

SURVIVAL AND LENGTH WEIGHT RELATIONSHIP OF A FASTER-GROWING *Clarias gariepinus* HYBRID FRY STOCKED IN A WETLAND IN BUEA, CAMEROON

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Abstract

*Fish stocking or restocking in natural water bodies, whereby production is generally extensive, can be an option in the attempt to compensate the dearth in fish production related to stock depletion in capture fisheries and high feed costs in aquaculture. While a major objective in fish production in aquaculture is the procurement of fast-growing strains through hybridization, survival rate is a major metric to evaluate the effectiveness of fish stocking programs. Consequently, 600 hatchery-bred *Clarias gariepinus* hybrid fry of mean total length 1.46 ± 0.16 cm and mean weight 0.097 ± 0.011 g were stocked in a wetland for 180 days, without supplementary feeding and protection from predators. Mean length gain was 49.85 ± 13.27 cm, mean weight gain $1,334.79 \pm 1088.268$ g with males recording higher mean final weight than females ($P < 0.05$), and growth hypoallometric. Survival rate was 7.17%, with the females outnumbering the males ($P < 0.05$). This effort showed a relatively significant growth and recovery rate of stocked *C. gariepinus* seed, indicating that there is a potential for an even higher growth and survival if the habitat is manipulated to preclude predation and if both stocking and harvesting are timed aptly.*

Keywords: *Fish stocking, Extensive production, Hybridization, Survival, Wetland*

Introduction

Generally, fisheries and aquaculture constitute the main sources of food fish for humans, supporting the livelihoods of about 120 million people, of whom 97% live in the developing world (FAO, 2024). However, in the face of a growing world population, production from capture fisheries has generally stagnated, since the late 1980s (FAO, 2024). Also, although aquaculture production can fill gaps created by the decline in capture fisheries in nourishing the world's populations

(Blasco *et al.*, 2020), and although global aquaculture has been expanding since the 1990s, growth in aquaculture production was not experienced in several African countries recently (FAO, 2022). This can be attributed in part to the high cost of aquafeeds, which constitutes over 50% of total production costs in high-tech aquaculture (Hughes *et al.*, 2025).

Fish stocking or restocking, implicating several finfish and crustacean species, has been employed for diverse purposes (Brown and Day, 2002; Rasowo

and Auma, 2006; New South Wales Department of Primary Industry, 2007, 2024; Hutchison *et al.*, 2012; Oben *et al.*, 2020; Michigan Department of Natural Resources, 2021; Victorian Fisheries Authority, 2021; Wang *et al.*, 2021; Washington Department of Fish and Wildlife, 2021; Utah Division of Wildlife Resources, 2024), including food fish production (FAO, 2022). Fish stocking or restocking in natural water bodies, where production is generally extensive (FAO, 2022), can contribute to fish production in aquaculture (Hu *et al.*, 2019).

Wetlands are among the most productive ecosystems in the world (US Environmental Protection Agency, 2025). Therefore, fish stocking in wetlands (Minnesota Department of Natural Resources, 2006; Chandra *et al.*, 2013) could contribute concomitantly in reducing production costs and in boosting fish production in developing nations. Through careful manipulation of factors such as fish population density and structure, fish stocking in suitable wetlands can substantially increase fish production when compared with culture in other production systems (Brummett, 2006; Oben *et al.*, 2020). This can be attributed to the potential to exploit their nutrient dynamics to circumvent or lessen the high costs of feeding involved in other aquaculture production systems (Oben *et al.*, 2020).

A major factor in evaluating the effectiveness of fish stocking programs is the survival rate (Hu *et al.*, 2019). Additionally, a major objective in fish production through aquaculture is the procurement of fast-growing species and strains, which are usually obtained through the process of hybridization (Ataguba and Angela, 2024). Consequently, since hatchery-reared fish

manifest lower fitness in natural environments compared to their feral counterparts (Araki *et al.*, 2008), the present study investigated the survival of a faster-growing *Clarias gariepinus* hybrid stocked in a wetland. This would provide insight on the potential of extensive fish culture in appropriate water bodies, which could be helpful for resource-poor communities.

