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RESEARCH ARTICLE

SURVIVAL RATE, FEED UTILIZATION AND GROWTH PERFORMANCE OF FINGERLINGS OF AFRICAN CATFISH, *CLARIAS GARIEPINUS* (BURCHELL, 1822), AT DIFFERENT STOCKING DENSITIES UNDER DARK CONDITION

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ABSTRACT: Fingerlings of *Clarias gariepinus* were reared at four different stocking densities in glass aquaria to evaluate the effect of stocking density on survival rate, feed utilization and growth performance. Two hundred fifty five fingerlings were stocked in 25 L volume glass aquaria at a density of 10, 15, 25 and 35 fingerlings in triplicates with mean weight of 35.52±1.23, 34.16±1.63, 35.66±0.37 and 35.67±0.63 g, respectively, for 12 weeks. Weight gain was recorded bi-weekly while water quality parameters were recorded daily. Temperature and pH ranged between 22.63–22.95°C and 7.08 to 7.23, respectively, while dissolved oxygen ranged between 5.45–5.60 mg/L among treatments. The highest survival rate (93.33%) was recorded in treatment with the highest stocking density (treatment IV). Feed Conversion Ratio was 2.51, 12.82, 6.23 and 6.65 for treatment I, II, III and IV, respectively. The final mean weights (±S.E) of the fingerlings stocked at densities of 10, 15, 25 and 35 fingerlings were 43.11±1.06, 36.16±1.84, 43.01±2.83 and 46.80±1.40 g, respectively. The highest mean weight gain (11.13 g) was recorded in treatment stocked with 35 fingerlings. Specific growth rate was 0.230, 0.067, 0.223 and 0.323%/day for treatment I, II, III, and IV, respectively. The results revealed that fingerlings treated at the highest stocking density exhibited higher survival and growth rate than those with lower densities. It is concluded that wild fingerlings of *C. gariepinus* can be used as seed for aquaculture farms.

Key words/phrases: Aggressiveness, *Clarias gariepinus* fingerlings, Feed conversion ratio, Growth, Stocking density.

INTRODUCTION

The African catfish (*Clarias gariepinus*), is one of the most important fish species that contributes largely to Ethiopian fishery and is found in almost all the water bodies of Ethiopia (Elias Dadebo *et al*., 2011). The species has been recognized as a fish made for African aquaculture due to its biological attributes (Hengsawat *et al*., 1997) and hence the species is described as a fish suitable for African fish farming and consumers (Atanda, 2007).

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Aquaculture production in Ethiopia has remained potential than actual despite favorable social, biological and ecological conditions that are found in the country (Eshete Dejen and Zemen Mintesnote, 2012). Even the current small production comes from artisanal fresh water fishery and extensive aquaculture (Asfaw Alemayehu, 2011), and due to this, the water bodies are no longer able to support the fishery at subsistence level (Yared Tigabu *et al*., 2011).

Most of the country's demand for fish is supplied from capture fishery which is still vulnerable to over-exploitation due to population rise and increasing demand (Reyntjens *et al*., 1998), urbanization, industrialization and other water resource development activities (Dereje Tewabe, 2014). It is believed that fish production from these water bodies, even if used to their full potential, couldn't satisfy the growing demand of fish in the country. Supporting this, it has been reported that the amount of fish production is far below the estimated yield and the pattern of production is by no means uniform and entirely dependent only on capture fisheries (Asfaw Alemayehu, 2011).

The demand and the supply of fish in Ethiopia are characterized by seasonality and the demand is higher during the lent period (Assefa Mitike, 2014). The demand gap due to seasonality of capture fishery can be filled only when alternative fish production sector is growing (Christopher, 2003). These situations lead to considering aquaculture as one of an alternative means of fish production (Singh *et al*., 2007).

However, the development of aquaculture in Ethiopia is primarily constrained by lack of quality seed (fingerlings) and feed (Rothuis *et al*., 2012). Hence, due to lack of commercial catfish hatchery in the country, the potential of wild collected fingerlings needs to be tested for their survival rate, feed utilization and growth performance responses treated at different stocking densities, though the supply from the wild is limited only to rainy season and is unreliable. It has been reported that stocking density is among one of the factors that affect the survival and growth of fish (FAO, 2007) and that determine the economic viability of the production system (Boujard *et al*., 2002).

