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Culture of Monosex Nile Tilapia under Different Traditional and Non-Traditional Methods in India

[1]*Suman Bhusan Chakraborty and* [2] *Samir Banerjee*

[1]Department of Zoology, Serampore College, Serampore, Hooghly 712201, West Bengal, India
[2]Department of Zoology, University of Calcutta, Kolkata, West Bengal, India

Abstract: Little is known about the growth performance of sex-reversed, all male *Oreochromis niloticus* under different traditional and non-traditional culture methods practiced in India. In this study, 17"-methyltestosterone treated monosex tilapia was cultured in concrete tank, flow-through system, cage, pen and earthen pond. Similar feeding regime and stocking density of fish were maintained for all the culture systems. Different growth parameters like body weight, length, depth, daily weight gain (DWG), specific growth rate (SGR) and proximate body composition were analyzed at the end of the four month culture period. It was found that culture in earthen ponds yielded the highest weight, length, depth, DWG, SGR and protein content compared to other four culture methods. On the other hand, culture in concrete tanks showed the lowest growth among all culture methods. There was no significant difference in fish yield for flow-through, cage and pen culture systems. Additional availability of energy-rich natural food materials and uniform water flow in ponds may attribute to such trend in growth pattern of the fish among the culture systems. Thus, culture of androgen treated monosex tilapia in earthen ponds can be regarded as the ideal method for socio-economically sustainable augmented fish production in India.

Key words: Nile tilapia % Monosex % Growth pattern % Culture methods

INTRODUCTION

The Nile tilapia, *Oreochromis niloticus* (Linnaeus) is one of the most important freshwater fish in world aquaculture [1]. It is widely cultured in many tropical and subtropical countries of the world [2]. Rapid growth rates, high tolerance to adverse environmental conditions, efficient feed conversion, ease of spawning, resistance to disease and good consumer acceptance make it a suitable fish for culture [3]. Farmed tilapia production increased dramatically in recent years, increasing from 383,654 mt in 1990 to 2,326,413 mt in 2006 [4]. Tilapia has established a secure position in a number of water impoundments of India. But, its performance in open water ponds of the country has been discouraging over the years [5]. The major concern for tilapia aquaculture is excessive reproduction and the resulting small size of the fish produced [6]. Hence, the desirability of monosex male populations of tilapia is well established for increased production potential and low management requirements. Besides, sex-specific differences in growth are significant in Nile tilapia where males grow significantly faster, larger and more uniform in size than females [7]. In a previous study, monosex population of male tilapia was produced by treating fry with a synthetic male hormone 17"-methyltestosterone (17"MT) at a treatment regime of 10 mg/kg food for 30 days [8]. Introduction of such hormone treated sex reversed tilapia in water bodies of India might prove effective to induce a positive approach towards tilapia culture in the country.

The culture practices of tilapia can be extensive, semi-intensive and intensive [9]. There has been a gradual shift in tilapia culture from traditional semi-intensive to non-traditional intensive farm systems [10]. But, deciding the optimal culture method for tilapia farming can be quite complex [11]. Traditionally, tilapia is often cultured in earthen ponds without supplemental feeding [12]. Intensive monoculture of the fish in concrete tanks is carried out in a few countries. Although practiced in some countries, cage culture of tilapia is yet to be commercialized on a wide scale basis. Pen culture of tilapia in open waters of lakes is practised in the Philippines on

Corresponding Author: Suman Bhusan Chakraborty, Department of Zoology,
Serampore College, Serampore, Hooghly 72201, West Bengal, India

an appreciable scale [13]. Flow-through culture of tilapia is also done on a very limited scale, for producing marketable fish. Extensive evaluations of various management strategies are required to select the optimal culture procedure under certain eco-socio-economical conditions.

Although exotic, Nile tilapia is rapidly gaining popularity among the fish farmers in the eastern region of India. But, only a few published data on the growout performance of androgen treated monosex *Oreochromis niloticus* in the Indian context is available [14]. Again, increase in yields can result from the development and adoption of new technologies and improved farming operations [15]. Hence, the propagation potentiality of monosex tilapia under various traditional and non-traditional culture practices must be clearly documented. Thus, the main objective of this study was to establish a low cost sustainable aquaculture method for the production of a major animal protein source by comparing the growth pattern of androgen treated sex-reversed tilapia under different culture methods.

