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Effect of Different Water Media on Growth and Production Performance Parameters of African Catfish *Clarias gariepinus* (Burchell 1822) Fry

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Abstract

This study evaluated and compared growth performance, feed utilization and survival of *Clarias gariepinus* fry cultured in three different water media. The water media used were: Rainwater (T1), Bore Hole Water (T2) and Well water (T3). Fourteen (14) days old C. gariepinus fry of initial mean weight 0.17±0.00-0.19±0.00 g and initial mean length 0.92±0.02-0.96±0.02cm was fed for 28 days with commercial feed in plastic aquaria tanks (30l). Weight gain, specific growth rate (SGR), feed conversion ratio (FCR) and survival rate were determined weekly for each water medium. Data resulting from the experiment were subjected to one-way analysis of variance (ANOVA) at (P<0.05) significance level. At the end of the experiment, the highest weight gain 0.57±0.04 g was recorded for fry reared in borehole water (T2), while fry cultured in rainwater (T1) obtained the least mean weight gain 0.18 ± 0.02 g. The best and the least specific growth rates (SGR) of 4.92 ± 0.32 and 2.67 ± 0.24 were also obtained in fry reared in borehole water (T2) and rainwater (T1) respectively. Fry survival rate was highest in bore hole water (T2) (73.3 ± 9.13 %), and lowest in rainwater (T1) (23.3 ± 2.03 %). These results show that though borehole water is the most excellent water medium for nurturing of *C. gariepinus* fry, well water is also suitable for the culture of *C. gariepinus* fry.

Keywords: Aquaculture; Growth parameters; Fish seed; Water quality; Total hardness; Clarias fry

Introduction

The practice of aquaculture in Nigeria has been successful due to catfish propagation through hypophysation. This consequently led to an increase in cultivation of catfish in the country [1]. The prominent catfish species cultured in Nigeria include *Clarias gariepinus*, *Heterobranchus bidorsalis* and their hybrid (Hetero-clarias). Catfish has become the preferred species due to their tolerance to high stocking density, ease of rearing and ability to resist disease infestation [2]. Besides, it is hardy, can tolerate adverse temperatures, low dissolved oxygen and high ammonia build up [3]. More so, they are highly adaptable and resistant to stress. More importantly, the species can be artificially propagated by induced spawning techniques for reliable mass supply of fingerlings [4]. Despite the acceptability of the African catfish and its enormous market potentials, its production is still at low level. This is due to insufficient or unavailability of fish seeds for stocking owing to mortalities encountered at the early fry stages of *C. gariepinus* [5].

The production of fish seed (fry, fingerlings and juveniles) is a critical stage of aquaculture. That is why this stage has been given regular investigations in order to improve and sustain fish production [6]. Many hatcheries are challenged with several operational difficulties. Some of such setbacks as reported by fish farmers include poor growth and high mortality rates of *C. gariepinus* at early and advanced fry stages [7]. These limitations are often associated with water quality of the culturing systems [8]. Optimal water quality determines to a great extent the success or failure of any aquaculture operation. In several places, water from different sources may be available for use in the hatchery. Such water sources like ground water from different depth (well and borehole water) and various surface water (stream and river water) supplies may likely influence the production in hatchery system [9].

In Abakaliki, South Eastern Nigeria, there have been reports of high larval/fry mortalities during the early stages of fish growth.

Water quality has been implicated as one of the major causes of fry mortalities during early stages of fry development [10]. Reports by [11,12] further affirms that surface and ground water sources in Abakaliki and its environs are compromised due to its hardness. This has been attributed to the occurrence of mineral deposits (Ca, Mg) and heavy metal ores (Zn, Fe, Pb) under the ground [13]. This therefore influences the suitability of common sources of water in the state for successful management of fish fry. Consequently, a broad investigation into the quality and suitability of various natural and common sources of water available to local fish farmers is imperative. It is thus believed that the result of this research work will help boost the production of *C. gariepinus* fry and fingerlings particularly in Ebonyi state and Nigeria generally. It is equally hoped that the outcome of this research will help fill the gaps created by the lack of information on water quality requirements for nurturing and rearing of *C. gariepinus* seeds in Ebonyi state. The main objective of this study was to determine and compare growth performance, feed utilization and survival of *C. gariepinus* fry nurtured in rainwater, borehole water and well water in Abakaliki municipality.