Previous studies on the *C. gariepinus* in the country are limited to the biological aspects of the species (Leul Teka, 2001; Elias Dadebo *et al*., 2011; Demeke Admassu *et al*., 2015). However, scientifically proven published data on the effect of stocking density on survival rate, feed utilization and growth performance of fingerlings *C. gariepinus* is still a gap. This study was conducted to generate scientific information on the survival rate, feed utilization and growth performance of fingerlings of the species at different stocking densities, which could be a scientific basis for catfish aquaculture development.

MATERIALS AND METHODS

Description of the study area

Wild *C. gariepinus* fingerlings were collected from Gudo Bahir, a wetland in Bahir Dar city. The city is located at 1800m.a.s.l and has warm to hot temperature year-round. Bahir Dar is one of the leading tourist destinations in Ethiopia, and located at the heart of Lake Tana; the largest lake in Ethiopia, source of the Blue Nile. Collected samples were then taken to Bahir Dar Fisheries and Other Aquatic Life Research Centre (BFOALRC), Bahir Dar, Ethiopia for the study.

Seed collection

Wild fingerlings of *C. gariepinus* were collected from Gudo Bahir, a wetland which serves as a spawning ground for *C. gariepinus*. Beach seine was used to collect the fingerlings. Four hundred sixty eight fingerlings of *C. gariepinus* were collected and were sorted into different size classes for the purpose of gathering fingerlings with the same size.

Experimental procedure

The research was conducted in triplicate for 12 weeks from February to May, 2017 in glass aquaria with a dimension of 90*45*45 cm. Two hundred fifty five wild collected fingerlings were used. The total lengths and the total weights of the fingerlings were determined at the beginning of the experiment and ranged from 14.5 to 21.0 cm and 21.0 g to 54.0 g using electrical sensitive balance, with a precision of 0.1g, and a measuring ruler to the nearest mm, respectively (Lagler, 1970).

Feed formulation and preservation

Iso-nitrogeneous experimental diet was prepared using basal ingredients of wheat bran, fish carcass, wheat flour, blood and bone meal. The ingredients were separately grounded and filtered using a mesh with a screen size of 0.8 mm and mixed in the required proportions to form a mash (Table 1). The resulting mash was pelleted mechanically using meat mincer with the size of 2 mm. The pelleted diet was then dried under shade and stored in water proof plastic bags to prevent spoilage.

Table 1. Inclusion level of locally available feed ingredients in the formulated diet.

Ingredient type	**Inclusion level (kg)**	**Crude protein (%)**	**Protein level**
Fish meal	53	50.25	26.63
Blood and bone meal	23	53.35	12.27
Wheat flour	12	10.79	1.29
Wheat bran	12	15.79	1.89
Total	100.0 kg		42.08%

The proximate composition of the diet were determined at Ethiopian Public Health Institute following validated analytical methods recommended by Association of Analytical Chemists (AOAC, 1990). Hence, the moisture, crude protein, crude fat, crude fiber and ash of the experimental ingredients were analyzed and are presented in Table 2. The experimental fingerlings were fed with a diet containing 42% crude protein. The feed was offered two times a day at 9–10 am and 4–5.00 pm at a rate of 5% of their body weight.

Table 2. The proximate composition of each of feed ingredients used for the experiment.

Ingredient type	**Crude protein**	**Crude fat**	**Crude ash**	**Moisture**	**Fiber**
Fish meal	50.25	12.04	29.20	7.52	0.60
Blood and bone meal	53.35	17.63	21.75	5.40	2.17
Wheat flour	10.07	2.45	2.62	7.73	3.05
Wheat bran	15.79	4.82	4.02	10.63	9.53

Survival rate, feed utilization and growth performance

The fingerlings were stocked in the experimental aquaria labeled according to the stocking density specified randomly for each of the aquarium. The four stocking densities were 10, 15, 25 and 35 fingerlings per aquarium which were labeled as treatment I, II, III and IV, respectively. There were 4 treatments with three replicates which were assigned to each treatment in a randomized complete block design (RCBD). The fingerlings were allowed to acclimatize the artificial environment for two weeks (Eyo *et al*., 2013) prior to the commencement of the actual experiment. Fish sampling was conducted every 15 days by using scoop net (12.7 mm mesh size) and their weights and lengths were measured. It was observed, however, that the fingerlings did not resume feeding on the day of sampling. The fish in each aquarium were batch-weighed biweekly and from the data, the quantity of feed to be dispensed was adjusted (Hogendoorn, 1983). During this period, undigested food particles and waste products were siphoned out with a rubber hose daily in the morning. Each aquarium was supplied with compressed air via air stones and UV treated water from Lake Tana to an effective depth of 20 cm.