Study Areas

The study sites are located in Buea and Limbe, towns in Fako Division of the South West Region of Cameroon (Figure 1). The broodstock of the strains of *C. gariepinus* used in this study were held in 3.6m³ capacity outdoor rectangular concrete tanks at the Fish, Animal Production and Agrofarms (FAPA) Hatchery complex in Buea. Hypophysation and indoor larviculture were carried out at the OKF Aquafish Center, a private-owned fish hatchery in Limbe. Fry were stocked in a wetland on the West and Central African Council for Agricultural Research and Development (CORAF) adaptive research integrated fish farm on the campus of the University of Buea (UB).

The wetland on the UB-CORAF Farm

The farm is located at 04°08' 44.65" N and 09° 17' 07.85" E, with an elevation of 557 m above sea level. The lower part of the farm consists of a roughly 3-hectare natural depression which, during the rainy season, is fed by precipitation, ground water and surface runoff. This results in an ephemeral lake, which is not connected to any upstream water body. There is a downstream outlet for discharge, screened with galvanized metal gauze and mosquito netting to prevent the escape of stocked fish into the wild and the migration of alien fish into the lake. Within the lake are four earthen ponds, which served as

refuge for stocked fish. Average pond length, width and depth were 22.5 m, 16.25 m, and 1.5 – 2.0 m respectively. The ponds were unprotected from predators during the present study. The lake or wetland (Ramsar Convention on Wetlands, 2018) is partially or completely flooded from July to November and sometimes from August to January; during

this study the water level reached 80 cm along the lower reaches. During the rainy season, this wetland abounds with aquatic fauna (e.g., toads, frogs, tadpoles, reptiles, earthworms, insects, and waterfowls) and flora (including emergent, submergent and floating macrophytes). The wetland is completely dry during the rest of the year.