Materials and Methods

Experimental site

The experiment was conducted at the Hatchery unit, Department of Fisheries and Aquaculture Fish farm, Ebonyi State University, Abakaliki, Ebonyi State, Nigeria. Ebonyi State is situated between latitudes 6.24 °N and 6.28 °N and longitudes 7.00 °E and 7.06 °E on the South-East of Nigeria.

Water quality parameters

The physico-chemical parameters of the water treatments were analyzed before the commencement and within the period of experiment. Mercury in a glass thermometer was used to measure water temperature. The water pH was measured using the pH Hannah Portable Meter model HI 991 300. Dissolved oxygen (DO) of water was also measured using Hannah Portable Meter model HI 9142 and also by the modified Winkler azide method (APHA, 1989). Hannah Portable Meter model HI 9142 was equally used to determine water conductivity and hardness. Nitrate, nitrite and ammonia in water were measured daily with the aid of Fresh Innovative Multitech, (NIFFRI) water testing kits.

Procurement of fry

Sexually mature male and female *C. gariepinus* broodstocks were procured from a reputable fish farm in Abakaliki. They were acclimated in two 45 L indoor concrete tanks (2m × 2m × 1m) and fed 35% crude protein diet [14] for two weeks before commencement of the experiment. Hormonally induced breeding of the mature *C. gariepinus* brood stocks was carried out according to the methods of [15]. Fertilized eggs hatched within 18-24h after fertilization. Three days after hatching and the complete yolk sac absorption, the larvae were fed decapsulated Artemia nupli for 11 days. On the fourteenth day of post hatching, the fry were adjudged to have entered the advanced fry stage when essential air-breathing organs must have developed as the fry often climb to the surface to breathe atmospheric air [16]. The fry was then weighed and ready to be used for the experiment.

Experimental design

The study adopted partial water flow through culture technique and lasted for 28 days. Complete randomized design (CRD) was used for this experiment. The A total of two hundred and seventy (270) 14-days old *C. gariepinus* fry of initial mean weight 0.17±0.00-0.19±0.00 g and initial mean length 0.92±0.02-0.96±0.02 cm was used. Thirty (30) fry was distributed randomly into nine plastic aquaria tanks each of 30L capacity at a density of 30fry/m^2. This was done to ensure optimum growth and survival according to [17]. The fry was distributed into three treatment groups as shown below. Three replicates were used for each treatment.

Treatment one (T1) = tanks containing Rainwater

Treatment two (T2) = tanks containing Borehole Water

Treatment three (T3) = tanks containing Well Water

Fry management and rearing

Prior to stocking, the tank was thoroughly washed with salt and water to prevent infections. Fish fry in each experimental tank were gradually fed pelleted artificial commercial diet, Coppens [50% crude protein]. The fry were fed at 5% body weight per day. Feeding was done thrice a day at 08:00hrs, 13.00hrs and 18:00hrs. Feed was dispensed evenly on the water surface of each tank to allow equal feeding opportunity. Leftover food particles, fry metabolites and other leftovers were siphoned out of the rearing tanks on daily basis before feeding. This is to avoid fouling of the water which could compromise water quality. About 50% of water in each rearing tank [18] was replaced with freshwater treatments accordingly so as to prevent the buildup of ammonia and the walls/bottom of the tanks carefully mopped with soft foam in order to remove dirt. Total renewal and washing of bowls with salt were done weekly [19]. The mean size of the fish {weight (g) and total length (cm)} for each treatment and its replicates were measured every 7 days. Ten fry were randomly sampled from each aquarium tank, placed on paper filter to absorb water and weighed on an electronic weighing balance (METTLER TOLEDO, PB602) to the nearest 0.01g. The length of each sampled fry was also measured by using a measuring board to the nearest 0.01cm [18]. The fry was carefully returned to their respective tanks. Mean weight gain and mean length gain of experimental fish were also noted and recorded. The feeding rate was recalculated to accommodate weight changes and mortalities. Dead fish in each of the tanks were removed and recorded to estimate percentage survival.

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Commercial artificial dry diet

A commercial dry diet (Coppens Netherlands) was purchased from a reputable local fish feed shop in Abakaliki town. Its composition is shown in table 1 below.