Data analysis

Water quality parameters (temperature, dissolved oxygen and pH) were measured using multi-meter probe kit (model YSI 556) during the experimental period (Table 3) and compared using One-way ANOVA. Fish were sampled for body weight and body length measurement every two weeks to determine how much the fish have grown. From the body weight and length data, the following growth parameters were calculated using the following formulae:

$$\text{Survival rate (\%)} = \frac{\text{Number of survivals at the end of the experiment}}{\text{number of fingerlings stocked}} \times 100\%$$

$$\text{Feed conversion ratio (FCR)} = \frac{\text{Food Quantity Fed}}{\text{Weight Gained}}$$

$$\text{Specific growth rate (SGR) in \%/day} = \frac{100 \ln(W2 - W1)}{\Delta t}$$

$$\text{Mean weight gain} = \text{Final weight (g)} - \text{initial weight (g)}$$

To test the effect of stocking density on survival rate and growth performance indices, data were analyzed using One-way ANOVA.

RESULTS AND DISCUSSION

Water quality parameters

The mean concentration of water quality parameters: water temperature, dissolved oxygen, and pH are presented in Table 3. They lie within acceptable ranges for the culture of *C. gariepinus* (Boyd, 1989; Swann, 2006) and are not significantly different among the treatments (p>0.05).

Table 3. Water quality parameters of the different stocking density treatments during the study period (Mean±standard error).

Water quality parameters	Treatments			
	I	II	III	IV
Temperature (°C)	22.79±0.9	22.63±0.81	22.7±0.71	22.95±0.65
Dissolved oxygen (mg/L)	5.60±0.26	5.54±0.39	5.48±0.34	5.45±0.34
pH	7.20±0.32	7.12±0.38	7.08±0.57	7.16±0.37

Survival rate

The mean survival rate of the treatments ranged between 85.3% and 93.3%. Treatment IV with the highest stocking density had the highest rate of survival (93.3%), followed by treatment I with survival rate of 90%, while treatment II and III showed relatively lower survival; 86.6% and 85.3% respectively (Fig. 1). However, the rate of survival in all of the treatments was not significantly different (p>0.05). The number of mortalities recorded during the experiment showed significant variation (p<0.05) between sampling weeks (Table 4). In spite of this, it was in the eighth week that highest mortality (37.0%) was recorded as compared to the other weeks for which fortnight measurements were made.

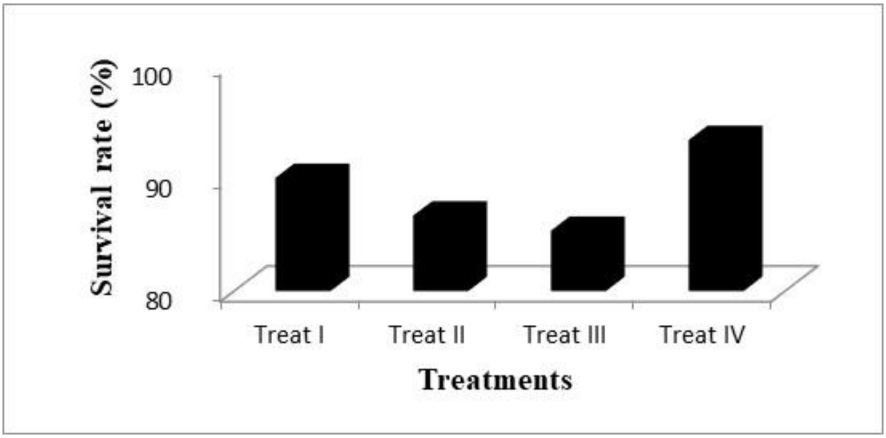

Fig.1. Survival rate of fingerlings of *C. gariepinus* among the stocking density treatments.

Table 4. Mortalities recorded in each stocking density treatment of fingerlings of *C. gariepinus* during the experimental period.