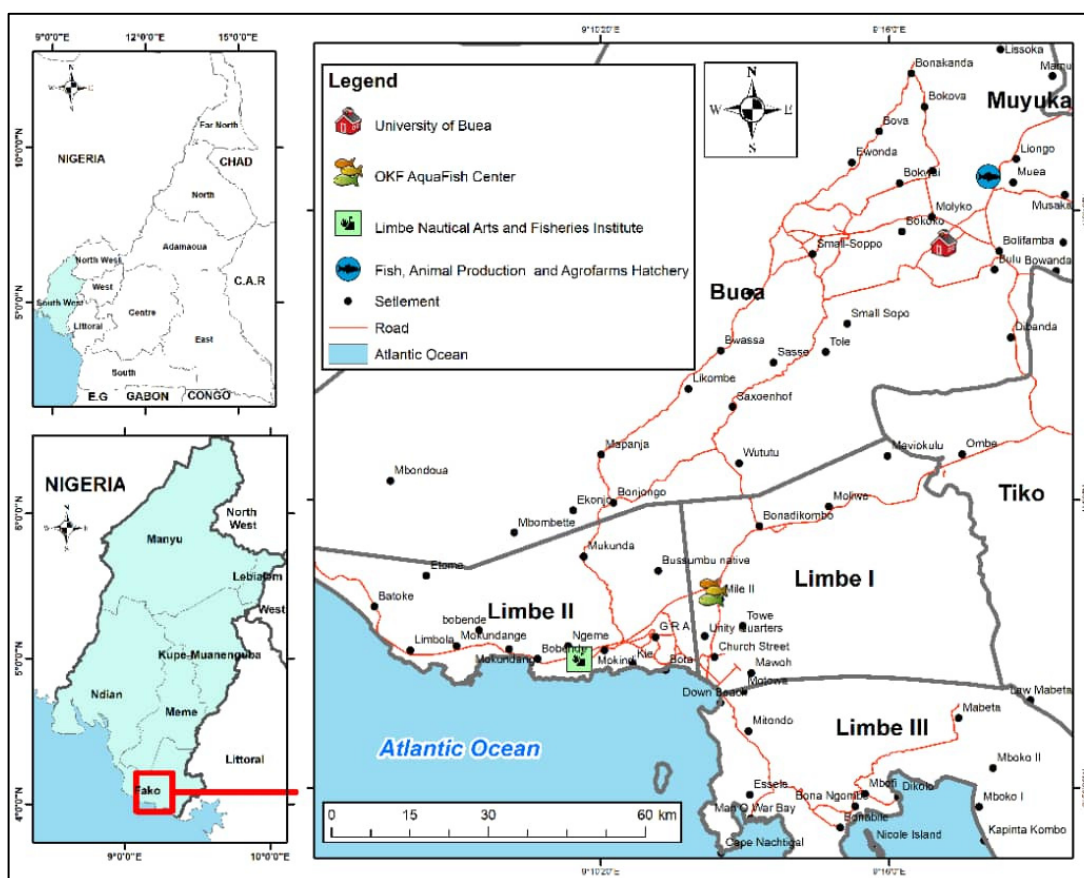


Fig. 1: Sites for broodstock holding, hypophysation, larviculture and stocking

Methodology

Biological Materials

Two strains of *Clarias gariepinus* were used as broodstock for the hybridization phase. The first, an exotic stock (Exotic), has been widely implicated in Cameroon's domestic aquaculture (Nguenga et al., 2008). The other (Mezam), from a native population of

River Mezam in the North West Region of Cameroon, had been characterized by Nkongho et al. (2019) as a distinct strain.

Hybridization of Exotic and Mezam strains of *Clarias gariepinus*

A diallel cross between the Exotic and Mezam strains of *C. gariepinus* was carried out to obtain two reciprocals. Each cross constituted a treatment, as follows:

Treatment 1: Mezam♀ x Exotic♂

Treatment 2: Exotic♀ x Mezam♂

For each strain, milt was collected from two individuals and pooled, and eggs collected from two individuals and pooled (Brzuska, 2003). The fertilized eggs of each treatment were incubated in a 1000 L capacity recirculating aquaculture system (RAS) unit at 28°C until hatching.

Fry Management in RAS Tanks

The hatchlings were allowed to feed from their yolk sac for the first three days. From the 4th to the 7th day, they were fed ad libitum with decapsulated Artemia (protein 54%, lipid 9%, ash 4%, fibre 6%, moisture ≤5%) (INVE AQUACULTURE®, USA). Feeding transitioned to the commercial extruded

feed Le Gouessant® (58% crude protein, 12% lipid, 0.2% crude fibre, 8.76% ash, 1.58% calcium, 1.27% phosphorus, 0.82% sodium) from Day 8 to Day 21.

Determination of Hybrid to Stock in Wetland

The selection of the hybrid to stock in the wetland was based on their growth rate, indicated by the values of the regression coefficients (slopes) of the length-weight plot of the fry in RAS culture at Weeks 1, 2 and 3 of growth. Hence, by Week 3, the Exotic♀ x Mezam♂ hybrid (slope 1.9786) was selected for stocking, instead of Mezam♀ x Exotic♂ (slope 1.3067) (P=0.001) (Figure 2).

