PRELIMINARY STUDY ON GROWTH OF MIXED SEX NILE TILAPIA (AKOSOMBO STRAIN) IN A RESERVOIR-BASED FISH CAGE IN GHANA

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ABSTRACT: Aquaculture has contributed significantly to food security and employment in Ghana. The Nile tilapia (Oreochromis niloticus) is the major farmed species and constitutes over eighty percent of aquaculture production in the country. The culture of all-male Nile tilapia is well established in Ghana making the acquisition of monosex seed very expensive for the ordinary fish farmers. Therefore, this study sought to investigate the growth performance of mixed sex of O. niloticus (Akosombo strain) in a reservoir-based small cage for affordable fish production. The study was conducted in the Binaba reservoir from August, 2012 to February, 2013. Fingerlings were stocked in a 5 x 4 x 2 m cage and fed with floating commercial feed for six months. Length-weight of fish and water quality data were collected once every month. The results showed that specific growth rate (SGR) was 1.24 %/day, daily weight gain (DWG) 0.87 g, food conversion ratio (FCR) 1.30, condition factor (K) 1.97 and survival rate (SR) 54 %. The highest percent (45 %) of fish harvested weighed 200 – 250 g. The water quality was within acceptable optimal range for fish survival and growth. The results indicated satisfactory growth of mixed sex O. niloticus though the survival was moderately low due to stress-related factors.

Keywords: Fish; stocking; fish weight; mortality and survival

INTRODUCTION

Tilapias are widely recognized as one of the most important groups of finfish for culture purposes in a wide range of freshwater culture systems, from simple waste-fed fish to intensively stocked and managed culture systems (Fitzsimmons 2000). Attempts have also been made in some developed countries to grow them in full-strength sea water. In Ghana, the Nile tilapia (Oreochromis niloticus) is the major farmed species and constitutes over eighty percent of aquaculture production in the country and it occurs in several rivers, and in natural as well as man-made lakes (FAO 2011).

Tilapia grows and reproduces in a wide range of environmental conditions and tolerates stress induced by handling (Tsadik and Bart 2007). However, this efficiency of reproduction in tilapia has undesirable consequences. Problems common for many Nile tilapia culture systems are the reduction of growth rates at the onset of sexual maturity and precocious and excessive reproduction, leading to various sizes of small fish production (Lèvesque 2002). There are a number of ways to control reproduction in mixed-sex population. One of these is the culture of all-male Nile tilapia (Phelps and Popma 2000). Although, desirability of monosex male populations of Nile tilapia is well established for increased production not many farmers are privileged to get seed for stocking. Coupled with that most common methods used in producing all-male Nile tilapia is the use of the male hormone, which is expensive, difficult to get and laborious to implement. Most of the hatcheries using this method report success of 70 - 80 %. This
does not defeat the purpose entirely in most instances. The situation is even worse when such fingerlings are cultured in ponds. Mixed sex Nile tilapia could also be considered in cage culture since they are unable to reproduce to a very large extent. The cage prevents unwanted reproduction by allowing the eggs to pass through the bottom mesh before they can be fertilised (Williams 2000). This implies that feed eaten could be used for growth rather than reproduction. Also this reduces the cost of producing fingerlings and the associated problems with use of hormones and other methods that are cumbersome and tiring.

Previously, small scale fishing in reservoirs contributed significantly to food security, nutritional requirements and economic status of riparian communities around reservoirs in the northern regions. However, the use of illegal fishing methods, notably the use of mesh sizes smaller than the minimum 2.5 cm permitted by the Ghana Fisheries Law, Act 625 (2002) and overfishing has resulted in downward trend in fish production from the reservoirs hence the strong need for cage culture using affordable seed like mixed sex Nile tilapia (Akosombo strain) fingerlings. This study sought to investigate the growth performance of mixed sex of Nile tilapia (Akosombo strain) in a reservoir-based small cage.

MATERIALS AND METHODS

Study area

The study was conducted in the Binaba reservoir in Bawku West District of Upper East Region of Ghana. Binaba is located on latitude 10°48′ N and longitude 0°28′ W. The surface area of the reservoir is estimated as 35 ha and average depth of 7 m. The mean atmospheric temperature is between 27°C and 36°C. The region is semi-arid. Most of the rains in the region fall as thunderstorm originating from squall.

Cage design

A one-unit 40 m³ cage made up of two rectangular frames (5 x 4 m), which formed both the top and base of the cage with a 2 m depth, was constructed locally. The frames of the cages were constructed from 3.81 cm diameter galvanized pipe and covered with nylon net with mesh size 1.5 cm. The cage was floated by polyvinyl chloride (PVC) pipes of diameter 38.1 cm. All the four corners were anchored using nylon ropes to heavy stones weighing between 10 – 25 kg each placed at the bottom of the reservoir bed. The top part of the cage was covered with 6 x 5 m net (5 cm mesh size) as shown in Figure 1.

