Comparative Study of Diets of Mixed-species-zooplankton and Formulated-feed Effects on Physicochemical Parameters, Growth and Survival Rate of *Clarias gariepinus* Larvae

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Abstract

Comparative analysis of live-mixed-species-zooplankton-diet (LMSZD) and formulated-feed-diet (FFD) effects on culture-media physicochemical parameters, growth and survival rate of *Clarias gariepinus* larvae were assessed for 15 days. The experiment was conducted in six plastic-aquaria (30 liters) in triplicates, designated as Tanks-A and Tanks-B. Each tank was stocked with 200 individuals 3-days old post-yolk larvae of initial mean-weight and mean-length of 0.0128 g and 0.65 cm respectively. Live-zooplankton-fed-larvae (LZFL) were placed in Tanks-A, while formulated-feed-fed-larvae (FFFL) were in Tanks-B. The larvae were fed twice daily at *ad-libitum*. Physicochemical parameters analysis was done at two days interval. The cumulative-mean-values recorded in Tanks-A and Tanks-B respectively were; temperature (24.24; 23.88 °C), pH (7.29; 6.96), electrical-conductivity (263.84; 276.7 µs/cm); total-alkalinity (74.99; 93.45 ppm), total-dissolved-solids (127.79; 138.8 ppm), dissolved-oxygen (7.02; 5.08 ppm), biological-oxygen-demand (1.08; 1.77 ppm) and free-carbon-dioxide (239.14; 11.08 ppm). The growth parameters for LZFL and FFFL respectively were length increment (1.20; 1.00 cm), weight gain (0.1755; 0.1456 g) and specific growth rate [SGR] (%) were 17.92; 16.78. The survival rates (%) were 89.50; 55.00, while the Condition Factor [K] (%) were 2.77; 3.53 for LZFL and FFFL respectively. BOD, Temperature, pH, and CO_2 did not have significant difference ($P>0.05$). EC, TA, TDS, and DO values exhibited significant differences at ($P\leq0.05$). Growth parameters mean exhibited a gradual daily upsurge in both treatments. LZFL maintained a higher mean values than FFFL, through the experiments. Both LZFL and FFFL growth indices values exhibited significant difference ($P\leq0.05$).

Keywords: *Clarias gariepinus* larvae, Formulated-feed, Live-mixed-species-zooplankton, Physicochemical-parameters, Survival-growth-rate.

Introduction

Perceptible water quality defect can be evaluated visually or examined with the aid of suitable technical instrument with regards to the parameter needing attention. Often affected freshwater parameters, such as dissolved oxygen (DO), biological oxygen demand (BOD), free carbon dioxide (CO_2), pH, total alkalinity (TA), total dissolved solids (TDS), electrical conductivity (EC) and temperature are interrelated

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(Marinou *et al.*, 2020). Their variation influences water quality and affects fish larvae wellbeing (Boyd, 1982). Water quality factor is maintained within optimum range at-all-times, in-order to sustain normal activity and physiological wellbeing of inhabiting organisms (Marinou *et al.*, 2020). Management of water quality parameters takes into account the variable needs of individual species between different developmental stages, such as yolk-larva, post-yolk-larva, fingerling, juveniles and adults as regards fishes. Regular water renewal, use of live-zooplankton-diet (LZD) and reduction of formulated-feed-diet (FFD) is necessary for the management of toxic ammoniac-nitrogen accumulation that is caused by un-ionized ammonia concentration (Marinou *et al.,* 2020; Obhahie *et al.,* 2025). LZD application can eliminate CO_2 accumulation that affect the pre-hatching stage of fishes' lifecycles in form of decreasing the hatching rate of fish eggs and significantly affecting their embryonic development at elevated temperatures (Huong *et al.*, 2025). It also eliminates CO_2 produced during metabolism of uneaten FFD putrefaction and formation of carbonic acid that leads to low pH (Marinou *et al.,* 2020). Use of LZD keeps larvae culture media pH level stable so as to avoid the instigation of intricate water quality deterioration (Marinou *et al.,* 2020).

Hatchlings of *C. gariepinus* obtain endogenous nutrients from yolk-sac within the first 72 hrs of their lives. At the resorption of yolk sac, the fish larvae will transit to suitable exogenous food (Lavens and Sorgeloose, 1996; Ukwe *et al.,* 2018; Obhahie *et al.,* 2025). Fish larvae are minute, immature and fragile. They possess very small mouth size, poor chemoreceptors, immature eyes and undeveloped digestive system that limit their choices of food intake at the commencement of first exogenous feeding larva stage. FFDs are among the readily fish larvae starter-diets (LSD) that are costly, low in nutritional value and inadequate in supply of required nutrients, when compared to LZD, which from previous experiments has shown potentials to meet the required fish larvae nutritional needs (Okogwu *et al.,* 2006; Obhahie, 2022).