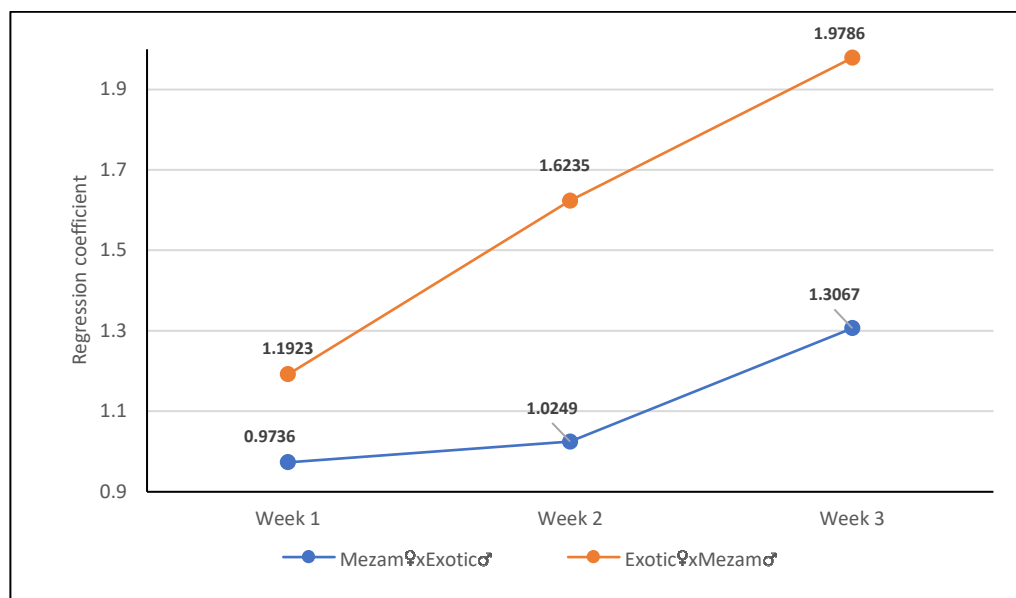


Fig. 2: Values of the regression coefficients of the length-weight plots of the *C. gariepinus* Mezam♀ x Exotic♂ and Exotic♀ x Mezam♂ hybrids at Weeks 1-3 in RAS culture (P<0.05).

Field Preparation and Fish Stocking

The downstream outlet of the wetland was screened with galvanised metal gauze and mosquito netting to prevent the escape of stocked fish into the wild. On Day 21 post-hatch 600 Exotic♀ x Mezam♂ fry of

mean total length 1.46±0.16 cm and mean weight 0.097±0.011 g were transported in an 80-litre plastic container with aerated water to the University of Buea campus. They were stocked in the wetland and

allowed to scavenge, without supplementary feeding, for 180 days.

Monitoring of Physicochemical Parameters of Water Quality

Water temperature, dissolved oxygen, pH and total dissolved solids were monitored in the indoor RAS tanks and in the wetland, while ammonia content was monitored only in the RAS tanks. Thrice daily at 08:00, 13:00 and 18:00, water temperature and total dissolved solids were measured using the electronic meter TDS-3 TDS/TEMP; pH using the Newdy digital pH Meter Tester (X001FYDQ1B); and dissolved oxygen using the Lutron® DO-5509 probe. Ammonia-N content was measured using the H96715-01 Hanna Instruments® Medium Range Kit.

Harvest and Sampling of Fish

At the end of the rearing period, the refuge ponds still contained some water, while the surrounding field was completely dry. The water in the refuge ponds was pumped out by a motorised pump and the fish harvested by seining and scoop nets. The harvested fish were counted and the sex, weight (g) and total length (cm) of each individual determined for computation of survival rate, growth indices and length-weight relationship (LWR).

Survival rate was determined by the

$$\text{equation: Survival rate} = \frac{\text{Final number of fish}}{\text{Initial number of fish}} \times 100 \quad (1)$$

Fish weight gain was measured by taking the absolute increase in weight from stocking to harvest (Sundström *et al.*, 2013).

Condition (K) factor was estimated by the following equation: $K = 100 \times W \times L^{-3}$ (2)

where W is the fish body weight (g) and L the total length (cm).

