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Growth performance evaluation of four wild strains and one current farmed strain of Nile tilapia in Uganda

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Abstract
Due to poor performance of Nile tilapia seed from hatcheries around the country, a selective breeding programme for the species for fast growth based on the native wild stocks was developed. Wild strains from lakes – Albert, Edward, Kyoga and Victoria were bred and pure lines were raised on-station. These pure lines together with one currently farmed strain were then tested for growth rate performance on-station. The parameters considered during this study were weight gain, Feed Conversion Ratio, average daily weight gain and specific growth rate. The test animals were raised in happas of 2x2x2m, placed in earthen pond that was fertilized with chicken manure. The animals were given supplementary feeding at rates of 10%, 8% and 5% body weight for months 1, 2, 3-4 respectively. Biometric measurements of total length and total weight for all stocked fish were taken at the beginning and end of the study with monthly sampling of 20 fish per month. Growth performance of the different strains was Albert – 1.12g/day, Edward – 1.40g/day, Kyoga – 0.89g/day, Victoria – 2.30g/day and Farmed strain – 0.52g/day. The findings showed significant differences between growth performance of the different wild strains and the currently farmed strain. The currently farmed strain dismal performance was most probably due to in breeding. The implications are that there may be genetic variation within the different native wild strains that can be exploited through selective breeding to improve growth performance of farmed tilapia in the country.

Keywords: Nile tilapia, strains, growth performance, Uganda

Introduction
Tilapia have become one of the most abundantly produced fish in aquaculture. They are produced in over 80 countries [1, 2]. The world production was more than 800,000 MT in 1996 [3]. Of the tilapias, *Oreochromis niloticus* is the principal species being produced. Its native range in Uganda includes lakes Albert, Edward and George and the Albert Nile river [4]. Its introduced range includes the Lake victoria region (LVR) waters – lakes Kyoga and Victoria and some of their associated satellite lakes and the Victoria Nile river [5].
Nile tilapia (*Oreochromis niloticus)* is one of the most sought after fish species for culture in Uganda [6] because of its unique qualities [2]. None the less, there have been persistent complaints about the poor returns from tilapia aquaculture in the country, suspected to be mainly caused by poor seed quality, poor broodstock management and bad farming practises [7]. Currently, the Nile tilapia fish seed that is being used is thought to have been founded on a small population base [6]. In addition, the parental stock has been used for long times a factor thought to have led to inbreeding for many generations [8]. The practice is that small hatchery operators do not get their broodstock from the wild but mostly other farmers leading to more inbreeding which has greatly lowered the genetic integrity of the fish leading to poorly performing farmed strains and consequently poor returns from the cultured tilapia. On evaluation of four strains collected from the wild and four strains with a longer history of domestication in Philippine [9], it was found that the three best performing strains were the recently collected ones. The wide native range of *O. niloticus* in Uganda permits the opportunity for genetic diversity within the species consequently allowing for designing experiements to improve and sustain the performance of cultured tilapia through a logical breeding and genetic improvement program. In this study the wild stocks were acclamatised on-station for a period of three months and bred to provide the foundation stocks for use in the genetic improvement programme.

The bred pure lines of each of the identified wild strains of Nile tilapia from lakes – Albert, Edward/George, Kyoga and Victoria systems plus one currently farmed strain of ARDC-Kajjansi were evaluated for on-station growth characteristics/performance. The best performing individuals of each strain were then selected to be used in the next generation of selective breeding with ultimate aim of producing faster growing strains of *O. niloticus* that can increase tilapia production in the country and in the region. The findings of the study will be used in guiding and improving the proposed selective breeding programme of Nile tilapia in Uganda.

Study Area

Nile tilapia in Uganda is native to lakes Albert, Eward and George, it was introduced into lakes Kyoga and Victoria in early 1950s [10]. Lakes Albert, Edward and George are found in the western rift valley, whereas Victoria and Kyoga in south east and central parts of the country (Figure1). The research station – ARDC-Kajjansi is located just north of Lake Victoria – (N00.222083 E32.53469166), 16km from the capital city Kampala and 1km off Entebbe Road.