![Figure 1. The 5x4x2 m fish cage mounted in Binaba reservoir](image)

Stocking of cage

The cage was stocked with 2,332 fingerlings of mean weight 19 ± 0.18 g. The female population was 70 % and that of the male population was 30 %. The stocking density was 58 fish per m³.
Feeding of fish

Fish were fed with pelleted floating commercial feed with crude protein level of 33% for 6 months period. Feeding was done twice daily – between the hours of 8:00 GMT and 9:00 GMT in the morning and 16:00 GMT and 17:00 GMT in the evening. The daily ration was usually divided into two equal parts and given to fish by broadcasting. The percent fish body weight adopted for feed estimation for the six months (from 1st month to 6th month) were 8%, 7%, 6%, 4%, 3% and 1.5%. The feeding rate was calculated as follows:

Feeding rate $= \% \text{ Fish body weight} \times \text{Fish weight (g)}$

Growth parameters and mortality

Fish were sampled monthly and growth parameters recorded. A sample of 30 to 50 individuals was used. The standard and total length was measured to the nearest ± 0.1 cm and the weight of fish measured to the nearest ± 0.1 g. Mortality of fish was recorded daily by handpicking and counting. Growth parameters such as specific growth rate (SGR), daily weight gain (DWG), feed conversion ratio (FCR) and survival rate (SR) were calculated following Pechsiri and Yakupitiyage (2005) and condition factor, K according to Gomiero and Braga (2005).

\[
\text{SGR (% day}\text{−}1) = \left(\frac{\ln \text{final weight} - \ln \text{initial weight}}{\text{time (days)}}\right) \times 100
\]

\[
\text{DWG (g day}\text{−}1) = \frac{\left(\text{mean final weight (g)} - \text{mean initial weight(g)}\right)}{\text{days}}
\]

\[
\text{FCR} = \frac{\text{total amount of dry feed consumed(g)}}{\text{wet weight gain of fish (g)}}
\]

\[
\text{SR} = \frac{\text{final number of fish}}{\text{initial number of fish}} \times 100
\]

\[
K = \frac{W}{L^3} \times 100; \text{ where } W = \text{weight of fish (g)}, \text{ L = Total length of fish (cm)}
\]

Physico-chemical parameters

Physico-chemical parameters such as dissolved oxygen, temperature, pH, and total ammonia-nitrogen of reservoir water were monitored monthly. From three location (upstream, midstream (close to the cage) and downstream of the reservoir, temperature and pH were measured in situ using the glass thermometer and Lovibond comparator respectively, Total ammonia-nitrogen by titration (APHA 2005) and dissolved oxygen using the winklers method by collecting water samples from the three locations.

Data analysis

The mean values of fish weight were presented in bar and pie charts to depict growth pattern Microsoft Excel 2007 was used for the analysis. Table was used to display the magnitudes of physico-chemical parameters.

RESULTS AND DISCUSSION

Growth of mixed sex Nile tilapia

The growth of mixed sex Nile tilapia cultured under the reservoir-based small cage system in terms of survival rate, specific growth rate, daily weight gain, condition factor and food conversion ratio are presented in Table 1. The survival rate was moderately low (54%). The results obtained for specific growth rate, daily weight gain, condition factor and food conversion ratio were satisfactory.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Survival rate (SR), %</td>
<td>54.00</td>
</tr>
<tr>
<td>Specific growth rate (SGR), %/day</td>
<td>1.24</td>
</tr>
<tr>
<td>Daily weight gain (DWG), g</td>
<td>0.87</td>
</tr>
<tr>
<td>Condition factor (K)</td>
<td>1.97</td>
</tr>
<tr>
<td>Food conversion ratio (FCR)</td>
<td>1.30</td>
</tr>
</tbody>
</table>

The survival rate of mixed sex Nile tilapia stocked in 40 m$^3$ cage in the Binaba reservoir was low (54%); nearly halve of the fish died at the time of harvest. This contradicted observation made by Ofori et al. (2009) that indicated that survival rate in smallholder tilapia cage culture is typically in the range of 70 - 80%, though survival rates as low as 60% have been associated with stocking densities in excess of 70 fish per m$^3$. The low survival rate could be attributed to severe stress due to delays in transportation of fingerlings to the study site.
Arguably, the high growth recorded for the fish suggests that, the fish grows fast in the cage system owing to efficient water exchange and less interest in reproduction. This is evident in the food conversion ratio (1.30) and specific growth rate (1.24 %/day) achieved (with mixed sex Nile tilapia in cages) which indicated effective feed utilization. Similar increase in growth rate of tilapia in cages has been reported by McGinty, (1991) and Mensah (2014).

