3(2): 75-81 (2017) doi: 10.3153/JAEFR17010

Journal of
Aquaculture Engineering and Fisheries Research

E-ISSN 2149-0236

ORIGINAL ARTICLE/ORİJİNAL ÇALIŞMA

FULL PAPER TAM MAKALE

FECUNDITY, GROWTH PARAMETERS AND SURVIVAL RATE OF THREE AFRICAN CATFISH (*Clarias gariepinus*) STRAINS UNDER HATCHERY CONDITIONS

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Received: 16.11.2015

Accepted: 20.12.2016

Published online: 24.02.2017

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Abstract:

Three strains of African catfish (*Clarias gariepinus*) from the Netherlands (Dutch), Indonesia and Kenya (Lake Victoria) were studied in hatchery conditions to compare their fecundity, growth performance and survival rates. The results indicated that fecundity was significantly higher ($P < 0.05$) in the Kenyan strain (145715.17 eggs Kg^{-1}) and lower in the Indonesian strain (86354.55 eggs Kg^{-1}). The Indonesian strain had significantly ($P< 0.05$) higher final mean body weight, specific growth rate and food conversion ratio. Survival rate was significantly different among the strains ($P <0.05$); with the Indonesian strain having the highest survival rate (68.13 ±4.50%) and the Kenyan strain the lowest survival of 23.28 ±0.40%. It was concluded that significant variations existed in the three strains of *C. gariepinus* available in Kenya and development of a population involving the three strains is ideal, but should be accompanied by further studies over a wide range of culture systems and conditions. Meanwhile, the Indonesian strain is recommended for aquaculture in Kenya.

Keywords: Growth, *Clarias gariepinus*, Strains, Fecundity

Introduction

The African catfish (*Clarias gariepinus*) is cultured in several countries throughout Africa as well as in Europe, Asia and South America (de Graaf and Janssen, 1996; Brummett, 2008). It is the second most important freshwater fish cultured in Africa. In Kenya, *C. gariepinus* is second most cultured fish species and it represents over 21% of the total aquaculture production in the country (Ogello and Opiyo, 2011; Otieno, 2011). Interest in the culture of *C. gariepinus* is increasing in areas that are not predominantly fish eating; due to the high flesh to bone ratio (Charo-Karisa *et al*., 2008; Obiero *et al*., 2014). One of the critical limiting factors in *C. gariepinus* culture in Kenya has been lack of good quality seed (Macharia *et al*., 2005). This has been attributed to lack of appropriate breed improvement programs based on local species or absence of imported genetically improved strains (Ponzoni and Nguyen, 2008). Development of a genetically improved strain of *C. gariepinus* that can adapt to a wide range of production environments and exhibiting higher fillet yield is a priority by researchers in Africa (Ponzoni and Nguyen, 2008).

Kenya is endowed with both local and imported strains of *C. gariepinus* including Indonesian, Dutch and several local strains majorly from Lake Victoria. Although *C. gariepinus* originated from Africa, the different stocks exported to other countries have been isolated for several generations and genetically divergent strains may have developed through natural selection and selective breeding under domestic conditions (Broussard and Stickney, 1981). It has been established that the development and effective use of genetically improved strains is one of the most powerful technologies to achieve the fast growing strain of catfish for aquaculture development in Africa (Ponzoni and Nguyen, 2008).

Selection of the best strains is crucial for efficient breeding program not only to reach the production goal but also to reduce production costs, improve disease resistance, utilization of feed resources and product quality (Gjedrem, 1997; Ibrahim *et al*., 2013). Few studies have included reproductive performance of catfish brood-stock as a selection criterion (Prinsloo *et al*., 1990; Legendre *et al*., 1992; Grobler *et al*., 1992). Currently, there is no research on fecundity, comparative growth and feed utilization of the different *C. gariepinus* strains in Kenya. The results from this study would guide decisions on implementation of *C. gariepinus* genetic improvement programs and enable hatcheries and farmers decide the best strains suitable for local conditions.