Table 1: Nutrient composition of Coppens (0.3-0.5mm) fish feed fed *C. garieinus* fry reared in different water media for 28 days.

Proximate composition	% Composition
Crude protein	45
Crude fat	12
Crude fibre	6.0
Crude ash	8.0
Calcium	1.5
Phosphorus	1.5
Moisture	8.0
NFE	18

Determination of Growth Performance

Growth parameters

From the experimental data obtained in replicate tanks for each treatment, the following growth and nutrient utilization parameters were determined accordingly:

Mean weight gain: Mean weight gain was calculated according to [20] thus:

Mean Weight Gain (g) = Mean Final Weight (g) – Mean Initial Weight (g).

Mean total body length: Mean total body length was calculated according to [21] thus:

Mean Total Length (cm) = Final length (cm) - Initial length (cm)

Specific growth rate (SGR): Specific growth rate (SGR % / d) was calculated using the formula adopted by [22]:

$$Specific\ growth\ rate\ (SGR\ \%/d) = \frac{(Log_e W2 - Log_e W1)}{T2 - T1} \times 100$$

Where:

Log_e = Natural logarithm to base e

W1= initial weight (g) of fish at the beginning of the experiment

W2 = final weight (g) of fish at the end of the experiment

T1- T2 = time in days.

Mean daily growth: Mean daily growth rate was calculated with the formular adopted by [23]:

$$Mean\ Daily\ Growth\ (MDG) = \frac{W2 - W1}{T}$$

Where:

W2= mean final weight

W1 = mean initial weight,

T = rearing period (days)

Feed utilization parameter

Feed conversion ratio (FCR): Feed conversion ratio was calculated according to [22] thus:

$$Feed\ Conversion\ Ratio = \frac{Weight\ of\ Feed\ Fed\ (g)}{Live\ Weight\ Gained\ (g)}$$

Survival parameter

Survival rate: This was calculated after [24]:

$$Survival\ rate\ (\%) = \frac{Ni - Nf}{Ni} \times 100$$

Where:

Ni = initial number of fish at the beginning of experiment

Nf = final number of fish at the end of experiment (28 days)

Statistical analysis

Data from each treatment was then subjected to one-way analysis of variance (ANOVA) at 0.05% significance level. The significance of difference between means was determined by Duncan's Multiple Range Tests (DMRT) using the SPSS computer statistic package for windows 7 (version 21). Graphs were generated by using Microsoft windows (2021) and all values were expressed as means ±SE.

Results

Water quality parameters

Table 2 shows results of the mean water quality parameters tested during the 28 days growth trial of *C. gariepinus* fry in different water sources are presented. Mean water quality parameters were within the range of acceptable limits for *C. gariepinus*

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nursing and culturing. There was no significant difference ($p>0.05$) in temperature, dissolved oxygen (DO), nitrate, nitrite and ammonia values obtained during the experiment. The mean water temperature during the experiment ranged from 27±0.00 - 28±0.00 °C, while the mean pH of water ranged from 6.5-7.0. The mean dissolved oxygen value of water ranged from 6.20±0.00-8.20±0.00 mg/l. The mean nitrate and nitrite values ranged from (0.12±0.00-1.85±0.00) and (0.00±0.00-0.01±0.0) respectively, while mean values of ammonia ranged from 0.21±0.00-2.38±0.00 mg/l. Conversely, conductivity and total hardness values were significantly different ($p<0.05$) among the treatments. Rainwater (T1) recorded the least conductivity value of 24.3±0.88 μS/cm while T2 recorded the highest conductivity value of 287.1±0.00 μS/cm. Total hardness value was also lowest in T1 (3.33±0.33) and highest in T2 (57.7±0.88).

Table 2: Mean Water Quality Parameters of Different Water Media Used to Nurture *Clarias gariepinus* Fry for 28 days.