The length-weight relationship was given by the equation: $W = aL^b$ (Le Cren, 1951) (3)

which was linearized by application of natural logarithm to base “e”, to obtain the equation:

$$\ln(W) = \ln(a) + b \cdot \ln(L) \quad (4)$$

where W and L are variables as defined in Equation 2, $\ln(a)$ the intercept and “b” the regression coefficient of the length-weight regression. The length and weight data were log-transformed in order to increase the linearity between the two indices, and then scatter-plotted to obtain length-weight graphs, whose validity was verified by means of residual plots.

Data Analysis

The independent samples t-test was used to compare the regression coefficients of the reciprocal hybrids in RAS culture and means of the data of male and female adult fish harvested from the wetland, with confidence level set at 95%.

Results

Physicochemical Parameters of Water Quality and LWR of Fish in RAS Tanks

Physicochemical parameters of water quality and the length-weight plots of the fish in the RAS culture at Day 21 post-hatch are shown in Table 1 and Figure 3, respectively.

Physicochemical Parameters of Water Quality and Growth, Survival and LWR of Exotic♀ x Mezam♂ Hybrid in the Wetland

Physicochemical parameters of water quality in the wetland are presented in Table 2, indices of growth and survival of the hybrid stocked in the wetland in Table 3, and the length-weight regression of the harvested adults in Figure 4.

Table 1: Physicochemical parameters of water quality in RAS tanks

Parameter	Statistic	Mezam♀xExotic♂	Exotic♀xMezam♂	T-test	Recommended range
Water temperature (°C)	Mean±SD	25.95±0.73	25.52±0.60	P>0.05	20-30 (Viveen <i>et al.</i> , 1985)
	Range	23.80-27.50	23.90-26.50		
Dissolved oxygen (mg/l)	Mean±SD	7.83±0.35	8.18±0.30	P>0.05	5-8 (Bhatnagar and Devi, 2013)
	Range	7.31-8.35	7.73-8.51		
pH	Mean±SD	8.29±0.45	8.24±0.52	P>0.05	6.5-9.0 (Wurts and Durborow, 1992)
	Range	7.61-8.75	7.44-8.75		
Total dissolved solids (mg/l)	Mean±SD	114±1	113±1	P>0.05	≤500 (Boyd and Tucker, 1998)
	Range	112-115	111-114		
Ammonia (mg/l)	Mean	0.00	0.00	P>0.05	≤0.05 (Viveen <i>et al.</i> , 1985)

SD = Standard deviation

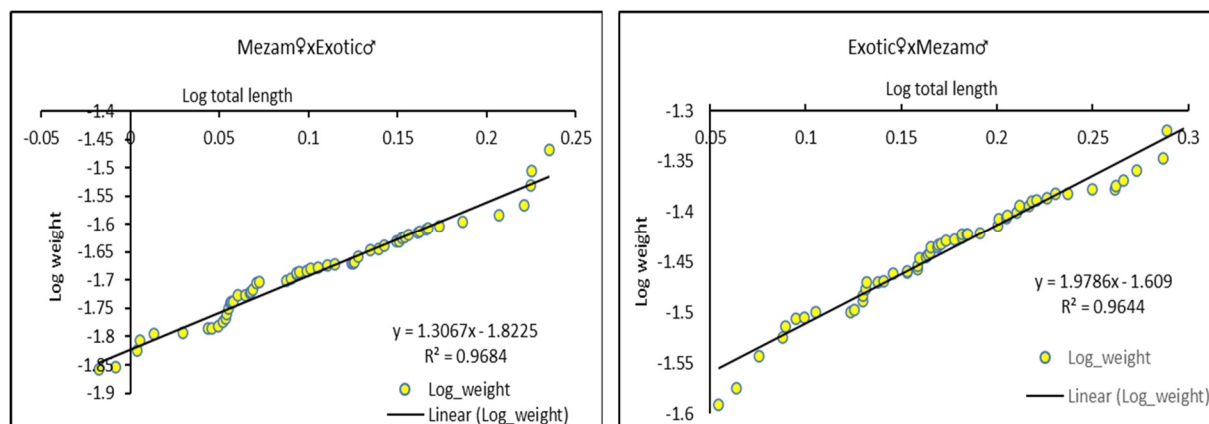


Fig. 3. Length-weight relationships of the Mezam♀ x Exotic♂ and Exotic♀ x Mezam♂ fry of *Clarias gariepinus* at Day 21 post-hatch in RAS culture.

