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Abstract

This study was conducted to compare the growth performance and survival of three strains of African catfish (*Clarias gariepinus*) cultured in Kenya. Three strains originally from the Netherlands (Dutch), Indonesia, and Kenya, (Lake Victoria) were studied. *C. gariepinus* having an average initial body length of 3.87 cm and weight of 0.51 g were stocked at 6 fish m2 in triplicate in 2.0 m × 2.0 m × 1m hapa nets mounted in an earthen pond. The fish were fed with commercial catfish diet 45% crude protein (Skretting fish feed Ltd). The results showed that the Indonesian strain had the best growth and had significantly ($P < 0.05$) higher final mean body weight (287.20± 16.78g) and mean daily weight gain (1.37± 0.06%). Specific growth rate (SGR) was not significantly different in the Dutch and Indonesian strain ($P > 0.05$). The FCR of the Indonesian strain (1.03 ± 0.00) was significantly ($P <0.05$) lower than the Kenyan and the Dutch strains which had similar FCR. The survival of the three strains was not significantly different ($P> 0.05$). However, the survival of the Dutch strain was higher (65.00±12.58%) compared to the other strains with the Kenyan strain exhibiting the lowest survival of 59.52±9.52%. There were no significant differences ($P > 0.05$) in Coefficient of Variation (CV) in the Dutch and the Indonesian strain, and the highest CV was recorded in the Kenyan strain. The overall conclusion is that growth performance between the three strains of *C. gariepinus* was significantly different and thus, it is crucial to select the right strain for production purposes depending on availability.

Keywords: Growth performance, *Clarias gariepinus*, strains

PERFORMANCE DE CROISSANCE ET SURVIE DE TROIS SOUCHES DE POISSON-CHAT AFRICAIN (*CLARIAS GARIEPINUS*, BURCHELL 1882) ÉLEVÉS DANS DES HAPAS AU KENYA

Résumé

La présente étude a été menée dans le but de comparer la performance de croissance et la survie de trois souches de poisson-chat africain (*Clarias gariepinus*) élevés au Kenya. Trois souches originaires des Pays-Bas (hollandaise), d'Indonésie, et du Kenya (lac Victoria) ont été étudiées. Des poissons *C. gariepinus* d'une longueur corporelle initiale moyenne de 3,87 cm et pesant 0,51 g ont été stockés à une densité de 6 poissons par m2 de poissons en trois répétitions dans des filets hapa de 2,0 m × 2,0 m x 1 m montés dans un étang de terre. Les poissons ont été soumis à une alimentation commerciale pour poisson-chat à 45% de protéines brutes (Skretting fish feed Ltd). Les résultats ont révélé que la souche indonésienne avait la meilleure croissance et un poids corporel moyen final significativement ($P <0,05$) plus élevé (287,20 ± 16,78 g) ainsi qu'un gain pondéral quotidien moyen (1,37 ± 0,06%) supérieur par rapport aux autres souches. Le taux de croissance spécifique (TCS) n'était pas significativement différent entre les souches néerlandaise et indonésienne ($P> 0,05$). L'indice de consommation FCR de la souche indonésienne (1,03

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± 0,00) était significativement (P <0,05) inférieure à celle des souches kenyane et néerlandaise qui avaient un indice de consommation semblable. La survie des trois souches n'était pas significativement différente (P> 0,05). Cependant, la survie de la souche hollandaise était plus élevée (65,00 ± 12,58%) que les autres souches, la souche kenyane ayant enregistré la plus faible survie de 59,52 ± 9,52%. On n'a pas relevé de différences significatives (P> 0,05) au niveau du coefficient de variation (CV) dans les souches néerlandaise et indonésienne, et le CV le plus élevé a été enregistré dans la souche kenyane. La conclusion générale est que la performance de croissance était significativement différente entre les trois souches de *C. gariepinus* et, par conséquent, il est crucial de sélectionner la souche appropriée pour la production en fonction de sa disponibilité.