	Treatments		
Parameters	T1	T2	T3
Temperature (°C)	27.00±0.00^a	28.00±0.00^a	28.00±0.00^a
Dissolved Oxygen (mg/l)	6.20±0.00^a	6.20±0.00^a	8.20±0.00^a
pH	7.00±0.00^a	6.50±0.00^a	6.50±0.00^a
Nitrate (mg/l)	0.12±0.00^a	1.83±0.00^a	1.85±0.00^a
Nitrite (mg/l)	0.00±0.00^a	0.01±0.0^a	0.01±0.0^a
Ammonia (mg/l)	0.02±0.00^a	0.02±0.00^a	0.02±0.00^a
Conductivity (μS/cm)	24.3±0.88^a	287.1±0.00^b	285.2±0.00^c
Total Hardness (mg/l)	3.33±0.33^a	57.7±0.88^c	38.6±0.67^b

*Values in the same row with different superscripts are significantly different ($p<0.05$)
*T1= Rain water, T2=borehole water, T3=well water

Growth performance and feed utilization parameters

Results of the growth performance of *C. gariepinus* reared in different water sources for 28 days are presented in table 3. The result obtained for mean weight gain in this study shows there was significant difference ($p<0.05$) among the treatments. The result indicated that fry reared in borehole water (T2) had the highest mean weight gain (0.57 ± 0.04 g) followed by well water (T3) 0.37 ± 0.03 g while the lowest mean weight gain of (0.18 ± 0.02 g) was obtained for fish reared in rainwater (T1).

Table 3: Growth Performance and feed utilization of *C. gariepinus* Fry nurtured in different water media for 28 days.

	Treatments		
Parameters	T1	T2	T3
Number of Fry Stocked	30	30	30
Mean Initial Weight (g)	0.19 ± 0.00^a	0.18 ± 0.00^a	0.17 ± 0.00^a
Mean Initial Length (cm)	0.96 ± 0.02^a	0.92 ± 0.02^a	0.94 ± 0.02^a
Mean Final Weight (g)	0.37 ± 0.04^a	0.75 ± 0.05^c	0.54 ± 0.07^b
Mean Final Length (cm)	1.36 ± 0.03^a	2.00 ± 0.05^c	1.59 ± 0.10^b
Mean Weight Gain (g)	0.18 ± 0.02^a	0.57 ± 0.04^c	0.37 ± 0.03^b
Mean Length Gain (cm)	0.44 ± 0.04^a	1.08 ± 0.08^c	0.65 ± 0.06^b
Number of Shooters	0	8	2
Number of survival at end of experiment	7	22	`18
Survival rate (%)	23.3 ± 2.03^a	73.3 ± 9.13^c	52.1 ± 2.92^b
1MDG	0.01±0.00^a	0.02±0.01^b	0.01±0.00^a
2SGR (%/day)	2.67 ± 0.24^a	4.92 ± 0.32^c	3.94 ± 0.09^b
3FCR	1.49 ± 0.17^b	1.03 ± 0.04^a	1.11 ± 0.09^{ab}

*All the values are means of triplicate feeding groups and values in the same row with different superscripts are significantly different ($P<0.05$)
[1]Mean Daily Growth = W2 – W1/T
[2]Specific growth rate (%/d) = (LnW2 - LnW1/T2 - T1) × 100
[3]Food conversion ratio = food fed (g)/live weight gain (g)
*T1= Rain water, T2=borehole water, T3=well water

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Results of the growth performance of *C. gariepinus* nursed and reared in different water media for 28 days are presented in table 3. The result obtained for mean weight gain (MWG) in this study shows there was significant difference ($P<0.05$) among the treatments. The result indicated that fry reared in borehole water (T2) had the highest mean weight gain (0.57 ± 0.04 g) followed by well water (T3) 0.37 ± 0.03 g while the lowest mean weight gain (0.18 ± 0.02 g) was obtained for fish reared in rainwater (T1). Shooters were observed to be more in T2 (22), while T3 recorded (18) shooters and none was obtained from T1. In the same manner, results obtained for mean total body length indicates that T2 recorded the highest mean total body length gain (1.08 ± 0.08 cm) followed by T3 (0.65 ± 0.06 cm) and T1 got the lowest length (0.44 ± 0.04 cm). Mean daily growth (MDG) records revealed that T2 was significantly different ($P<0.05$) from other treatments. Values for MDG show that T2 recorded 0.02±0.01 while T3 and T1 recorded 0.01±0.00 respectively. Specific growth rate (SGR) followed the same tendency as it was observed to be high in T2 (4.92 ± 0.32 %/day), compared to the low mean value recorded in the T1 (2.67 ± 0.24a %/day) (Table 3).