Table 2: Physicochemical parameters of water quality in the wetland

Water quality parameter	Mean ±SD	Range	Recommended range
Water temperature (°C)	24.22±1.40	21.0-30.0	20-30 (Viveen <i>et al.</i> , 1985)
Dissolved oxygen (mg/l)	4.04±1.88	1.05-9.60	5-8 (Bhatnagar and Devi, 2013)
pH	6.25±0.70	5.48-8.23	6.5-9.0 (Wurts and Durborow, 1992)
Total dissolved solids (mg/l)	52.04±10.23	35.50-72.00	≤500 (Boyd and Tucker, 1998)

SD = Standard deviation

Table 3: Survival rate and growth variables of the *Clarias gariepinus* Exotic♀xMezam♂ adults harvested from the wetland at 180 days post-stocking.

Parameter	Females	Males	*T-test	Whole batch
Number of fry stocked	NA	NA	NA	600
Number of adults recovered	26	17	P<0.05	43
Survival rate (%)	NA	NA	NA	7.17
% in recovered batch	60.47	39.53	P<0.05	100
Initial mean total length (cm)	NA	NA	NA	1.46±0.16
Final mean total length (cm)	46.13±04	59.23±14.34	P<0.05	51.31±15.42
Mean length gain (cm)	NA	NA	NA	49.85
Initial mean weight (g)	NA	NA	NA	0.097
Final mean weight (g)	1061.54±975.43	1752.94±1146.80	P<0.05	1334.88±1088.28
Mean weight gain (g)	NA	NA	NA	1,334.79
Average daily growth (g/day)	NA	NA	NA	7.4155
Specific growth rate (%)	NA	NA	NA	5.04
Final Condition factor (K)	0.87±0.10	0.73±0.12	P<0.05	0.81±0.12