Animals ingest food it has the ability to detect, similarly fish larva need efficient organs for sight (eye), smell (olfactory) and taste, but at the beginning of exogenous feeding, the fish larva eyes are confronted with the inability of containing no rods that carries the visual pigments, but have only cones in the retina, which results in inefficient eyesight (Lavens and Sorgeloose, 1996; Evans and Browman, 2004; Eilertsen *et al.*, 2022). The contrasting appearance of zooplankton in water column when compared to formulated feeds presents a triggering effect associated with their constant movement which allows an improved visibility to the fish larvae as they feed. The swimming effects of zooplankton enhance their dispersion in the water column thereby enhancing frequent encounter by the fish larvae (Lavens and Sorgeloose, 1996; Obhahie *et al.,* 2025).

Aquaculturists usually apply the criteria illustrated in Fig. 1 when selecting suitable diet for fish larvae. A promising fish larvae diet should be readily available, relatively cheap, simple and flexible to apply (Delbare and Dhert, 1996). Thus, the need for simulated mass production of live-zooplankton-diet (Obhahie *et al.,* 2025).

Criteria for Selecting Fish-larvae Food-resources

for Aquaculturist
Easy-accessibility *Cost-effectiveness* *Versatility, Simplicity*

for the Fish-hatchlings	
Physical:	*Acceptability, Availability, and Purity*
Nutritional:	*Nutrient requirements* *Digestibility and Energetic requirements*

Figure 1: Aquaculturists' criteria for fish-hatchlings food selection Modified by Obhahie *et al.* (2025); from: Lavens and Sorgeloose (1996).

Freshwater zooplankton taxa that are commonly cultured, mostly on the bases of monospecies-zooplankton (MZ) production for fish larvae culture are rotifers, cladocerans and copepods (Ajah, 2010), but considering the procedures involved in zooplankton mass-production, mixed-species-zooplankton (MSZ) are relatively easier to produce when compared to MZ production (Ovie *et al.,* 1997; Obhahie *et al.,* 2025). Live-mixed-species-zooplankton (LMSZD) seem to have brighter potentials to turn-out a relatively higher growth and survival rate than live-monospecies-zooplankton-diet (LMZD), owing to the fact that LMSZD provides a wider spectrum nutrient composition and sizes distribution that best simulates the ecological setting of fish larvae natural habitats (Rumsey, 1994; Obhahie *et al.,* 2025).

Several fish larvae starter-diets (LSD), such as boiled chicken egg, grinded dried fish, FFD, *Artemia* cyst and dry-decapsulated *Artemia* have been tried, but *Artemia* products that are foreign, imported and expensive were the favourite exogenous LSD preferred for *Clarias gariepinus* larvae, because of their relative successes (Al-Sulivany *et al.*, 2025; Obhahie *et al.,* 2025), however, the recent prohibitive cost of their procurements have shifted Aquaculturists search for suitable LSD to the use of FFD such as "Skretting Gemma wean - 0.2 mm", "Copens 0.2 mm" and other brands that are as-well relatively costly when compare to the cost of LMSZD mass production. Beside the exorbitant cost of FFD and *Artemia* species products procurement, LMSZD has shown better performance, (Ovie *et al.,* 1997; Amali and Solomon, 2001) than both *Artemia* species products and artificial FFDs.

Freshwater LMSZD preference over *Artemia* species is also anchored on the fact that *Artemia* species are marine organism that are adapted to saline environment (Al-Sulivany *et al*., 2025), which makes their physiochemical composition less-suitable as LSD for freshwater larviculture, being that hatched live *Artemia* nauplii exhibits declining liveliness and die within 30 to 60 minutes in freshwater, thus requiring regular stocking intervals, (Eya, 2003; Obhahie *et al*., 2025).

Growth is irretrievable increase in weight and size of an organism, while survival rate is the population's percentage alive in a study group over a given period of time. After the resorption of yolk sac, the fish larvae in natural habitat feed exogenously on any available food substances, which inadvertently would be live-mixed-species-zooplankton (LMSZ) and other food substances within their reach (Rumsay, 1994; Ovie *et al.,* 1997), thus the idea of culturing LMSZ seems an immense potential for reliable source of exogenous LSD (Obhahie *et al.,* 2025).