Materials and Methods

Origin of stocks

Three *C. gariepinus* strains of different origins were used for this study: 1) Dutch strain obtained from Fleuren and Nooijen Fish farms Ltd, in the Netherlands and were bought from Jambo fish Ltd in Kenya; 2) Indonesian strain obtained from Main Center for Freshwater Aquaculture Development in Indonesia; 3) Kenyan strain obtained from Lake Victoria in 2011. All the exotic strains of *C. gariepinus* were imported to Kenya in 2011 from the Netherlands and Indonesia respectively and domesticated in ponds at National Aquaculture Research Development and Training Centre (NARDTC), Sagana. All the strains consisted of breeders hatched under artificial conditions and matured in captivity. Brood-fish from each of the different populations were kept in different tanks and fed on formulated diet containing 35% crude protein. The fish were reared under the same culture environment in a hatchery at the Emmick Fish Farm in Kirinyaga County, Kenya (0.603° N, 37.227° E), North East of Nairobi). Four pure *C. gariepinus* from each strain were used for spawning according to de Graaf & Janssen (1996). Fry were reared in nursery tanks in the hatchery for 13 days.

Determination of fecundity

From each strain, a female *C. gariepinus* previously induced with OVAPRIM (sGnRHa) at 0.5ml Kg^{-1} was weighed using an electronic weighing balance to nearest gram, stripped into a dry plastic bowl and the eggs weighed to calculate the number of eggs from each egg mass of the female. A sample of 1 g was collected from each egg mass and fixed in buffered 10% formalin for 12 hours then transferred to 70% ethanol for storage before counting. The samples were counted in a calibrated petri dish using a tally counter under a dissecting microscope at ×20 magnifications. The number of eggs spawned was calculated by multiplying the weight of the egg mass (from each female) by the number of the eggs present in 1 g of the respective egg mass. Fecundity (the number of eggs per kilogram female) was determined by number of eggs

spawned divided by the ovulated female's body weight.

Experimental set up

C. gariepinus fry of an average weight of 0.04g were stocked at 200 fish m^{-3} in triplicates in 2.0 m×2.5 m×1.5 m raised liner tanks of 1 m water depth ($5m^3$). Each rearing tank was covered with a black polyethylene sheet to provide darkness in the tank. The fish were fed at 10% body weight, three times a day (0900 h, 0100 h and 1600 h) on commercial catfish starter feed 45 % crude protein (Skretting Fish Feed Ltd). The tanks were cleaned by siphoning out the bottom debris (faecal matter and uneaten food) twice a day and 10% of the culture water was replaced daily with fresh well water. Dissolved oxygen (DO) concentrations, temperature and pH were measured daily using multi-parameter water quality meter, model H19828 (Hanna Instruments Ltd., Chicago, IL., USA). Ammonium nitrogen and (NH_4^+- N), nitrate nitrogen (NO^3- N) and total alkalinity were determined weekly using standard methods (APHA, 1999). The fish were reared in the experimental tanks for 42 days.

Fish sampling

Sampling was done every 7 days to determine the weight of the fish and to adjust feeding. Growth was monitored by taking individual weight of 40 larvae collected randomly from each liner tank. The fish were caught by fine mesh net, gently placed on absorbent paper for approximately 5 seconds and weighed in a plastic bowl containing water using an electronic weighing balance (readability 0.01g) (model KERN 572-33, Germany). They were then returned to their respective tanks. After the 42 days period, the surviving juveniles were counted and all fish from each tank were weighed by taking the individual weights. The performances of the different strains were evaluated based on final weight (g), weight gain (%) =100* ($W_t - W_0$)/W_0, specific growth rate [SGR, % day^{-1}= 100*($\ln W_t - \ln W_0$ / t], where ln = Natural logarithm, W_0 = initial weight (g), W_t = final weight (g) and t = time in days from stocking to harvesting. Survival (%) = number of fish harvested/number of fish stocked) ×100 and feed conversion ratio (FCR) = feed given (g)/body weight gain (g). The coefficient of variation (CV) of the final weight of the fish was also calculated to determine heterogeneity in sizes of the fish.

Data Analysis

All the experimental data including final mean weight, weight gain, SGR, FCR and survival rate, were compared using analysis of variance (one-way ANOVA) followed by Fisher's LSD tests to determine the significant difference among means. Significance level was declared at ($P < 0.05$). SPSS (version 20) for windows was used for all statistical analysis.

Results and Discussion

Growth performance of different *C. gariepinus* strains are presented in Table 1. After 42 days growth period, differences were observed in final body weight of the three strains. The final mean weight of Indonesian strain was significantly ($P < 0.05$) higher compared to the Dutch and Kenyan strains. The SGR of Indonesian strain (8.98 ± 0.09%) was higher compared to the other strains, the FCR of 1.54 ± 0.04 was observed in the Indonesian strain but no significant difference ($P > 0.05$) was recorded in FCR between the Dutch and the Kenyan strains. The survival was 68.13%, 36.22% and 23.28% for the Indonesian, Dutch and Kenyan strains respectively. The Indonesian strain exhibited significantly ($P < 0.05$) higher survival rate while the Kenyan strain had the lowest survival rate. The Indonesian strain which exhibited the lowest CV of 20.60 indicating highest level of uniformity in sizes while the Kenyan strain exhibited the highest CV of 52.19 and Dutch strain 39.97.