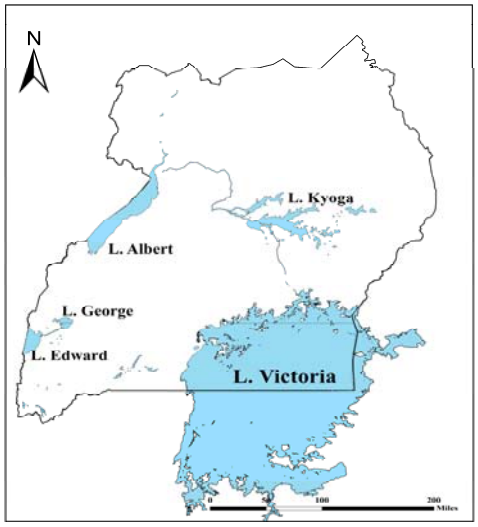

Fig 1: Map of Uganda showing the country's major lakes

Materials and Methods

This study was conducted at the Aquaculture Research and Development Centre, Kajjansi in Uganda in 2014-15. Nile tilapia parental stock were collected from the four major lake systems in the country - Albert, Edward/George, Kyoga, Victoria (Figure 1) and acclamatised on-station for three months before their breeding. Earlier morphometrics analysis had shown that the Nile tilapia of Uganda clustered into four different clades according to the source or lake from which they were caught. After acclamatisation the four strains were bred to produce four pure lines of the respective strains. The different strains were then subjected to growth performace evaluation experiments. The experimental activity lasted for 132 days.

Research Design

Four strains of Nile tilapia from the major water bodies in Uganda (Albert, Edward/George, Kyoga, Victoria) and one currently farmed were evaluated to determine their culture characteristics for use in the species mass selective breeding. The evaluation consisted of 02 phases namely: fingerlings and juveniles-adults.

Phase 1: 100 fry (0.5-1.0g) of each strain were stocked into 1x1x1 happas and nursed to 5g, this lasted a period of just over one month or 42 days. Ponds were fertilized with bi-weekly applications of chicken droppings manure (100kg [dry wt]/ha/month). The fry were also given supplementary feeds (30% CP) at rate of 15% of body weight. Growth and survival were determined at the end of that period. Growth and survival were determined for each happa at the end of the production period.

Phase 2: The small fingerlings (5.0g) were then transfered and stocked into 2x2x1 hapas and reared for three months or 90 days. Ponds were fertilized with bi-weekly applications of chicken droppings manure (100kg [dry wt]/ha/month). The fish were also given supplementary feeds (30% CP) at rate of 10%, 8% and 5% for months 1,2, & 3 respectively of body weight. Growth and survival were determined at the end of the study period. The experiments were managed as per the protocol similar to that used for the GIFT tilapia programme of the Worldfish [11]. All happas were sampled every two weeks to determine average weight and average size of each strain. This phase was conducted for 3 months after which all happas were harvested and growth and survival determined.

In both Phases 1 and 2 the following pond water quality monitoring program were conducted: water temperature, dissolved oxygen and pH were taken weekly in the morning and afternoon at 5, 25, 50, and 75 cm depth. Chlorophyll *a* (taken using a standardised colour water colour and quality chart) and total ammonia nitrogen were measured every two weeks.

Growth performance parameters

The following parameters were used to evaluate tilapia growth performance: Weight gain (W)=Final Weight (Wt)–Initial Weight (W_0) (g); Individual Weight Gain (IWG) (g/ex)=(Final Weight (Wt)–Initial Weight (Wo))/Total Fish; Food Conversion Ratio (FCR)=Total feed (F)/Total Weight Gain (W) (g/g) [12]; Specific Growth Rate (SGR)=100 × ln(Wt–Wo)/t (%BW/day) [13]; Protein Efficiency Ratio (PER)=Total Weight Gain (W)/Amount of protein fed (g).

Data analysis

Null hypothesis: There are no differences in the strains in regard to growth performance, feeds utilisation and survival during growout production.

Statistical data was analyzed using the t-test (p=0.05) and ANOVA to determine if there are differences among strains in the above characteristics. The coefficient of valuation (CV) was calculated as the ratio of the standard deviation to the mean to give the measure of dispersion.

