors are grateful to Director, Central Institute of Brackishwater Aquaculture (ICAR) for providing all the necessary facilities for the conduct of this study. The first author is also grateful to her colleagues and staff at fish culture division, CIBA, for their support and encouragement during the course of this work.

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