NA = Not applicable

*There is significant difference at P<0.05

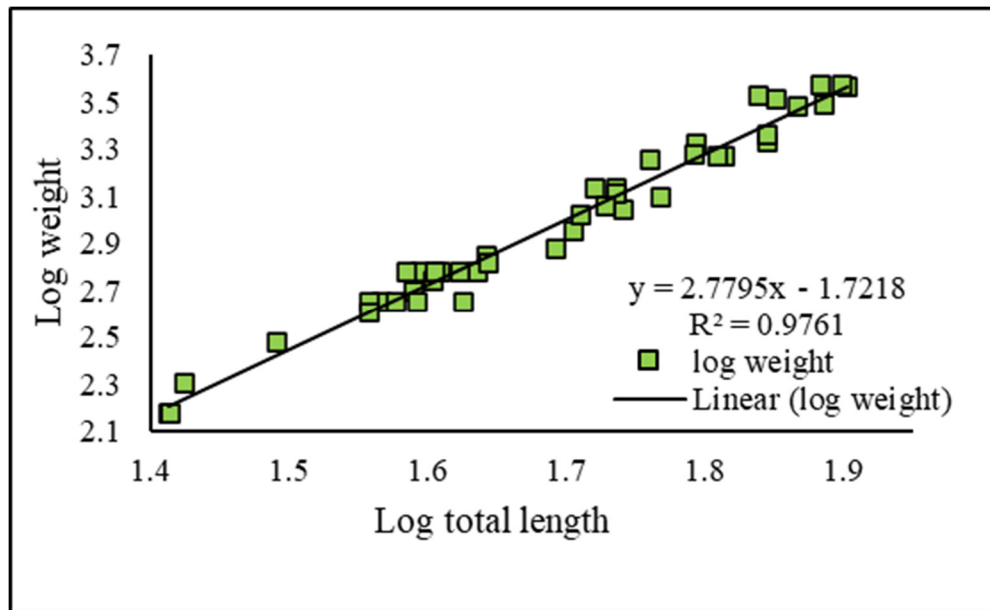


Fig. 4: Length-weight relationship of adult Exotic♀ x Mezam♂ *Clarias gariepinus* harvested from the UB-CORAF wetland 180 days post-stocking

Discussion

Physicochemical Parameters of Water Quality in RAS Tanks

The health and subsequent growth of fish are directly related to the quality of

the water in which the fish are raised (Bhatnagar and Devi, 2013). In both RAS tanks, mean values for water temperature, pH, total dissolved solids (TDS) and ammonia were within recommended

ranges for tropical catfish culture. Although observed diurnal water temperature was sometimes as low as 23.8°C, the growth of the fry based on temperature may nevertheless be considered acceptable, as corroborated by Oben et al. (2015) and Nkongho *et al.* (2021), who successfully bred 1-month old clariid fry and 3-day old clariid larvae at a mean temperature of 22.17 and 24.28°C, respectively, in the Mount Cameroon region.

LWRs of Fry in RAS Culture

The regression coefficients of the length–weight models of fish growth in the RAS tanks, 1.3067 (Mezam♀ x Exotic♂) and 1.9786 (Exotic♀ x Mezam♂), respectively, indicated hypoallometry, confirming the observation by Froese (2006) that in their early developmental stages fishes increase faster in length than in weight. The coefficients of early fish growth in the present study indicate that the Exotic♀ x Mezam♂ hybrid offered the higher potential for fish weight increase per unit increase in length, which factor determined its choice for stocking in the wetland, rather than the other hybrid.

Physicochemical Parameters of Water Quality in the Wetland

Mean water temperature (24.22±1.40°C) and mean TDS (52.04±10.23 mg/l) of the water in the wetland were within recommended ranges for *Clarias* growth (Boyd and Tucker, 1998). The mean temperature was similar to the observations of Oben *et al.* (2020) (24.5±0.3 and 24.7±0.8°C), who had previously carried out wetland culture of *C. gariepinus* for 12 weeks in the same region. TDS ranged similarly in both works.

The low mean dissolved oxygen (DO) (4.04±1.88 mg/l), well below the lower

bound of recommended range for tropical fish culture (5-8 mg/l) (Bhatnagar and Devi, 2013) ($P<0.05$), could be indicative of a high organic load in the wetland. RAS culture of the same hybrid had recorded a mean water temperature 25.52±0.60°C and mean DO content of 8.18±0.30 mg/l. The wetland, of lower temperature (24.22±1.40°C), should have been expected to harbour higher DO (Mallya, 2007). Rather, DO was much lower in the wetland than in the RAS tanks ($P<0.05$). Three factors might have accounted for this incongruity. The first is the respiration of the abundant aquatic biota with which the site teemed. This would place a substantial biochemical oxygen demand (BOD) on the wetland water. Secondly, the BOD involved in the degradation of dead organic matter would also reduce the DO in the wetland water. Thirdly, while the RAS tanks were aerated by means of an air pump, no aeration was carried out in the wetland. The wide DO range (1.05-9.60 mg/l) could be postulated to affect fish growth negatively. However, Ekubo and Abowei (2011) posited that dissolved oxygen concentrations of even <1.0 mg/l can sustain catfishes for long periods. Furthermore, *C. gariepinus* has the capacity to thrive in low-oxygen environments because of its air-breathing ability (Teugels, 1986). On these grounds, the wetland was acceptable for the survival and growth of the test hybrid with respect to DO content. However, because fishes grow slowly at dissolved oxygen levels between 1 and 5 mg/l (Boyd and Lichtkoppler, 1979), the low levels recorded in the wetland may have affected the growth of the fish to some extent, especially during the period when only the refuge structures had water and the rest of the field was dry.