Results

Growth performance evaluation of farmed and pure strains of wild Nile tile tilapia on-station

The findings showed that the different strains performed different, that is, their growth rates were different with Victoria strain having the best growth rate, followed by Edward, Albert, Kyoga and Kajjansi in that order (Table 1). The average daily weight gain and specific growth rates also followed the same order (Table 2). This implies that Lake Victoria strain had the best growth rate followed by lakes Edward, Albert and Kyoga strains in that order, with the currently farmed Kajjansi strain having the least growth rate.

Table 1: Growth performance parameters of strains of Nile tilapia (*Orechromis niloticus*) - ABT – L. Albert strain, ED – L. Edward strain, KY – L. Kyoga strain, VC – L. Victoria strain and STK – currently farmed ARDC-Kajjansi strain

Parameter	ABT	ED	KY	VC	STK
Average initial wt (g/fish)	2.86	5.63	1.2	19.25	1.21
Average final wt (g/fish)	150.65	190.26	110.55	320.55	70.38
Weight gain (g/fish)	147.79	184.63	109.35	303.10	69.17
Number days	132	132	132	132	132
Growth rate (g/day)	1.12	1.40	0.89	2.30	0.52

*Expected well managed growth rate: 1.5-2.0 grams/day
*Fish were fed at rates of 10%, 8% and 5% at month 1, month2, and month 3-4 respectively

For the FCR the currently farmed strain was best performer, followed by Victoria, Kyoga, Edward and Albert in that order, whereas, for the protein efficiency ratio (PER), still the currently farmed strain performed best, followed by the Victoria strain, Kyoga strain, Albert strain, with the Edward strain performing worst (Table 2).

Table 2: Technical indicators of growth performance of the Nile tilapia strains at end of the study period

Indicator	ABT	ED	KY	VC	STK
Initial numbers	100	100	100	100	100
Final numbers	100	97	100	98	89
Survival (%)	100	97	100	100	89
Initial biomass (g)	286	563	120	1925	121
Final biomass (g)	14779.00	18455.22	10935.00	31413.90	6263.82
Biomass gain (g)	14493.00	17892.22	10815.00	29488.90	6142.82
Mean initial individual weight (g)	2.86	5.63	1.2	19.25	1.21
Mean final individual weight (g)	150.65	190.26	110.55	320.55	70.38
Average Daily Gain – ADG (g/day)	1.12	1.40	0.89	2.30	0.52
Specific growth rate - SGR (%/day)	3.785	3.953	3.557	4.324	3.210
Feed conversion ratio - FCR (g/g)	1.89	2.01	1.78	1.75	1.62
Protein efficiency ratio (PER)	1.512	2.587	2.587	2.768	2.857

The results of calculations of ANOVA (Table 3) indicated that that the weighted means for the different parameters of the five strains where significantly (p<0.05) different from each other (Table4).

Calculation of the Analysis of Variance (ANOVA)

Table 3: Summary Table showing how the One-way ANOVA was calculated

Source	Sum of squares	Degrees of Freedom	Variance Estimate (mean Square)	*F* Ratio
Between	SS_B	K - 1	$MS_B = SS_B/K$ - 1	MS_B/MS_W
Within	SS_W	N - K	$MS_W = SS_W/N$ - K	
Total	$SS_T=SS_B + SS_W$	N - 1		

Where K is the number of strains (Groups) = 5, N the total of means of samples = 40, SS = sum of squares, SS_B = SS between, SS_W = SS within, SS_T = SS total.

Table 4: Analysis of Variance of body weight gain indicator of growth performance of different strains of Nile tilapia

Source	Sum of squares	Degrees of Freedom	Variance Estimate (mean quare)	*F* Ratio	F_{CV}
Between	186061.79	4	46515.45	9.20*	2.64
Within	177027.93	35	5057.94		
Total	363089.72	39			

* p<0.05

Water quality parameters

The averages of water quality parameters taken over the the study period were as follows; temperature – 25.5 ^oC; dissolved oxygen – 4.25mg/l; pH – range of 7.6 – 8.5; ammonia – ranged between 0.0 to 0.25 mg/l; and chlorophyll *a* – from the water colour and quality chart was between 2a and 3a – implying that for the dissolved plant material had no problem on water quality. All waater quality parameters were found suitable and within acceptable ranges for grow-out of Nile tilapia [14].