Researches' reports have confirmed that African catfish larval can be rear with LZD (Madu *et al.,* 1990; Okunsebor, 2014). Experiment on the effectiveness of LMZD, LMSZD and FFD on *Clarias anguillaris* larvae's growth and survival showed that LMSD and LMSZD fed larvae had a positive significant difference ($P \leq 0.05$) above FFD treatment (Ovie and Ovie, 2002). In another investigation on the growth and survival of 72 hours old post-yolk *C. anguillaris* larvae fed comparatively with *Artemia nauplii*, live *Moina micrura* and frozen *M. micrura*, after four weeks of feeding showed that larvae fed live *M. micrura* had a higher growth and higher survival rate when compared to those fed with other diets (Ovie and Egborge, 2005).

Market survey reports indicate that *Artemia* products, such as the hatch-able cyst and the dry-decapsulated type, and the formulated feeds starter-diet, such as "*Skretting Gemma-wean*" (0.2 mm) and "*Copens*" (0.2 mm), are all costly to procure. These costs surveys reports showed values that are higher than what it cost to propagate live freshwater zooplankton (Obhahie *et al.*, 2025). Thus, in-order to reduce the cost of production, provide suitable, efficient and balanced LSD for freshwater fish larvae, LMSZD is the best choice.

Materials and Method

Description of Study Location

The experiment was carried-out at the Hatchery Unit, in freshly constructed concrete tanks and plastic aquaria, at the Dept. of AEB, FUOYE, phase II, main campus, Oye-Ekiti, Nigeria. The entire experiment took 12 weeks duration, 6 weeks was used for zooplankton culture, sampling and water quality analysis and larviculture was carried-out in 15 days, between the months of Nov. and Dec. The research hatchery comprises two reservoir plastic tanks of 1,500 liters (L) and 1,000 L, two zooplankton culture concrete tanks that respectively have L × B × H of 125cm × 80cm × 115 cm, but normally filled to 100 cm, in-order to accommodate 1,000 liters L of water, two hatching and nursery concrete tanks that respectively have L × B × H of 200cm × 100cm × 65cm, but normally filled to 50 cm, in-order to hold 1,000 L of water, two Broodstock holding plastic drums of 300 L and 160 L, in addition to four 60 L plastic basins and fifteen 30 L plastic aquaria. Water was regularly supplied to the hatchery from a borehole sank about 50 m from the hatchery. The zooplankton culture tanks are situated outdoor and covered with 0.75 mm mesh size screen. The hatching and nursery tanks are situated indoor in an area that is screened-off with 0.75 mm mesh size.

Zooplankton Mass Production, Harvest and Application

Regular supply of zooplankton was secured by mass production of LMSZD in the two zooplankton culture concrete tanks. The tanks earmarked as Tank A and B were each filled up to 1,000 L of water volume and fertilized with inorganic fertilizers, (20 g each of Urea and NPK-15:15:15) and organic fertilizer (200 g of dried-pure chicken-manure), respectively. When phytoplankton was established, mixed-species-zooplankton sample made-up of three taxa comprising rotifers, cladocerans and copepods were inoculated into the concrete tanks' culture media, from zooplankton nursery culture aquaria in accordance to Obhahie *et al.* (2025). When LMSZ culture was established after a week, samples were harvested twice daily with 50 µm mesh-size-plankton-net from the culture tanks and poured into 10L plastic bucket, till 7.5L is collected, filtered with 0.75 mm mesh size and fed to the fish larvae, in accordance to Goswami (2004); Obhahie *et al.* (2025).

Broodstock Source, Collection, Acclimatization and Selection

Broodstock comprising *C. gariepinus* were obtained from the Hatchery Unit of the Dept. of AEB, DELSU, Abraka and transported to Hatchery Unit of Dept. of AEB, FUOYE. The males and females were kept apart in separate in broodstock holding tanks and fed twice daily, with a diet ratio of 5% of their body weight, divided into two rations of morning and evening. Water renewal was done daily, being that the holding drums were small (160L and 300L). After two weeks acclimatization over eight months old one female and two males broodstock, weighing between 750g and 1kg were selected and moved into three separate 60 L plastic basins.