The condition factor (K) obtained in this study was higher than 1 (Table 1). The condition factor was greater than 1 indicating that they were in good condition and healthy. It can be inferred from this study that the growth of mixed sex Nile tilapia in the cage was good as condition factor has been used as an index for growth studies several years (Fagade 1979).

**Monthly weight of Nile tilapia**

The results revealed a fairly consistent increase in mean weight from stocking (August, 2012) to harvest (February, 2013). Thus, the mean weight was 19.00 g at stocking, 27.50 g in the 1st month, 51.20 g in the 2nd month, 72.30 g in the 3rd month, 132.56 g in the 4th month, 140.31 g in the 5th month and 176.00 g in the last month as presented in Figure 2.

![Figure 2. Monthly mean weight of mixed sex O. niloticus in a reservoir based small cage](image)

The result at harvest revealed the greatest number (45%) of fish in the size category of 200 – 250 g followed by < 200 g (40%) and least was 15% for the size category of >250 g (Figure 3).

![Figure 3. Percentage of Nile tilapia sizes at harvest from a reservoir-based small cage](image)

The results showed increase in fish weight from stocking to harvest (Figure 2). There was consistent growth pattern – that is considerable weight gain was observed from stocking with fingerlings to maturity (over a period of six month). However, from December, 2012 (132.56 g) to January, 2013 (140.31 g) the monthly increase in weight was small (7.75 g); growth almost retarded. This could be as a result of feed shortage which occurred during the study leading to poor rationing of feed.
The results showed satisfactory growth of mixed sex Nile tilapia. Fish size of 200 g and above is generally preferred by consumers in Ghana (Ofori. 2009). Therefore majority of the fish at harvest fell within the acceptable size range. Tilapia of more than 200 g attracts premium prices in Hanoi (Cao 1998). Dan and Little (2000) observed both mixed or monosex Nile tilapia, reached a size of 300–400 g within a culture period of 6 months in either cages or ponds using a stocking density of 80 fish per m². The difference in fish sizes could be attributed to variation in feed nutrient, strains and water quality.

**Relationship between fish weight and mortality**

The relationship between mortality and weight of fish is presented in Figure 4. High fish mortality occurred (815 individuals) after stocking in the first month with a corresponding individual mean weight of 36 g. Subsequently, mortality reduced at an increasing weight until harvest (Figure 4).

![Figure 4. Relationship between mean weight and mortality of mixed sex Nile tilapia reared in a reservoir-based small cage](image)

The initial high mortality recorded during the study could be due to stress induced by handling and poor feeding practices (Masser 1997). A similar observation was reported by de Oliveira et al. (2012) on the performance of juvenile pirarucu (*Arapaima gigas*) in cages.

**Physico-chemical status of the reservoir**

The water quality of the reservoir in terms of physico-chemical characteristics was good. The mean temperature (°C), pH, DO (mg/l) and NH₃-N (mg/l) were 27.5 ± 0.65, 7.0 ± 0.21, 3.6 ± 0.57 and 0.2 ± 0.07 respectively as shown in Table 2.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Range</th>
<th>Mean ± S.D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature, °C</td>
<td>27 – 28</td>
<td>27.5 ± 0.65</td>
</tr>
<tr>
<td>pH, units</td>
<td>6.8 – 7.1</td>
<td>7.0 ± 0.21</td>
</tr>
<tr>
<td>Dissolved Oxygen, mg/l</td>
<td>3.2 – 4.0</td>
<td>3.6 ± 0.57</td>
</tr>
<tr>
<td>Total Ammonia-Nitrogen, mg/l</td>
<td>0.1 – 0.2</td>
<td>0.2 ± 0.07</td>
</tr>
</tbody>
</table>

All the physical-chemical parameters of the water in the culture area where the cage was located were within the acceptable optimal range for fish culture (FAO 1993; Hussain 2004). It was reported that dissolved oxygen lower than 3.0 mg/l could cause suffocation in fish culture (Hussain 2004). The concentration of ammonia-nitrogen was within acceptable limits. All values obtained were within the optimal ranges conducive for fish growth and survival.

This study has shown that mixed sex Nile tilapia (Akosombo strain) can efficiently grow to acceptable market-size in cages for consumption. It can provide employment and additional income to local fishers and increase the supply of fish protein. Its main effect will be to reduce pressure on native fish by diverting fishers from fishing of wild stocks to aquaculture and thus provide alternative livelihoods.

**Acknowledgement**

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