Mots-clés : performance de croissance, *Clarias gariepinus*, souches

Introduction

The African catfish (*Clarias gariepinus*), is found in several countries throughout its native distributional range as well as in Europe (the Netherlands, Germany, and Belgium), Asia (Indonesia and Thailand) and South America (Brazil) (de Graaf and Janssen, 1996; Brummett, 2008). *C. gariepinus* is the second most important freshwater cultured fish (after tilapia) in Africa (Barasa *et al.,* 2014) with the exception of Nigeria where its production far exceeds tilapia production and accounts for 70 - 80 % of the total freshwater fish production (Ponzoni and Nguyen, 2008). In Kenya, *C. gariepinus* is second most cultured fish species (Ogello and Opiyo, 2011) and it represents over 21% of the total aquaculture production in the country (Otieno, 2011). One of the critical limiting factors in *C. gariepinus* culture has been a serious lack of good quality seed to supply farmers and producers (Macharia *et al.,* 2005). This has been as a result of poor performance of available local broodstock and poor management practices at hatcheries, as well as the non-existence of any appropriate breeding structures or improved strains (Ponzoni and Nguyen, 2008). Development of a genetically improved strain of *C. gariepinus* with higher fillet yield which can adapt to a wide range of production environments in Africa has been made a priority by researchers in Africa (Ponzoni and Nguyen, 2008) since *C. gariepinus* is a popular food fish 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).

There are several strains of *C. gariepinus* in Kenya, drawn from the indigenous strains as well as imported ones. These include Indonesian, Dutch and several local strains including the Lake Victoria and River Ewaso Nyiro strain. The Dutch strain was imported to Kenya because of their improved performance resulting from selective breeding (Fleuren, 2008). 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 mass or individual 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. In Kenya, proper selective breeding programs for genetic improvement of farmed fish began recently with genetic improvement programs targeting fast growth of the African catfish and Nile tilapia being established in 2011 at National Aquaculture Research Development and Training Centre, Sagana (Charo-Karisa *et al.,* 2012). Selection of the best strains is crucial for efficient breeding program not only to reach the production goal but also to reduce production cost, to improve disease resistance, utilization of feed resources and product quality (Gjedrem, 1997; Ibrahim *et al.,* 2013). Currently, there are no research findings on the growth, survival and feed utilization of the different *C. gariepinus* strains in Kenya. The results from this study would guide farmers in Kenya to make decisions on the best strain for farming in local conditions and give basic information for genetic improvement of *C. gariepinus* in Kenya.

Materials and Methods

Origin of stock

Three *C. gariepinus* strains of varying genetic and domestication histories were used: 1) Dutch strain obtained from Fleuren and Nooijen Fish farms Ltd, in Netherlands and was bought from Jambo fish Ltd in Kenya. It has undergone several mass selection and individual selective breeding trials (Fleuren, 2008); 2) Indonesian strain was obtained from Main Center for Freshwater Aquaculture Development in Indonesia, the fish was imported from Taiwan in 1985 (Yusuf, 1995) and has undergone selective breeding for more than 3 generations (Sunarma, 2008); and 3) Kenyan strain was obtained from Lake Victoria in 2010. Both the non-indigenous strains of *C. gariepinus* were imported to Kenya in 2011 from 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 at the centre. To ensure populations were not mixed up; brood-fish from each of the different populations were kept separately in liner ponds and fed on formulated diet of 35% crude protein. For the purpose of this experiment, the fish were reared under the same culture environment at NARDTC Sagana (0°39'S, 37°20'E and 1230 m above mean sea level North East of Nairobi). Healthy and active individuals were chosen for breeding.