Treatments	Sampling weeks						
	Week 2	Week 4	Week 6	Week 8	Week 10	Week 12	Total
Treatment I	--	--	--	3	-	--	3
Treatment II	1	--	1	1	1	2	6
Treatment III	2	--	1	4	2	2	11
Treatment IV	--	1	--	2	1	3	7
Week total	3	1	2	10	4	7	27
Percentage mortality (%)	11.11^{a}	3.70^{b}	7.40^{a}	37.03^{c}	14.81^{a}	25.92^{ac}	100

Subscripts with different letters in a row are significantly different (p<0.05)

Survival rate recorded in this study was generally high and, therefore, highest survival rate was recorded for treatment with the highest stocking density (Han *et al*., 2005; Effiong *et al*., 2012). Survival rate and growth are directly proportional to each other provided that environmental variables and husbandry necessities in the rearing environment remain constant (North *et al*., 2006). The highest survival rate in the present study may be attributed to proper handling of fish, possibly good water quality and dark growing condition, which is in agreement with Seble Getahun (2014) who reported a survival rate of 92.8%. In addition, the fingerlings in all of the treatments were active under the dark growing condition. This confirms the preference of darkness by *C. gariepinus* as an innate behaviour and is in agreement with Britz and Pienaar (1992) who reported a reduced aggression and enhanced growth of *C. gariepinus* fingerlings reared under conditions of continuous darkness or low light intensity.

In this study, it was found that mortality of the fingerlings was caused by either natural mortality or cannibalism-induced mortality (Plate 1). However, cannibalism-induced mortality was especially higher in treatments with lowest stocking densities. This might be due to the large swimming area available which might promote a face to face confrontation followed by chasing and biting (Ellis *et al*., 2002).

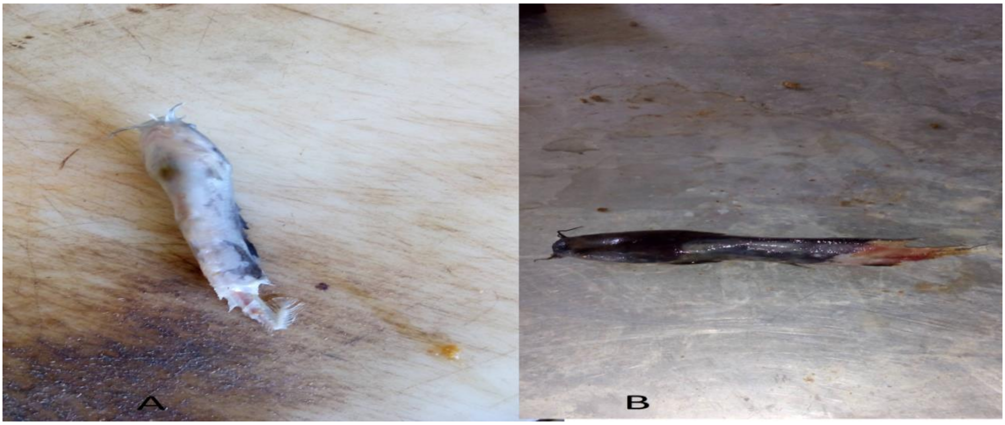

Plate 1. Cannibalism-induced mortality (a) fingerling died due to cannibalism in treatment I of lowest density (b) fingerling died due to cannibalism in treatment II of lowest density.

Feed utilization

The feed conversion ratios of all treatments ranged from 2.25 to 13.55 with mean values of 2.51±0.07, 12.82±0.29, 6.23±0.05 and 6.65±0.14 for treatments I, II, III and IV, respectively. The analysis of the feed conversion ratio was highest in treatment I (2.51), while the least (13.55) was recorded in treatment II. The mean feed conversion ratio between treatments was affected by stocking density ($p<0.05$).

Better FCR values were obtained for treatments with lower stocking densities than the highest density treatment (Fig. 2). In this study, FCR was significantly affected by stocking density ($p< 0.05$) and the best FCR for the fingerlings (2.51) was obtained for Treatment I with the lowest stocking density. This result is in agreement with Edward *et al*. (2010) and Akinwole *et al*. (2014) who reported that FCR in *C. gariepinus* fingerlings was affected by stocking density under controlled conditions. However, poor FCR values were recorded in the treatments. These poor FCR values could be attributed to larger pellet size, lower digestibility and improper utilization of feed, stocking density and feed quality (Chiu *et al*., 1987).