Table 3 shows the feed utilization parameters assessed during the experiment. Mean food conversion ratio recorded during the experiment show that T2 and T3 recorded a significantly ($P<0.05$) low food conversion ratio (FCR) from T3. Mean FCR values for T2 and T3 are 1.03±0.04, 1.11±0.09 respectively. A high food conversion ratio (FCR) of 1.49 was observed in T1 while T2 and T3 recorded lower FCR values.

Survival rate

Results for mean survival rates are presented in table 3. There was a significant difference ($p<0.05$) in the mean survival rates of fry cultured in the different water treatments. The weekly survival rates of the fry are also shown in figure 3. Mean survival of fry was highest in T2 (73.3 ± 9.13 %), followed by T3 (52.1 ± 2.92 %) and lowest in T1 (23.3 ± 2.03 %). In comparison, the mean cumulative weekly mortality rates are shown in table 4. Borehole water (T2) recorded the least mean mortality rate of 23.3±5.78 %, followed by well water that recorded 47.8±2.94 % while rainwater recorded the highest mean mortality rate of 76.7±19.3 %.

Table 4: Mean Cumulative Weekly Mortality Rates of *Clarias gariepinus* Fry Reared in Different Water Media for 28 days*.

Treatments			
Period	T1	T2	T3
Day 1	0	0	0
Day 7	6.3	6	7
Day 14	15	6	10.3
Day 21	19.3	6.7	12.3
Day 28	23	7	14.3
Mean mortality	23.00±0.58^{c}	7.00±1.73^{a}	14.33±2.39^{b}
Mean Mortality Rate (%)	76.7±19.3^{c}	23.3±5.78^{a}	47.8±2.94^{b}

*All the values are means of triplicate feeding groups and values in the same line with contrasting superscripts are significantly different ($P<0.05$)

*RW= rain water, BW=borehole water, WW=well water

Discussion

The water physicochemical parameters observed in this study were within the tolerable range reported by [15] and [25] as ideal requirement for *C. gariepinus* and there was no significant difference ($p<0.05$) among treatments. Except conductivity and total hardness which were significantly different ($p>0.05$) [Table 2]. Mean conductivity and total hardness values obtained for rainwater (T1) were not within acceptable limits for the successful nurturing and culture of *C. gariepinus* fry. This suggests that low conductivity and low total hardness noticed in rainwater treatment may have negatively affected the growth of the fry. According to [26] fry and small fish of most species are more susceptible than adult fish to low conductivity. [27] assert that mid-range conductivity of 200 - 1000 µS/cm is conducive for fry development and growth but low conductivity of 0 - 200 µS/cm and high conductivity of 1000 - 10,000 µS/cm discourages fry growth. This may have accounted for the high fry mortalities and poor growth performance noted in fry nursed and reared in T1 treatment. Furthermore [28,29] stated that hardness should be between 50 and 300 ppm in the pond for best or optimal fish growth. At least, a total hardness value of 30mg / liter should be maintained for optimum growth of aquatic species.

The results obtained in this experiment shows that growth performance of fry was significantly affected ($p>0.05$) by the different water sources. *C. gariepinus* fry reared in borehole water showed superior growth performance over those reared in other water sources (Figures 1 & 2). This is because *C. gariepinus* fry raised in borehole water recorded the highest final body weight, highest weight gain, highest body length gain, the highest mean daily growth rate, the highest specific growth rate (SGR) and the highest percentage survival when compared to fry nurtured in rainwater (T1) and well water (T3) (Table 3). This result therefore indicates that borehole water was the most suitable water source since the *C. gariepinus* fry performed best in it. This aligns with the

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reports [30,31] that cultured *C. gariepinus* fry in different water sources. These workers found that *C. gariepinus* fry performed best in borehole water than in other common sources of water used in culturing fish. The advantages of using borehole water to nurse fry have been reported by [32,33]. These researchers asserted that ground waters are preferred for aquaculture where they supply is dependable. This is because they are usually free from suspended matter, pollutants and fish disease organisms. Moreover, its temperature and chemical composition are relatively constant.