Broodstock Inducement, Gamete Extraction, Fertilization and Incubation

The selected broodstock were weighed and injected with "Ovaprim," in accordance to brand prescription (0.5 ml per 1 kg of female's body weight and 0.25 ml per 1 kg of male's body weight). The induced fish were placed back in their separate water-bath immediately after injection and left for between 10 - 14 hours (latency period) depending on the water temperature, in adherence to the methodology of Okoro *et al.* (2021); Agbebi *et al.* (2013). At the expiration of latency period, gametes (male's sperm-sac and female's ova) were harvested. The sperm-sacs were shredded to release the milt into a Petri-dish. About 3 - 4ml 0.6 - 0.7% saline solution was added to the milt, after-which it was spread over the eggs to fertilize it inside the plastic bowl. The fertilized eggs were then place on the prepared incubation net (Kakaban) raised to 2 - 3 cm, at 20 to 30 cm below the water surface, inside the hatching tanks, in accordance to Janssen, (1987). The eggs hatched 22 hours later at about 24 - 25^{o}C.

Feeding Trials Research Set-up in Replicates

The yolk-larvae were left in hatching tanks for 72 hrs, for the resorption of the natal-yolk. At the commencement of exogenous feeding the 3 days old larvae with mean-weight and mean-length of 12.80 mg and 6.50 mm respectively, were randomly collected and transferred into six plastic aquaria (30L), which were each filled with 25 L of water. The 6 aquaria were divided into 2 portions comprising triplicate (3) aquaria in each set, which were designated as Tanks-A and Tanks-B. Each aquarium was stocked with 200 individuals (inds.) *C. gariepinus* larvae, making a total of 600 inds. per set. Tanks-A were fed LMSZD, while Tanks-B were fed and 0.2 mm *Copens* fish feed. Tanks-A treatment fed LMSZD were designated Live-zooplankton-fed-larvae (LZFL), while Tanks-B treatment fed FFD were tagged formulated-feed-fed-larvae (FFFL). The larvae were fed at *ad-libitum* twice daily at 7 - 9 am and 4 - 6 pm for 15 days.

Determination of Physicochemical Parameters of Larvae Culture Media

Fish larvae rearing aquaria were sampled at 2 days interval for 15 days and the culture media were analyzed for physicochemical parameters like temperature, TDS, EC and pH, with Digital Multiple Parameters Tester (DMPT), while the TA, DO, BOD and CO_2 were analyzed by titration technique, in adherence to APHA *et al.* (2017).

Growth Rate Indicators Measurements

Growth parameters of the stocked larvae, such as length (cm) and weight (g) were randomly measured and recorded from each aquarium at the start (day 1), followed by a continuous two-day interval assessment and at the end (day15) of the experiment. The growth indices determined were:

Weight Gain (WG) = $W_f - W_i$

Where: $\mathbf{W_i}$ = initial mean weight; $\mathbf{W_f}$ = final weight;

Daily Weight Gain (**Wg.d^{-1}**) = $(W_f - W_i)/T$; ***Where:*** **T** = days

Relative Weight Gain [**RWG**] (%) = $[(W_f - W_i)/W_i] \times 100$

Specific Growth Rate (**SGR**) formula is:

SGR (**%**) = $(\ln W_f - \ln W_i)/T \times 100$ Fermin and Bolivar, (1994); Taher *et al.* (2023)

Where: **T** = experimental days

Condition Factor (K) was determined using:

$K = W/L^3 \times 100$ Hubbs and Lagler, (1964)

Where: **L** = length (cm); **W** = weight (g)

Length Increase (**LI**) **Measurement**

Increase in length was determined as follows:

Length increment (**LI**) = $L_f - L_i$

Where: $\mathbf{L_i}$ = initial length; $\mathbf{L_f}$ = final length

Daily Length Increase (**Li.d^{-1}**) = $(L_f - L_i)/T$

Relative Length Increase [**RLI**] (**%**) = $(L_f - L_i)/L_i \times 100$

Survival Rate Indices Determination

Survival rate (%) was measured in percentage using the formula below:

Survival Rate (**%**) = $N_f/N_i \times 100$

Where: $\mathbf{N_i}$ = initial quantity of larvae stock at inception;

$\mathbf{N_f}$ = quantity of live fish larvae at survival assessment

Mortality Rate (%) = $[(N_i - N_f)/ N_i] \times 100$

Data Analysis

Physicochemical parameters, growth and survival rate indices data analyses were carried-out to obtain mean and the standard deviation via descriptive statistics, while the significant difference among means was arrived-at using t-Test: Paired Two Sample for Means at 0.05 confidence level. The outcome of two types of diets, LMSZD and FFD on fish larvae growth and survival rates values are presented in column charts and pie-charts figures.