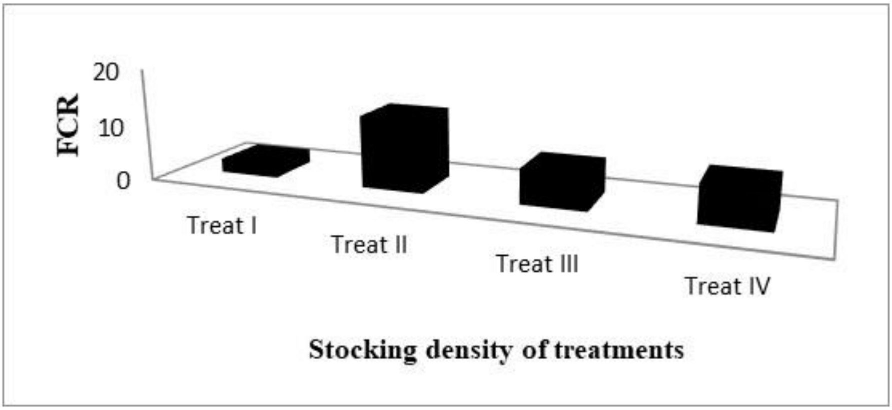

Fig. 2. Feed conversion ratio of the fingerlings of *C. gariepinus* reared at different stocking densities.

The lower feed conversion ratio (6.2–13.5) might also be associated with the use of locally available feed ingredients, which is in agreement with Agbo *et al*. (2014) who reported poor FCR for Clarotid catfish fed on practical diets using locally available feed ingredients. In addition, the poor FCR recorded might be due to poor adaptation of the wild collected fingerlings to feed on artificial feed as a prior residence effect may lead to poor performance of fish (Bohlin *et al*., 2002). Therefore, this poor FCR could have been one of the reasons for the low growth performance of the fingerlings in the present study.

Growth performance parameters

Growth performance responses of *C. gariepinus* fingerlings to stocking density are presented in Table 4. Mean initial length and weight of the fingerlings before stocking was not significantly different ($p>0.05$). The results showed highest values for mean length gain, mean daily weight gain, mean weight gain, mean final weight gain, specific growth rate and percentage weight gain for the treatment with the highest stocking density (Table 5). Highest and lowest final body weight and length gains were observed at treatment IV and treatment II, respectively (Table 5). Mean weight gain was variable in all of the treatments with different stocking densities.

Feed composition, ration size, feeding frequency and stocking density are among the most important factors affecting growth (Jobling, 1998). The effects of stocking density on the growth of fish were documented by various authors who reported an inverse relation between stocking density and growth for a number of fish species (Bjørnsson, 1994; Irwin *et al*., 1999). On the other hand, findings on rainbow trout (*Oncorhynchus mykiss*) (North *et al*., 2006) and of sea bass (*Dicentrarchus labrax*) (Papoutsoglou *et al*., 1998) show that high stocking densities for these species had positive effect on their growth performance.

Table 5. Summary of growth performance indices of the fingerlings of *C. gariepinus* at different stocking densities after twelve weeks of rearing (Mean± Standard Error).

Growth performance indices	**Treatments** I	**II**	**III**	**IV**
Mean initial length (cm)	17.58±0.16a	17.44±0.23a	17.63±0.1a	17.84±0.04a
Mean final length (cm)	20.01±0.26a	19.28±0.3a	20.19±0.33a	20.78±0.21a
Mean length gain (cm)	2.43±0.4a	1.84±0.25a	2.56±0.35a	2.94±0.18a
Mean initial weight (g)	35.52±1.23a	34.16±1.63a	35.66±0.37a	35.67±0.63a
Mean final weight gain (g)	43.11±1.06a	36.16±1.84 b	43.01±2.83a	46.80±1.40a
Mean weight gain (g)	7.59±2.27a	2±1.21b	7.45±3.04a	11.13±1.12a
Specific growth rate	0.230±0.07a	0.067±0.0b	0.223±0.09a	0.323±0.03a
Percentage weight gain (%)	17.37±4.73a	5.37±3.08b	16.51±6.0a	23.69±1.75a

Subscripts with different letters in a row are significantly different ($p<0.05$)

Previous studies on *C. gariepinus* are in line with the general assumption that growth performance decreased when stocking density is increased (Haylor, 1993). However, this turned out not to be the case in this study and therefore, measurements of the growth performance indices recorded higher value at treatments with the highest stocking density than lower stocking densities (Almazán-Rueda, 2004).