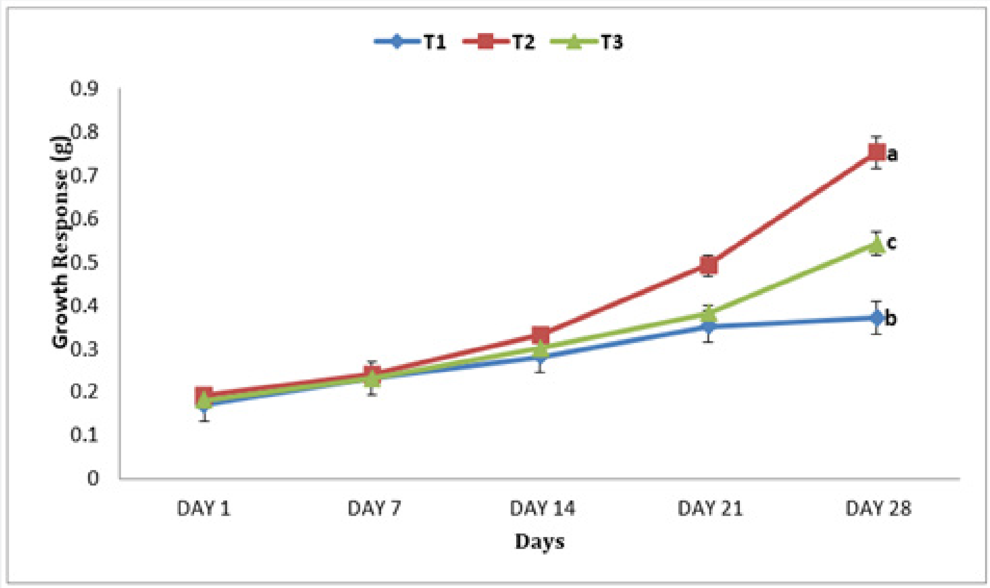

Figure 1: Mean Weight gain of C. gariepinus Fry nurtured in Different Water media for 28 days. Different superscripts indicate significant differences (P<0.05). *T1=rainwater, T2=borehole water, T3=well water.

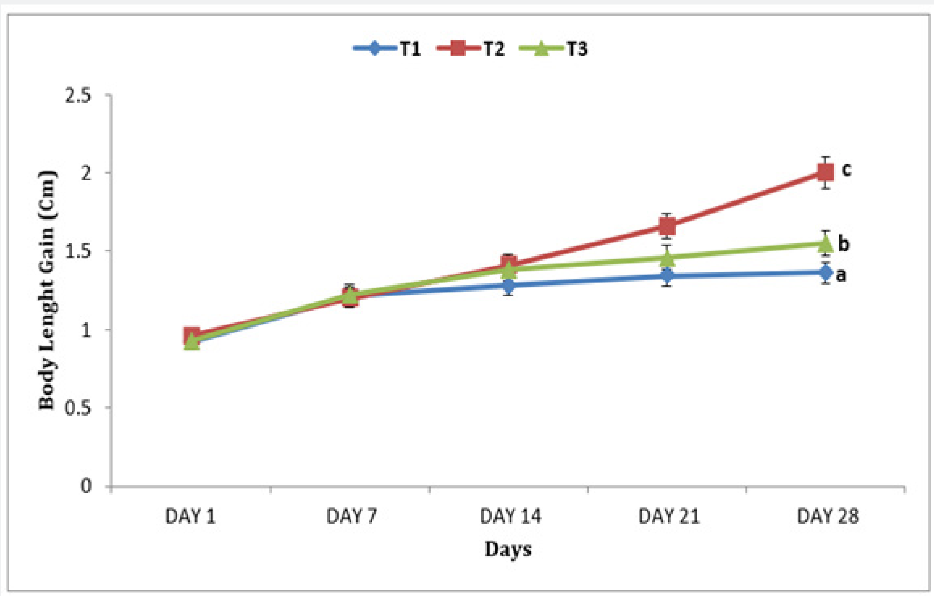

Figure 2: Mean Total body Length Gain of C. gariepinus Fry nurtured in Different Water media for 28 Days. Different superscripts indicate significant differences (P<0.05). *T1=rainwater, T2=borehole water, T3=well water.