Table 1. Growth parameters, feed conversion ratio, coefficient of variation and survival rate of three *C. gariepinus* strains during 42 days experimental period.

Parameter	Indonesian	Dutch	Kenyan
Initial body weight (g $fish^{-1}$)	0.04±0.00^a	0.04±0.00^a	0.04±0.00^a
Final body weight (g $fish^{-1}$)	1.76±0.02^a	0.69±0.04^b	0.45±0.02^c
SGR (% day^{-1})	8.98±0.09^a	6.50±0.15^a	5.62±0.12^c
FCR	1.54±0.04^a	2.05±0.24^b	2.09±0.01^b
Weight gain (%)	4513.51±174.51^a	1751.58±133.81^b	1080.38±56.98^c
Survival rate (%)	68.13±4.50^a	36.22±1.17^b	23.28±0.40^c

*Values are expressed as mean± SE. Mean values in the same row having the same letters are not significantly different ($P > 0.05$).

Table 2: Fecundity of three *C. gariepinus* strains

	Indonesian	Dutch	Kenyan
Female weight (Kg)	0.45 [a]	1.13 [b]	0.84 [c]
No. of eggs (eggs g $^{-1}$)	650 [a]	700[b]	845[c]
Fecundity (Eggs Kg $^{-1}$ fish)	86354.55±2074.87[a]	93672.50±477.92[a]	145715.17±1283.51[b]

* Values are expressed as mean± SE. Mean values in the same row having the same letters are not significantly different ($P > 0.05$).

The fecundity of the three *C. gariepinus* strains are presented in Table 2. Fecundity varied significantly among the three strains ($P < 0.05$) of which the Kenyan strain was most fecund (145,715.17 eggs Kg^{-1}) and Indonesian strain least fecund (86,354.55 eggs Kg^{-1}). The number of eggs per g of egg mass was significantly higher in the Kenyan strain compared to the Dutch and the Indonesian strain.

The ranges of values of the water quality parameters during the experimental period were: pH 7.67 - 7.69; dissolved oxygen 4.79 - 4.81 mg L^{-1}; temperature 24.12 - 24.18 °C; total alkalinity 371.72 - 372.75 mg L^{-1}; Ammonium nitrogen 0.02 - 0.03 mg L^{-1} and nitrate nitrogen; 0.20 - 0.21 mg L^{-1}. All recorded mean values of the water quality parameters were within the acceptable ranges for *C. gariepinus* culture and were not affected ($P > 0.05$) by the different strains.

Growth in fish differs between species, strains or populations within the same species and even between individuals within the same population (Martins, 2005). The current study indicates that Indonesian strain outperformed the Dutch and the Kenyan strain in all the aspects of growth. This finding is in line with Giddelo *et al*. (2002) who indicated considerable variation in growth in different populations of *C. gariepinus* from Western Rift, Lake Baringo and Rufiji River in the East African region due to geographical separation. Significant morphometric differences have also been established between strains of *C. gariepinus* in the Nile and Lake Victoria (Teugels, 1998) and Lake Kanyaboli (Barasa *et al*., 2014). The differences in growth among strains have been reported to result from either competition favoring one of the strains or a particular strain's inherent capacity to grow (Ibrahim *et al*., 2013). The difference in final weight among the different strains observed in this study is similar to findings of Nguenga *et al*. (2000) on African catfish (*Heterobranchus longifilis*) in Cameroon where the final body weight of the Noun strain was lower than Layo strain and the crosses of the two strains when reared in controlled hatchery conditions.

Difference in final weight among the different strains in this study seem not to be of a direct consequence of social hierarchies in each group where the larger fish suppress the growth of smaller fish but could be as a result of the feeding behavior with the heavier fish exhibiting feeding behavior that may give advantage when feed is limited (Martin *et al*., 2005). The survival of the different strains in the present study is in line with the work of Nguenga *et al*., (2000) who observed that the survival of juvenile *H. longifilis* was high in Layo and reciprocal crosses of Layo and Noun strains but lower in Noun strain cultured in tanks in controlled hatchery conditions. The lower survival rate in the Kenyan strain could be as a result of high incidences of cannibalism due to heterogeneity in sizes evidenced by the high value of the coefficient of variation (CV) indicating that the prey was smaller than the cannibal. It has been established that cannibalism occurs more severely when there is larger size differences between the prey and predator (Hecht and Appelbaum, 1988; Baras and Almeida, 2001).