The most likely reason for the difference between literature data (Eyo *et al*., 1998; Edward *et al*., 2010) and the finding of the current study are the differences in stocking density used in the various experiments (Kaiser *et al*., 1995) and changes with the size of the fish (Hossain *et al*., 1999). Most previous studies on *C. gariepinus* which have dealt with the effect of stocking density on growth performance have been carried out on juveniles with an initial weight smaller than 9 g (Kebus *et al*., 1992; Hossain *et al*., 1999), whereas fingerlings with the smallest weight used in the present study had an initial weight of 34.16±1.63 g.

The other possible explanation may be aggressiveness. During the behavioural observations, it was found that agonistic behaviour manifested by cannibalism and escape attempts were higher in treatments with lower densities while highest density treatments were observed making shoal and resting more at the bottom of the aquarium (Hengsawat *et al*., 1997). Hence, the agonistic behaviours in treatments with lower stocking density may have cost the fingerling some more energy which would rather have been used for maintaining growth. Furthermore, it was reported that aggressive activities caused a lot of energy which otherwise could be used for growth as aggression can result in stock losses, reduced food conversion efficiency and slower growth (Hecht and Uys, 1997; Ellis *et al*., 2002).

Similar reports to the present study were also reported on fingerlings of African catfish (Otubusin, 1997; Solomon and Udoji, 2011), *Clarias batrachus* fry and larvae (Sahoo *et al*., 2004) as long as good water quality was maintained. Although a positive trend of growth in all of the treatments during the study period was recorded, the final weight gain after 12 weeks of treatments was not impressive for all of the stocking density treatments as compared with others. For example, previous work (Eyo *et al*., 2013) reported a better growth performance of wild collected fingerlings. This difference might be attributed to differences in feed used and culturing temperature. The absence of natural food in the culturing environment may also affect growth, as the fingerlings were collected from the wild. In addition, in restricted spaces, fingerlings of catfish exhibit behavioural problems such as reduced feed intake and aggression, which have a profound influence on the growth of fish (Almazán-Rueda, 2004). The lower growth performance of the fingerlings in this study might be due to the variability of biotic and abiotic factors in the artificial culturing environment (Piersma and Drent, 2003) and the fingerlings lack of experience for feeding on artificial feed.

The highest specific growth rate (0.323%/day) was obtained for treatment with the highest stocking density and it was not affected significantly by stocking density ($p>0.05$), except for treatment II (Oguguah *et al*., 2011). However, this finding was in contrast with another finding (Amon *et al*., 2016), who reported that specific growth rate was inversely related to stocking density. On the contrary, the present study found better specific growth rate (Table 5) among the stocking density treatments than the findings of Jambo and Kereemah (2009) who reported 0.036% as the highest specific growth rate for the same stocking density treatments.

Mean daily weight gain and specific growth rate recorded in the present study were low when compared with others (Edward *et al*., 2010; Akinwole *et al*., 2014) and this might be due to the wild nature of the fingerlings, the quality of feed and the type of feed ingredients used in the present study. It is known that locally available feed ingredients were used for the present study while commercial catfish feed (Coppen) with balanced nutritional quality was used in others (Edward *et al*., 2010; Eyo *et al*., 2013; Akinwole *et al*., 2014).

CONCLUSION

In this study, survival rate of the fingerlings treated under different stocking densities was high and was not density dependent. Although, better performance in growth performance indices were recorded for treatments with the highest stocking density than the lower densities, growth performance of the fingerlings of *C. gariepinu*s was not affected by stocking density. Based on the current finding, it is possible to use wild fingerlings for aquaculture purposes, although it is very difficult to make maximum profit in the aquaculture sector by using fingerlings of *C. gariepinus* collected from the wild.

Comparative study on survival rate, feed utilization and growth performance of *C. gariepinus* fingerlings should be conducted under different culture conditions in order to have a clear distinction between the wild collected and hatchery bred fingerlings. Mechanism should be developed in the country to promote artificial propagation of *C. gariepinus* so as to obtain hatchery bred fingerlings.

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