In this experiment, FCR mean values were not significantly different (p<0.05) in two treatments. Borehole water (T2) and well water (T3) treatments recorded lower FCR. Only rainwater (T1) treatment was significantly (p>0.05) different from other

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treatments. Therefore, low FCR exhibited by T2 and T3 is an indication that the *C. gariepinus* fry reared in the two water sources utilized the feed well. This was reflected in their improved growth rates as indicated in figure 3. According to [22] FCR is a vital indicator of feed utilization and a low FCR is a sign of enhanced use of the feed by fish. Therefore, the conducive water environment offered by borehole water (T2) made the fry to direct much of its energy towards growth [34]. The result obtained in this study corroborates the reports of [35] that reared *C. gariepinus* fry in different water sources and reported that borehole water or underground water supplies are ideal for nursing and rearing catfish fry.

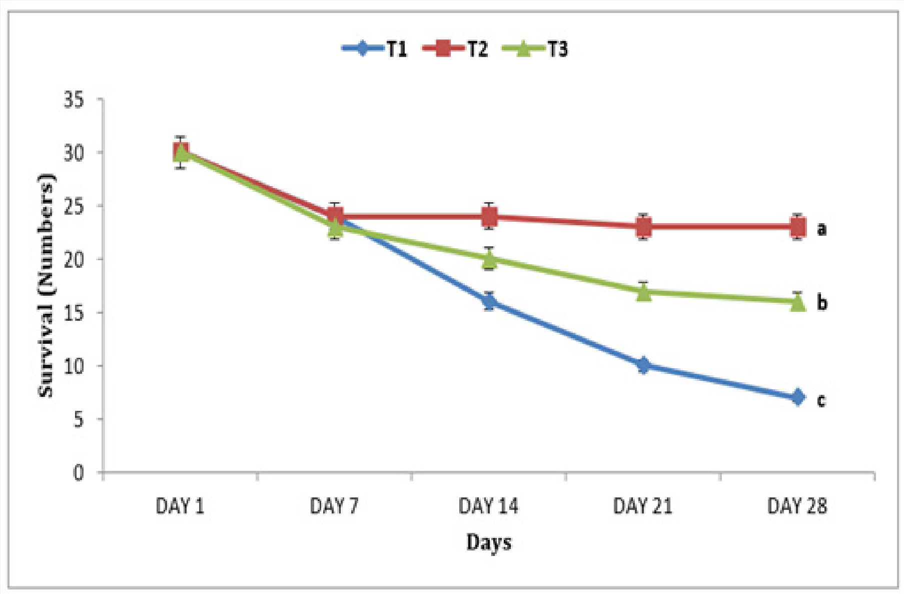

Figure 3: Weekly Survival rates of C. gariepinus fry nurtured in the different water media for 28 days. Different superscripts indicate significant differences (P<0.05). *T1=rainwater, T2=borehole water, T3=well water.

Generally, *C. gariepinus* fry nursed in borehole water (T2) had the highest survival rate followed by well water (T3) as shown in figure 3. The highest survival rate in T2 infers the suitability of borehole water for nurturing of *C. gariepinus* fry. This finding is in agreement with the reports of [26,35] and [10]. As had been earlier stated, groundwater (borehole and deep well) is considered the most desirable source of water supply to the hatchery. That is because it is more consistent in quality than other water sources, and much less likely to be contaminated by pathogens [9,33].

Conclusion

Findings from the study show that all water quality tested in the water sources were within the optimal water quality ranges for the culture of *C. gariepinus* except water conductivity and water hardness which were very low in rainwater (T1). Growth and production performance parameters investigated were significantly different among the water treatments. However, fry reared in borehole water performed better than fry cultured other water treatments. Furthermore, fry survival was observed to be highest in borehole water and lowest in rainwater. The study has shown that though borehole water is the most suitable water medium for nurturing and rearing *C. gariepinus* fry, well water may equally be appropriate for early production *C. gariepinus* fry. The information and skill gained will be useful to fish farmers in early management and rearing of *C. gariepinus* fry especially in peculiar geological locations like Ebonyi state, Nigeria. This will help minimize mass mortalities often encountered in the early stages of fish fry culture and boost massive production of fish seed.

Ethical Approval

All experimental trials were approved by the Ebonyi State University (EBSU) Abakaliki Ethics Clearance Committee. This was done in accordance with the university's animal welfare act and the National Environmental Standard Regulations Enforcement Agency (NESREA) Act of Nigeria on the protection of animals against cruelty.

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