Growth of Hybrid Fish in the UB-CORAF Wetland

The Exotic♀ x Mezam♂ hybrid harvested from the wetland recorded a mean weight gain of 1,334.79 g. The fish would probably have recorded a higher weight increase if they were stocked much earlier. Many fauna species in the habitat (e.g., reptiles, snails, worms, gastropods, crustaceans, insects, other invertebrates) may have already bred earlier in the year, at the beginning of the rainy season (Wells, 2010), before the fish were stocked. The young of such species, which can constitute food for *C. gariepinus* (FAO, 2014), may already have outgrown the mouth size of the experimental fish at stocking. In that case, the stocked fish were deprived of important protein sources (Degani *et al.*, 1988).

Furthermore, the adult fish were harvested from the refuge ponds at a time when the rest of the site was completely dry, implying a general dearth of food source and therefore reduced possibilities for biomass increase in the fish stock. In an earlier study, clariid fingerlings (initial mean weight 2.86 ± 0.02 g) stocked in the month of September observed a mean weight gain of 329.21 g after just 84 days of culture (Oben *et al.*, 2020). This increase, which when extrapolated under the prevailing conditions to 180 days, would be higher than the 1,334.79 g gained in the present study ($P < 0.05$). This difference can be attributed to the timing of, and fish size at, stocking. In September, the young of some of the fauna in the wetland would still be small enough to serve as prey for the stocked clariids.

Survival of Hybrid Fish in the UB-CORAF Wetland

Although the fish survival rate of 7.17% may appear unimpressive for an aquaculture project, it was nevertheless

relatively substantial. It has been recognised that post-release survival rates of hatchery-reared stocked fish in the wild are generally poor, with numerous works recording survival rates such as $<5\%$, 1 – 3%, and $<1\%$ (Brown and Day, 2002; Hutchison *et al.*, 2012). A number of factors, including poor foraging success (Norris, 2002) and insensitivity to predation risk (Alvarez and Nicieza, 2003), have been advanced as responsible for poor survival of hatchery-bred fish seed in the wild in comparison to their feral counterparts. In this study no protection from predators was provided for the fish in the wetland; this rendered the fish vulnerable to the piscivorous birds, snakes, insects and other predators found in the wetland. The small size of the fry at the time of stocking (mean total length 1.46 ± 0.16 cm and mean weight 0.097 ± 0.011 g) might have rendered them more vulnerable to predation. These factors probably contributed to the natural mortality of the stocked fish. Sulem and Brummett (2006) observed a 21.7% reduction in fish mortality in Cameroon by installing netting over fish ponds to preclude predators.

Another factor that could have been responsible for the low fish survival rate is opportunistic cannibalism (Olufeagba and Omokoda, 2016). During the dry months that the fish spent in refuge ponds without supplementary feeding, and when there was paucity of animal prey because aquatic organisms were not likely to spawn then (Wells, 2010), the clariids probably preyed on each other, being carnivorous (Degani *et al.*, 1988; FAO, 2014). In a work similar to the present study, tilapiine fish stocked in rice plots recorded a significantly higher survival rate of 43% after 77 days (Rasowo and Auma, 2006), probably due to the absence

of cannibalism in the species and a shorter time for the effect of predators.

Conclusion

This trial showed that stocking the Exotic♀ x Mezam♂ *Clarias gariepinus* hybrid in a restricted habitat without protection and without supplementary feeding resulted in a relatively substantial recovery rate and growth in terms of weight. There is potential for an even higher survival rate if the habitat is manipulated to preclude cannibalism and higher growth if the stocking and harvesting are timed aptly, rendering controlled fish stocking a potential option for resource-poor communities.

Acknowledgement

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