Results and Discussion

Physicochemical Parameters of Larvae Culture Media

The culture media samples obtained from Tanks-A (LZFL) and Tanks-B (FFFL) were analyzed for physicochemical parameters such as temperature, TDS, EC, pH, TA, DO, BOD and CO_2. The daily mean values, the daily minimum and maximum mean and the day 1 - day 8 cumulative mean and standard deviation (SD) of the physicochemical parameters were recorded. Tanks-A values varied slightly against those of Tanks-B, however the overall values were within optimum ranges suitable for tropical freshwater, particularly African catfish larvae culture when compared to larvae-culture water analyses results of previous studies, such as those of Okogwu *et al.* (2006); Arimoro (2007); Marinou *et al.* (2020) and other numerous research Scientists.

The temperature and pH mean values are plotted in column-chart, Figs. 2 and 3. Tanks-A, LZFL culture media mean values were slightly higher in temperature and pH. Both temperature and pH mean values showed significant difference (P≤0.05), when Tanks-A culture media were compared against Tanks-B culture media.

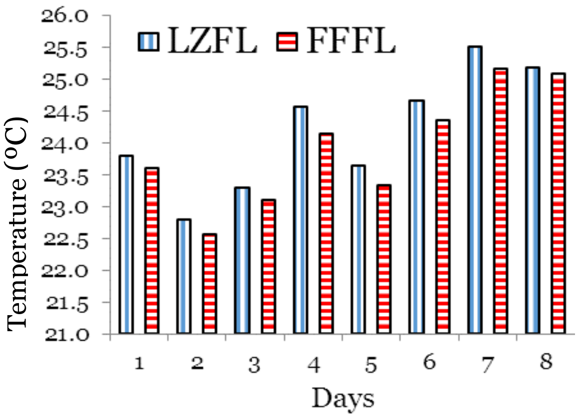

Figure 2: Ave. daily temperature range

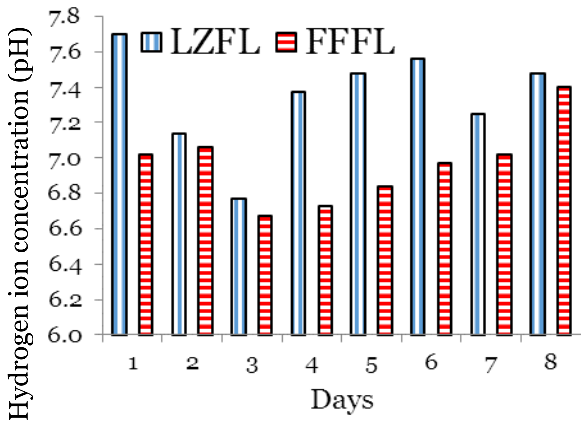

Figure 3: Average daily pH range

The cumulative temperature means obtained in Tanks-A and Tanks-B were 24.24 and 23.88°C respectively. These means are within optimum range for fish larvae rearing, Arimoro *et al.* (2008). The experiment's environs temperature range between 24 and 27 °C that is suitable for fish larvae rearing (Ovie *et al.*, 1997).

The obtained collective pH means were 7.29 and 6.96 in Tanks-A and Tank-B respectively, which corroborated the previous studies of Okogwu *et al.* (2006) and Okunsebor (2014). Fish larvae rearing reports earmarked aquaculture pH optimum requirement to be within 6.5 – 8.5 pH range (Eya, 2003; El-Naggar *et al.,* 2008), which supports this investigation's result.

The EC and TDS mean values are plotted as column-chart in Figs. 4 and 5. Tanks-B FFFL culture media recorded higher mean in EC and TDS. The values of EC had significant differences (P≤0.05), while TDS did not have significant differences (P>0.05).