Fingerling production

Four pure *C. gariepinus* pairs from each strain were used for mating. The *C. gariepinus* females were harvested two days prior to the expected dates of ovulation by seining the pond. The females were selected to receive gonadotropin hormone injections based on secondary sexual characteristics such as well-rounded, distended abdomen, a reddened or swollen urogenital area, or darkened pigmentation. The male broodfish were harvested one day prior to the estimated ovulation date of the selected female stock. The gravid females from each group were injected with OVAPRIM (sGnRHa) hormone to induce them to ovulate. Ripe eggs were collected into a dry plastic bowl by hand stripping. Milt was obtained through surgical removal of testes according to de Graaf and Janssen, (1996). The eggs were fertilized by mixing with 0.2 ml of diluted milt and adding 5 ml of clean hatchery water. The fertilized eggs were shaken gently for 1 min, rinsed to remove excess milt and mucous materials incubated in aquaria incubator under darkness. The aquaria incubators were covered to provide darkness. When African catfish eggs are incubated in darkness the survival is higher since African catfish larvae are photophobic. Water temperature in the incubators was maintained between 27-29°C using aquaria heaters and the eggs were completely hatched over a period of 18 hours.

Yolk sac fry hatched in the aquaria incubators were reared in nursery tanks in the hatchery. The fish were fed ad libitum four times daily with dried decapsulated cysts of Artemia spp for a period of 5 days. This was followed by a gradual introduction of starter feed (55% protein and 13% lipid) (Skretting Fish Feed Ltd) over a 5-day period. During the 3 days weaning period, larvae were fed ad libitum with decapsulated Artemia cysts and starter feed respectively at alternating intervals. This was followed by use of starter feed only for a period of 1 month until fingerling stage (3.8cm; 0.5g). The fingerlings were then harvested graded for uniformity and individual weight and length measured for a sample of 20 fish from each strain before distribution into the experimental hapas.

Experimental set up and feeding

Each strain of *C. gariepinus* fingerlings were stocked at a stocking density of 6 fish m-2 into three hapa nets each 2.0 m × 2.0 m × 1 m mounted in a 2400m2 earthen pond. The experimental fish were fed on 45% CP commercial catfish diet (Skretting fish feed Ltd) at 5% (should be 10-8%) of their body weight

Table 1: Proximate composition of commercial feed used (Skretting fish feed Ltd)

Parameter (% of dry matter)	Composition
Crude protein (%)	45
Crude fat (%)	14
Total Ash (%)	7
Fibre (%)	3
Calcium (%)	1
Sodium (%)	0.40
Phosphorus (%)	0.90
Lysine (%)	1.50
Methionine (%)	0.50
Copper mg/Kg	5

Table 2: Growth parameters of three *C. gariepinus* strains reared in hapas for 210 days at NARDTC Sagana

Parameter	Dutch	Indonesian	Kenyan
Initial length (cm fish -1)	3. 87±0.09[a]	3.85±0.11[a]	3.88±0.07[a]
Initial weight (g fish -1)	0.51±0.03[a]	0.51±0.04[a]	0.50±0.02[a]
Final length(cm fish -1)	32.93±0.61[a]	33.27±0.70 [ab]	29.19±1.09[b]
Final weight (g fish -1)	265.95±14.29[a]	287.20±16.78[a]	190.81±19.63[b]
SGR (% day -1)	3.03±0.04[a]	3.02±0.05[a]	2.84±0.04[c]
FCR	1.05±0.00[a]	1.03±0.00[b]	1.05±0.020[a]
Weight gain (g)	272.16±11.83[a]	288.38±13.54[a]	204.79±14.22[b]
Daily weight gain (g day -1)	1.30±0.06[a]	1.37±0.06[a]	0.98±0.07[b]
Survival (%)	65.00±12.58[a]	63.16±13.18[a]	59.52±9.52[a]
CV (%)	36.44±0.16[a]	32.54±0.35[a]	49.34±0.55[b]

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

daily at four intervals (0800h, 1100h, 1400h and 1300h). The feeding level was reduced to 3% (7-5%) bodyweight at two intervals (0900h and 1500h) after 1 month. The feeding rate was based on the intensity of the system. Since semi intensive system was used, 5% body weight is recommended. The nutritional composition of the commercial diet (Skretting fish feed Ltd) used in the study is shown in Table 1.