The differences in growth performance of the fish indicate differences in the adaptability of the strains to local farming conditions. In Indonesia, the farming of the *C. gariepinus* has been largely based on freshwater systems mainly in raised liner ponds and earthen ponds where fish are stocked at high stocking densities of 150 fish m^{-2}, while in Kenya the widespread culture system are earthen ponds with low stocking densities of 3 fish m^{-2}. By contrast, culture systems in the Netherlands are mainly closed recirculating system with stocking densities of between 25 - 30 fish m^{-3}. There are also possibilities that the degree of improvement of the *C. gariepinus* through selective breeding may have occurred to a greater extent in Indonesia compared to the Netherlands and Kenya (Fleuren, 2008; Sunarma, 2008). Selective breeding has been used to increase growth

from one generation to another in channel catfish (*Ictalurus punctatus*) whereby 55% of intraspecific crosses resulted in an average increase of 10% body weight above the parental strain (Tucker and Stickeny, 1987; Dunham *et al*., 1987). Hence, the fish from Indonesia could be having a higher tolerance level of the culture environment as a result of selection (Sunarma, 2008). The difference in growth performance could also be linked to the history of domestication of the different strains. Smitherman *et al*., (1984) defines a strain as a fish having a common geographic origin and history and is considered domesticated if propagated in a hatchery environment for at least 2 generations. Considering the domestication history of each of the strains, the Kenyan strain could be considered more of a wild strain. On the other hand, the Indonesian and Dutch strain have been used for years under captivity and have been propagated for several generations and could hence be considered domesticated (Fleuren, 2008; Sunarma, 2008). Burnside *et al*. (1975) compared wild and domesticated strain of channel catfish grown in brackish water and found out that the domestic strain grew faster than the wild strain. The slow growth of the Kenyan strain was similar to the growth recorded for Noun strain of *H. longifilis* which was captured from the wild and reared in a pond environment before use (Nguenga *et al*., 2000).

The high fecundity in The Kenyan strain could also be an indicator of natural selection favoring more eggs. In most species of catfish, the total number and weight of eggs spawned are positively correlated with female weight (Broussard and Stickney, 1981; Nguenga *et al*., 2000). The difference in the number of eggs per Kg of fish in the present study is in line with other studies on Channel catfish where large strain differences were observed for various reproductive traits; in the production of eggs and eventually in the fry per Kg of different strain of channel catfish (Broussard and Stickney, 1981; Dunham *et al*., 1983; Ballenger, 2006). The number of eggs per Kg of fish for all the strains of *C. gariepinus* in this study were higher than the number of eggs per Kg of fish reported in reciprocal pairing of two strains of Channel catfish (Smitherman *et al*., 1984). The differences in egg number per Kg among the three strains in this study may indicate presence of variation that can be utilized in selection for increased production of eggs for improved reproductive output of the *C. gariepinus* in aquaculture in Kenya. However, studies should be undertaken to determine the genetic correlation between reproductive traits and growth in African catfish.

Conclusion

We conclude that the Indonesian strain is suitable for grow out aquaculture in Kenya and is ready for release to the aquaculture industry. Further research is needed to evaluate the growth; survival and reproductive performance of the reciprocal crosses between the different strains of *C. gariepinus* in Kenya to establish a fast growing fish with reduced heterogeneity. The growth performance of the three different strains may be used as a guideline to form a base population for genetic selection to improve performance of *C. gariepinus* in Kenya. If the genetic improvement is targeted at the development of a fast growing fish with reduced heterogeneity then the Indonesian strain is appropriate to be included in the population for selective breeding program. However, the genetic correlation between reproductive traits and growth should be determined.

Acknowledgement

The authors wish to thank Association for Strengthening Agricultural Research in East and Central Africa (ASARECA) for funding this research work through the project "Building Public-Private Sector Partnership to Enhance Productivity and Competitiveness of Aquaculture - Grant No. RC10 LFP-02." Special thanks go to Kenya Marine and Fisheries Research Institute (KMFRI) technicians; Ismael Oketch Otama and Elijah Gichana for technical support during sampling and sample analysis. National Aquaculture Research Development and Training Centre Sagana and Emmick Enterprises are acknowledged for providing working facilities to accomplish this study.

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