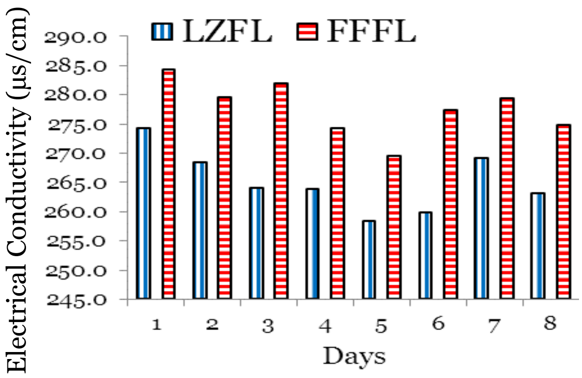

Figure 4: Average daily Elect. Cond. range

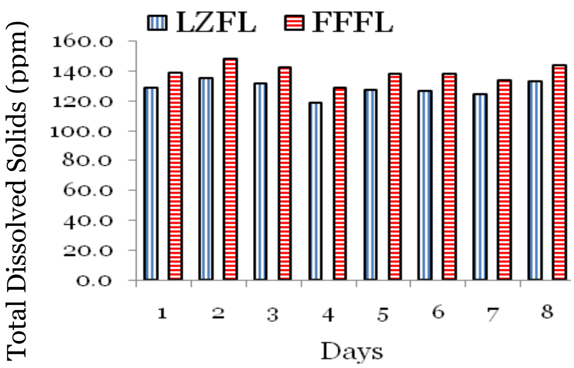

Figure 5: Average daily TDS concentration

The larvae culture media cumulative EC mean values obtained were 263.84 and 276.7 µs/cm in Tanks-A and Tanks-B respectively. These values were moderate and within optimum range when compared to the 143 and 160 µs/cm obtained by Ovie *et al.* (2001), the 387.16 and 443.66 µs/cm recorded in zooplankton culture media by Obhahie *et al.* (2025) and the 439 and 463 µs/cm recorded in "An integrated recirculating aquaculture system (RAS) for land-based fish farming" by Zhang, *et al.* (2011). This study moderate EC mean is likely due to the daily water renewal of the larvae culture tanks in contrast to others that retains their media over a long period.

TDS tends to be higher in culture media with increased metabolism activities. The same trend was observed in this investigation. Tanks-B used for culturing FFFL recorded a cumulative mean of 138.8 ppm while Tanks-A used for LZFL had 127.79 ppm. This relatively higher TDS in Tanks-B could be attributed to the disintegration of uneaten FFD, which is akin to accumulation of effluents sediments in water bodies (Obhahie *et al.,* 2007; 2025).

The total-alkalinity (TA) and dissolved-oxygen (DO) mean values are plotted as column-chart in Figs. 6 and 7. The mean values fluctuated moderately, with FFFL ......

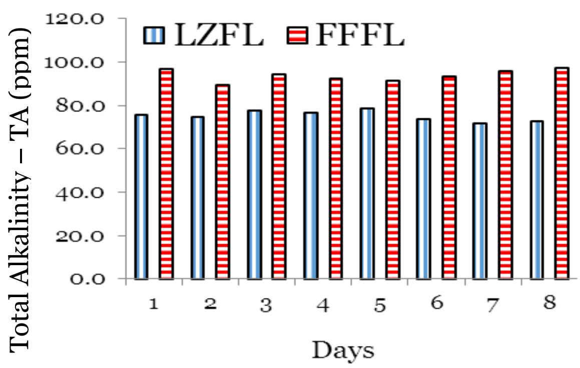

Figure 6: Average daily TA concentration.

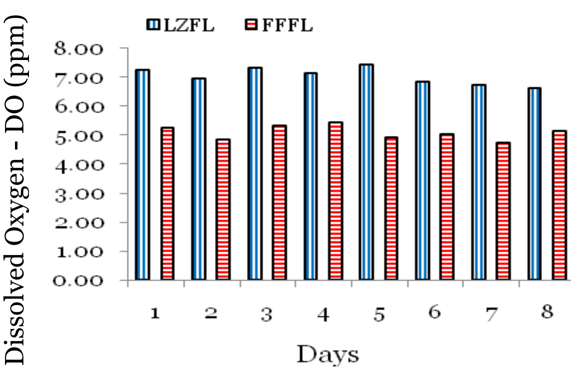

Figure 7: Average daily DO concentration.

culture mean values slightly higher in TA, while LZFL culture media recorded a higher mean value in DO. The values of TA had significant differences ($P \leq 0.05$), while DO have no significant differences ($P > 0.05$). The total alkalinity collective mean values recorded in Tanks-A was 74.99 ppm while Tanks-B was 93.45 ppm. These investigation's values were within the 40.0 - 41.50 ppm obtained by Ovie *et al.* (2001); while the 60.0 - 340 ppm recorded by El-Naggar *et al.* (2008) and the 108.1 -

154.98 ppm mean values obtained by Obhahie *et al.* (2025) in concrete tanks experiments.