Water quality monitoring

Dissolved oxygen (DO) concentrations, temperature and pH were measured bi-weekly using multi-parameter water quality meter, model H19828 (Hanna Instruments Ltd., Chicago, IL., USA). The hapas were mounted in a 2400m^2 which is large enough for adequate water exchange and the pond did not have any other fish. The DO was above 3mg/L which is within the recommended DO levels for Catfish culture in ponds. Ammonium nitrogen ($NH4^{+-}$ N), nitrate nitrogen (NO3- N) and total alkalinity were measured monthly using standard methods (APHA, 1992).

Fish sampling

Fish growth was monitored monthly by recording individual weight of 20 fish collected randomly from each hapa. 20 fish was used as a sample size. The fish were caught using a scoop net and weighed individually by an electronic balance (readability 0.01g; model KERN 572-33, Germany) and total length using a measuring board to the nearest 0.1cm.

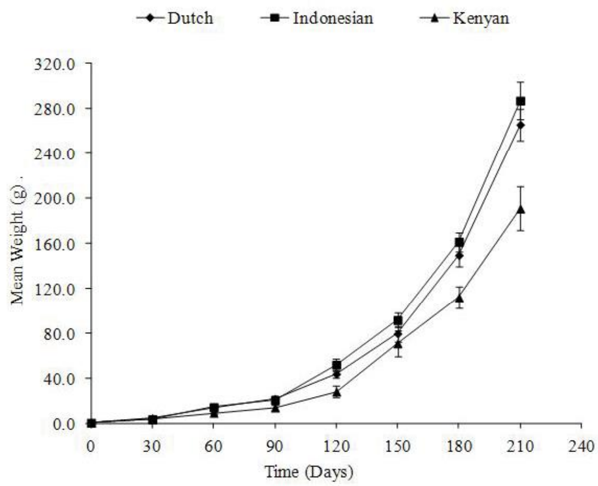

Figure 1: Growth of three different *C. gariepinus* strains reared in hapas

Survival was determined by counting the number of fish remaining in each hapa against the initial stocking number. The performances of the different strains were evaluated based on final weight (g), daily weight gain (g day^{-1}) = 100* (Wt - W0)/t, weight gain (%) = 100* (Wt – W0)/W0, specific growth rate [SGR, % day^{-1} = 100*(lnWt – lnW0 / t], where ln = Natural logarithm, W0 = initial weight (g), Wt = 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).

Data analysis

All the experimental data including final length, final mean weight, weight gain, SGR, FCR, DWG, and survival, were analyzed using analysis of variance (one-way ANOVA) to determine differences among the strains. Differences between means were further tested for significant differences using Post-Hoc Tukey's HSD tests. Significance level was declared at (P < 0.05). SPSS (version 17.0) for windows was used for all statistical analysis.

Results

Growth performance and survival of the fish

Growth performance of different strains of *C. gariepinus* is presented in Table 2 and the growth trends are presented in Figure 1. After 210 days culture period, the final mean weight of Indonesian strain was significantly (P<0.05) higher (287.20±16.78 g) compared to the Dutch strain (265.95± 14.29 g) and Kenyan strain (190.81±19.63g), daily weight gain was significantly highest (P < 0.05) in Indonesian strain (1.37±0.06 g day -1) followed by the Dutch strain (1.30±0.06 g day -1) and no significant difference was recorded in the daily weight gain of the two strains. The specific growth rate of Indonesia and Dutch strains were significantly higher compared to the Kenyan strain and there was no significant difference between the Dutch and Indonesian strain (P>0.05). FCR between strains recorded a significant difference (P<0.05) with Indonesian strain being the lowest (1.03±0.00). The Dutch strain exhibited significantly (P<0.05) higher survival (65.00±12.58%) while the Kenyan strain had the lowest survival of 59.52±9.52%. The coefficient of variation was higher in the Kenya strain compared to the Dutch and the Indonesian strain, while there were no significant differences (P>0.05) recorded in the CV for the Dutch and the Indonesian strain respectively.