MATERIALS AND METHODS

Culture systems: The study was conducted in the districts of North 24 Parganas and Kolkata, West Bengal. The traditional culture method comprises rearing tilapia in open earthen pond while the non-traditional methods include closed concrete tank, flow-through, cage and pen culture systems. The tank culture system was consisted of 9 m^3 rectangular concrete tank. The flow-through tank was identical to the ordinary tank with the added system of continuous water flow at a constant rate of 4 L min^{-1} through it. Rectangular, fixed type cage of same size was constructed with bamboo frames and nylon nets. The pen was of similar size and completely closed rigid structure constructed with bamboo. The earthen pond was also of the same size. Throughout the entire culture period different water quality parameters like temperature, DO_2, free CO_2, pH, total alkalinity and turbidity were regularly monitored using the standard procedures of American Public Health Association [16] and maintained within ideal value limits for all the culture systems (data not shown).

Monosex Tilapia Production: Three days old mixed sex juveniles of Nile tilapia (mean weight 0.025±0.009 g; mean length 1.25±0.012 cm) were collected from the Fish Hatchery at Naihati, West Bengal and randomly stocked in each of the culture systems at a density of 50 fish m^{-3}. The fish were reared in the respective culture systems for four months. During the first month of culture, the fish were fed with 17" methyltestosterone (17"MT) treated diet with a dose of 10 mg/ kg at a rate of 20% body weight / day. The hormone treatment regime was deduced through a previous study [8] and the hormone treated diets were prepared by the alcohol evaporation technique [17]. After the first month, the fish were fed twice daily with hormone untreated control diet (crude protein content 30% and total digestible energy 3000±400 kcal/Kg foods) at a constant rate of 10% body weight/day for the next two months and 5% body weight/day for the last month of culture. The entire experiment was conducted in three replicating units for statistical validation.

Grow-out Performance Analysis: Fish from each tank, flow-through, cage, pen and pond were measured individually for weight and length every 4 weeks and at the end of the trial. Besides, growth parameters like specific growth rate (SGR), daily weight gain (DWG), food conversion ratio (FCR), protein efficiency ratio (PER) and apparent net protein utilization (ANPU) were measured according to standard formulation [18] at the end of the culture period. Equal amount of wet muscle tissue from 10 fish from each experimental set were taken to determine proximate body composition using standard methods [19]. Moisture content was measured by drying a sample at 105°C in an oven for 24 hours and ash content was estimated by burning the sample at 550°C overnight in a muffle furnace. Crude protein and crude lipid were determined using the Kjeltec system 1026 distilling unit and Soxtec system HT 1043 (Tecator, Hognas, Sweden) respectively. To determine these body composites by wet mass, the proportion of dry tissue composed of protein, fat and ash was multiplied by percent solids from the original sample. The percent solid was calculated as the ratio of dry mass to wet mass.

Statistical Analysis: The data were expressed in terms of mean±standard error. All data were subjected to one-way ANOVA. When appropriate, Duncan's multiple tests (at 5%) [20] were applied to evaluate the differences among means. The statistically homogenous means were denoted by similar alphabets.

RESULTS

The survival percentage of the control and treated groups for all the culture methods were around 90% and the hormone treatment regime applied in the study could yield almost 100% male tilapia population [8]. Comparing

Table 1: Comparative account of weight, length and depth of monosex Nile tilapia under different culture methods. Similar alphabets denote homogenous means

Culture methods	Weight (g)	Length (cm)	Depth (cm)
Cistern	$125.89^{b}\pm14.98$	$18.165^{b}\pm0.71$	$6.91^{b}\pm0.21$
Flow-through	$153.15^{ab}\pm17.86$	$19.52^{ab}\pm0.79$	$7.23^{b}\pm0.19$
Cage	$140.93^{ab}\pm16.01$	$18.955^{ab}\pm0.78$	$7.16^{b}\pm0.2$
Pen	$170.65^{ab}\pm20.67$	$20.165^{ab}\pm0.82$	$7.41^{ab}\pm0.2$
Pond	$188.02^{a}\pm23.47$	$20.965^{a}\pm0.92$	$7.99^{a}\pm0.28$