Tanks-A and Tanks-B dissolved oxygen mean values recorded were 7.02 and 5.08 ppm respectively. These mean values meet the acceptable standard for aquaculture, (Eya, 2003). DO of 5.0 ppm is the recommended optimum for fish healthiness, most fish species are distressed at a level of 2 - 4 ppm and fish-kill usually occur at concentrations below 2 ppm. The rate of DO depletion casualty in an event is dependent on how low the DO is, and the duration of anoxicity, (Francis-Floyd, 2003). Previous research reports, such as that of Ovie *et al.* (1997), which recorded 4.4 - 6.2 ppm and the 6.1 - 7.6 ppm reported by Okogwu *et al.* (2006), align with the DO mean values obtained in this investigation. Extreme cautiousness is required when monitoring larvae culture DO owing to the fact that low DO affect larger fish faster than fish larvae, (Francis-Floyd, 2003).

The BOD and the free-CO_2 mean values are plotted as column-chart in Figs. 8 and 9. The means varied moderately. FFFL culture media maintained higher mean in BOD and CO_2 all through the experiments and both parameters had ($P<0.05$) significant difference when Tanks A and B were compared.

Tanks-A BOD mean value was 1.08 ppm, while that of Tanks-B was 1.77 ppm. The relative lower BOD in Tanks-A could be attributed to its medium reduced metabolic activity, owing to the fact that LMSZD produces very little or no residual organic matter, compared to FFD in Tanks-B (Obhahie *et al.,* 2025).

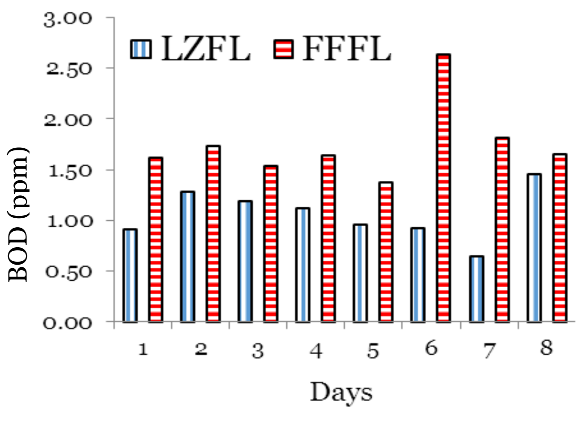

Figure 8: Average daily BOD range.

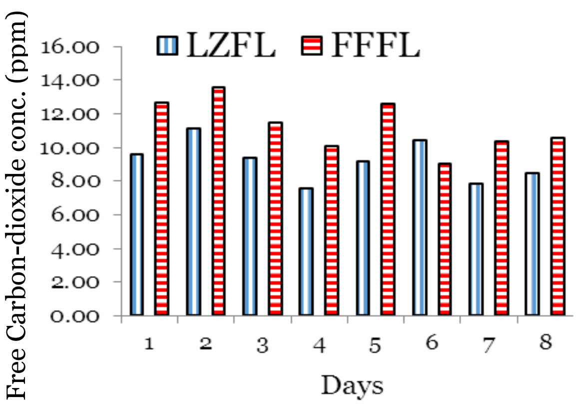

Figure 9: Ave. daily free CO_2 concentration.

However, this investigation's mean values (1.08 and 1.77 ppm), were relatively low, in contrast to previous reports of 1.6 - 2.05 ppm obtained from Kiri and Dandi kowa reservoir by Ovie *et al.* (2001), the 1.7 - 2.6 ppm recorded in NNFR Estate Integrated poultry-fish reservoir and 2 new reservoirs by Azionu *et al.* (2001) and the 2.23 - 2.42 ppm mean values recorded by Obhahie *et al.* (2025) in concrete tanks experiments. The low BOD values reported in this study likely resulted from the daily water renewal of the larvae rearing tanks in contrast to the reservoirs and other aquacultural procedures that retains culture media for weeks, months or years.

The free-CO_2 mean values in Tanks-A was 9.14 ppm while Tanks-B had 11.08 ppm. The relative higher CO_2 in Tanks-B is likely due to the increased residual organic matter load of FFFL environs media when compared to that of LZFL in Tanks-A, which produces very little or no residual organic matter (Obhahie *et al.,* 2025). CO_2 optimum threshold consideration for freshwater aquaria is 20 - 30 ppm, while 4 - 7 ppm is recommended for marine, (Marinou *et al.,* 2020; Hargreaves and Brunson, 1996). Thus, the CO_2 values (9.14 and 11.08 ppm) recorded in this investigation were within the acceptable range required for fish larvae culture.