Discussion

The findings showed that the best performing strain in terms of growth performance was the Lake Victoria followed by strains from lakes Edward, Albert and Kyoga in that order with the currently farmed strain of Aquaculture Research and Development Centre (ARDC) - Kajjansi coming last and performing dismally compared to the others (Table 1). Whereas the best performing based on the FCR was the currently farmed strain, followed by the strains from lakes Victoria, Kyoga, Albert and Edward in that order (Table 2). The good performance of the Kajjansi strain in food conversion ratio is most probably attributed to the fact that it was well acclamatised to the station, feeding in captivity and on dry rations for many generations for over five years as compared to the F1 generations of the wild srains from the lakes whose parents had been acclamatised on the station for only three months.

But considering both aspects or parameters of growth performance, FCR and rate of growth, together the findings indicate that the best performing strain was that of Lake Victoria followed by strains from lakes Kyoga, Albert and

Edward with the Kajjansi strain coming in last. The ANOVA results confirmed that there was a significant difference between the growth performance of the different strains studied. The poor performance of the currently farmed strain may be attributed to inbreeding caused by use of the same broodstock for long time [15] and poor broddstock management by hatcheries operators and farmers [16].

The good performance of the Lake Victoria strain may be attributed to both genetical and environmental factors. The lake has many rivers bringing fish into the lake from different parts of the catchment and with the Nile tilapia having been moved around East Africa [17] the fish finds itself into Lake Victoria, which allows for genetic exchange between the different stocks of the species leading to higher genetic diversity. For the environmental factors, Lake Victoria just like Lake Edward are very productive lakes almost threatened with eutrofication, so the the fishes like the tilapias next to the primary trophic level do not have to invest alot of energy in hunting for food. This may most probably be the reason why strains from the two lakes performed best in growth rate compared to the others based on the fact that the study pond was always well fertilised and with ample greening.

Trials in Phillipnes for the growth performance of the Genetically Improved Tilpia Fish (GIFT) after just five generations yielded rates ranging from 1.390 g/day to 3.009 g/day after rearing in ponds for 100 days [18]. These values as compared to the Ugandan F1 generations of the wild strains from the Ugandan major lakes – Albert, Edward, Kyoga and Victoria that ranged from 0.89 g/day to 2.30 g/day, which are not far apart, indicate that the native Nile tilapia strains are good potential candidates for use in selective breeding of the species and in a few generations they should result into very good performing product/strain of the species. For the FCR performance parameter tested in diffrent pond environments, gave values of 1.06 to 0.8 [19, 9] quite different as compared to what obtained with the wild strains of Nile tilapia in Uganda that ranged from 2.01 to 1.75. This is explained by the fact that the wild strains had only been acclamatised to the station and feeding on dry rations in captivity for only three months as compared to the improved strains above that had been in their respective stations for some time.

The high potein efficency ratio for the currently farmed ARDC– Kajjansi strain is most probably attributed to the fact that the strain has been in captivity for many generations making it well acclamatised to feeding in captivity and good utilisation of proteins in the fish feeds [20]. The difference in the protein efficiency ratio among the wild strains is probably attributed to the differences in enviroment of the sources of these strains. The fact that Lake Victoria and the research station are in the same locality/environment thus the close values. Lake Kyoga is located nearest to Lake Victoria share same flora and fauna whereas the rift lakes Albert and Edward have different environments.

Generally with more acclamatisation of the native species on-station, crossing between the different identified strains whilst selecting for fast growth and lower FCR, we expect to greatly improve the performance of resultant progeny. Use of genetically improved Nile tilapia strains with fast growth and low FCR will be of high economic benefit to fish farmers. These improved strains when distrubted to seed multipliers and farmers will greatly improve fish production and productivity and consequemntly have a positive impact on the livelihoods of the farmers.

Conclusion

The currently farmed strain of Nile tilapia in most parts of the country and region that obtained their seed from the station before the genetic improvement programme commenced is very poor with limited returns on investment. The country is endowed with ample native wild Nile tilapia genetic resources that should be exploited to replenish the declining farmed Nile tilapia resource.

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