Table 2: Comparative account of different growth parameters of monosex Nile tilapia under various culture methods. Similar alphabets denote homogenous means

Culture methods	SGR (%)	DWG (g/day)	FCR	PER	ANPU (%)
Cistern	$4.8^{ab}\pm0.09$	$0.7^{a}\pm0.2$	$3.4^{b}\pm0.04$	$0.97^{a}\pm0.01$	$10.0^{a}\pm1.0$
Flow-through	$4.92^{ab}\pm0.09$	$0.85^{a}\pm0.2$	$3.5^{ab}\pm0.03$	$0.96^{a}\pm0.01$	$11.0^{a}\pm2.0$
Cage	$4.68^{b}\pm0.08$	$0.78^{a}\pm0.2$	$3.8^{a}\pm0.06$	$0.88^{c}\pm0.01$	$9.0^{a}\pm1.0$
Pen	$4.97^{a}\pm0.1$	$0.96^{a}\pm0.2$	$3.6^{a}\pm0.02$	$0.92^{b}\pm0.01$	$10.0^{a}\pm2.0$
Pond	$5.01^{a}\pm0.04$	$1.05^{a}\pm0.1$	$3.54^{a}\pm0.03$	$0.95^{ab}\pm0.01$	$10.0^{a}\pm0.6$

Table 3: Comparative account of body composition (% wet weight basis) for monosex Nile tilapia under various traditional and non-traditional culture methods. Similar alphabets denote homogenous means

Culture methods	Water (%)	Protein (%)	Fat (%)	Ash (%)
Cistern	$79.89^{a}\pm0.7$	$12.4^{b}\pm0.8$	$3.9^{c}\pm0.2$	$3.54^{ab}\pm0.3$
Flow-through	$74.36^{c}\pm0.4$	$14.28^{a}\pm0.4$	$6.2^{a}\pm0.2$	$4.24^{a}\pm0.2$
Cage	$81.05^{a}\pm0.9$	$13.61^{ab}\pm0.7$	$1.91^{d}\pm0.1$	$3.06^{b}\pm0.2$
Pen	$77.53^{b}\pm0.7$	$14.48^{a}\pm0.4$	$4.61^{b}\pm0.1$	$3.1^{b}\pm0.1$
Pond	$74.34^{c}\pm0.8$	$14.75^{a}\pm0.4$	$5.86^{a}\pm0.1$	$4.08^{a}\pm0.3$

the weight and length growth pattern of the monosex tilapia under different culture methods it was evident that cistern culture system belonged only to the lower homogenous subset while pond culture system possessed a significant growth advantage over it belonging to the higher homogenous subset (Table 1). All other culture systems belonged to both these homogenous subsets. But for pattern of depth increase, pond culture system belonged to a higher homogenous subset, pen culture belonged to both higher and lower subsets while the cistern, flow-through and cage culture systems belonged only to the lower subset category (Table 1). SGR for cage culture was found significantly lower compared to pen and pond culture systems and the other methods belonged to both the homogenous subsets (Table 2) but all the methods had no statistically significant difference for DWG (Table 2). Interestingly, the highest values for weight, length, depth, SGR and DWG were observed for pond culture system (Table 1, 2). FCR was highest for cage culture and lowest for cistern culture system (Table 2). Conversely, cistern and flow-through culture system had the highest PER values while cage had lowest (Table 2). Interestingly, pond culture showed the highest protein content but lowest water content among all the culture methods (Table 3). Although fat content is the highest in flow-through culture system, pond culture also has a high fat content belonging to the same homogenous category (Table 3).