Water quality

The ranges of values of the water quality parameters during the experimental period were: pH 7.87 - 7.92; dissolved oxygen 3.78 - 3.91 mg L-1; temperature 23.08 - 23.12 °C; total alkalinity 370.72 - 372.76 mg L-1; Ammonium nitrogen 0.01 - 0.02 mg L-1 and nitrate nitrogen; 0.15 -0.20 mg L-1. All recorded mean values of the water quality parameters were within the acceptable ranges for *C. gariepinus* culture in ponds and were not affected (P > 0.05) by the different *C. gariepinus* strains.

Discussion

The current study indicates that Indonesian strain outperformed the Dutch and the Kenyan strain in growth performance. This finding is in line with Giddelo et al. (2002) who indicated considerable variation in growth in different populations of *C. gariepinus* 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 the strains have been reported to result from either competition favouring a particular strain's inherent capacity to grow (Ibrahim *et al.,* 2013). It could also be associated with competition for space and food because of hapa confinement and feed being given at a central feeding point as described by Charo-Karisa et al. (2006) who observed a similar trend in Nile tilapia reared in hapas. 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 reared in controlled hatchery conditions. Difference in final weight among the different strains in this study seem not to be of a direct consequence on 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 having an advantage when feed is limited (Martins *et al.,* 2005; Charo-Karisa *et al.,* 2006). The survival of the different strains in the present study is in line with the work of Nguenga *et al.* (2000) who observed high survival rate of juvenile *H. longifils* in Layo strain and reciprocal crosses of Layo and Noun strains but lower survival in Noun strain cultured in controlled hatchery conditions. The lower survival in the Kenyan strain could be as a result of cannibalism due to heterogeneity in sizes evidenced by the high value of the coefficient of variation (CV) which indicates that the prey was smaller than the cannibal (Hecht and Appelbaum, 1988; Baras and Almeida, 2001).

The differences in growth performance of the fish could also be related to 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 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 2-3 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 upgrading 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 have 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 (Smitherman and Dunham, 1985; Dunham *et al.,* 1987). Hence, the fish from Indonesia could be having a higher tolerance level of the culture environment in which the study was conducted 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 duration each of the strains in this study have been domesticated, the Kenyan strain, captured from the wild in 2010 and reared in earthen ponds hence could be considered 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 (Yusuf, 1995; 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 relatively low growth of the Kenyan strain was similar to the low growth recorded for Noun strain of *H. longifilis* which was captured from the wild and reared in a pond environment before use, compared to the Layo strains which had been used for years under captivity (Nguenga *et al.,* 2000).

The coefficient of variation (CV) of harvest weight can be interpreted as indicating the intensity of the competition among the fish in each tank. Several authors have identified increases in CV as an indication of inter-individual competition and dominance hierarchy in fish (McCarthy *et al.,* 1992; Jobling, 1995; Adams *et al.,* 2000). In the present study, the lowest CV was realized in the Indonesia strain and was an indication of homogeneity in sizes of the Indonesian strain. Selective breeding often lead to homogeneity in sizes by eliminating shooters which lead to high disparity in growth within a population as they grow bigger than other fish in the same cohort (Baras and Jobling, 2002). Size homogeneity is a very important aspect in *C. gariepinus* culture to reduce incidences of cannibalism in the catfish larvae which requires the prey to be slightly smaller than the cannibal (Hecht and Appelbaum, 1988; Baras and Almeida, 2001). Cannibalism is normally reduced in *C. gariepinus* with lower size heterogeneity and lower variability of growth rates (Baras and Almeida, 2001). On the other hand, a low CV is suggestive of less competition and of a good social environment within a population as exhibited by the Indonesian strain.

Conclusion

In conclusion, the Indonesian strain is suitable for grow-out aquaculture in Kenya. 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 for improved aquaculture performance in the country. The growth performance of the three different strains may be used as a guideline to form a synthetic 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. At the same time, measures have to be taken to ensure the long-term viability of the strain.

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