DISCUSSION

Aquaculture has become the world's fastest growing food producing sector, with a growth rate of 10% annually since 1984 and its production more than doubled between 1990 and 1999 (from 16.8 million t in 1990 to 42.8 million t in 1999) [21]. India contributes about 9.90% of the total freshwater fish production in the world but its contribution is gradually declining. Tilapia has good potential for the enhancement of production in the fishery sector of India but considerable research is required to adopt different techniques of tilapia culture that are practiced in other countries. The fish is actually cultured in diverse systems in inland rural areas, in areas around large cities, in wastewater ponds and even in brackish water ponds in coastal areas [6]. Semi-intensive production in ponds using fertilizers and supplementary feeding is a mean of producing low-cost fish in developing countries like India. The advantages of such culture are widely recognized for rural food supply. It can provide an opportunity to balance the use of supplementary feeding in correlation with the natural food availability and hence reduce the production cost. Semi-intensive and intensive cage cultures are also viable in a range of circumstances [6]. The management flexibility of close culture systems can be achieved in open water through such cage culture method [22]. Pens have natural earthen substrata as the bottom surface and here the fish can procure natural food and exchange materials. But, in

order to sustain a high biomass within a restricted area, intensive pen culture surely requires supplementary feeding and maintenance of good water flow leading to increase in the production cost. Nowadays, entrepreneurs are exploring ways to farm tilapia by high-cost intensive culture to satisfy rising demand for high quality fish in the developed world. Intensive tank culture can produce very high yield on small parcels of land. Several factors like increasing land costs, decreasing freshwater supplies, savings in manpower and easier stock management are the main reasons for intensification of fish farming in concrete tanks [3]. A better water quality management practice than this can be achieved in flow-through culture where there is a regular water flow to constantly drain out the organic deposits from the tank bottom. But, tilapia has limited access to natural foods in tanks and must depend completely on supplementary diet in order to optimize growth performance. Confinement of fish in tanks at high densities creates stressful conditions and increases the risk of disease outbreaks. Thus, intensive culture of Nile tilapia needs a high level of expertise and is expensive in capital and operative cost [6].

The high survival percentage of the hormone treated fish indicates that androgen treatment has no adverse effect on the general health of the juvenile fish. Under the same feeding regime and stocking density, the variance in growth of monosex Nile tilapia between various culture methods may be due to dietary or exploitation differences. The better growth of fish in pond culture system compared to the other four culture methods (Table 1, 2) can be partly facilitated by the uniform water flow in this system and the additional availability of relatively energy-rich natural food materials that may confer an energetic advantage for increased growth [7, 23]. The availability of additional dietary protein source may attribute to the highest SGR in pond culture (Table 2) similar to an earlier observation [24]. The lowest fish growth in tank culture (Table 1) can be attributed to the non-availability of natural food materials as well as no continuous water flow through this system. Pen and cage culture have the availability of additional natural food materials. But, the continuous water flow through these two systems can be hindered due to algal clogging. Thus, fish growth in these two systems is comparatively lower than pond. The continuous water current in flow-through system can justify the better growth propensity of this culture method than tank and cage culture systems. But non availability of additional natural food materials can be the reason behind the comparatively lower fish growth in flow-through system than the pen and pond culture methods. It has been observed that for a given food composition, the body protein percentage on a wet weight basis is mainly affected by the body weight in salmonids [25]. Similar observations have been noticed in Nile tilapia also where body protein content increases with wet weight [26, 27]. This explains the highest protein content of the treated fish in the pond culture system where growth of fish is also the highest (Tables 1, 3). A general trend has also been observed in the proximate body composition of fish where increase in body lipid percentage is associated with decrease in the water content (Table 3).

Every culture methods analyzed in this study has its own benefits and shortcomings. In view of the relatively wide regional distribution of tilapia in India and its acceptability by the consumers, high priority must be placed on the modification and improvements of the techniques for its culture. But, considering the objective of providing cheap animal protein for household consumption, intensification through high-cost culture methods requires more extensive economical evaluations. Thus, under the eco-socio-economical condition of India, where a large number of freshwater impoundments are available for aquaculture, rearing of monosex tilapia through semi-intensive pond culture system may be considered as the ideal method of choice for a sustainable fish production.

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