The daily renewal of culture media was necessary for the management and reduction of organic matter accumulation, owing to fact that uneaten formulated-feed, larvae-faeces and dead-decaying fish larvae will after a certain period degrade and increase the level of CO_2, carbonic acid, ammonia, humic acids and BOD, which will result in the inhibition of DO and pH level of the culture media (Boyd, 1982; Marinou *et al.,* 2020; Kahami *et al.*, 2023; Obhahie *et al.,* 2025).

Growth Parameters of LZFL and FFFL

Growth parameters of *C. gariepinus* larvae reared on LMSZD and FFD for 15 days were determined using growth rate indicators measurements. The indices for analyses were based on growth parameters, such as length (cm), daily length increase ($Li.d^{-1}$), Relative length increase [RLI] (%), Weight (g), Weight gain (Wg), daily weight gain ($Wg.d^{-1}$), Relative weight gain [RWG] (%), Specific growth rate [SGR] (%), Condition Factor [K] (%). Results of this study showed that LZFL achieved a higher growth, with cumulative length increase (CLI) of 1.20 cm and a cumulative weight gain (CWG) of 0.1755 g in 15 days duration, in contrast to FFFL that attained CLI of 1.00 cm and CWG of 0.1456 g within the same period. The SGR of LZFL was 17.92, while that of FFFL was 16.78. LMSZD seems suitable for length increment, weight gain and higher SGR attainment, than FFD. These findings align with the studies of Ovie *et al.* (1997); Amali and Solomon, (2001); Ovie and Ovie (2002).

Using standard formulae, a hypothetical daily growth rates measured in weight gain per day ($Wg.d^{-1}$) and the length increase attained per day ($Li.d^{-1}$) were obtained. Weight (g) and length (cm) were converted to (mg) and (mm) respectively and plotted as column-charts, in Figs. 10 and 11. The parameters mean values exhibited a

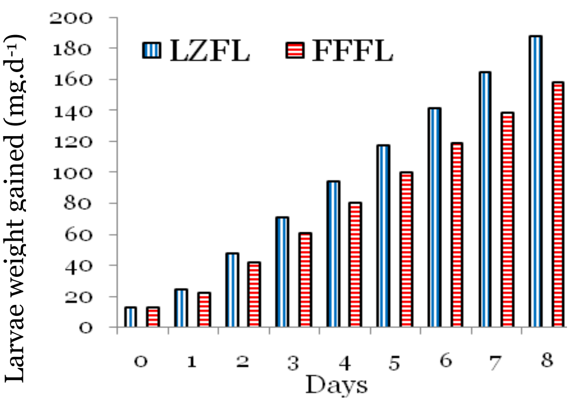

Figure 10: Larvae daily weight gained.

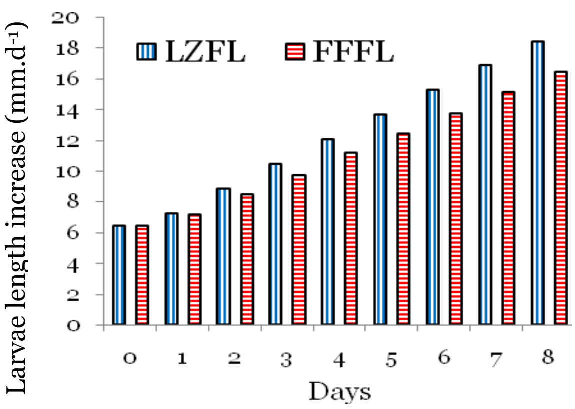

Figure 11: Larvae daily length increase

gradual daily upsurge from day 1 – 15 in both treatments. LZFL maintained a higher growth mean values than FFFL throughout the period of experiments. LZFL and

FFFL both growth indices values exhibited significant difference (P≤0.05) when compared against each other.

The obtained condition factor (K) of LZFL (2.77) and FFFL (3.53) indicated that they were fit, robust, well-nourished, healthy and in optimum well-being, although the growth and survival rate of FFFL were relatively lower, their condition factor showed they were in good condition, in consonance with the works of Hubbs and Lagler (1964); Ovie *et al.*, 1997; Arimoro *et al.* (2008) and Gao (2024).

Survival Rate Parameters of LZFL and FFFL

Survival parameters of *C. gariepinus* larvae reared on LMSZD and FFD for 15 days were appraised using survival rate indicators measurements. The index factors used for analyses were based on survival indices, such as quantity of stocked larvae, total survival, total mortality, Survival rate (%) and Mortality rate (%). The result of the study showed that out of the 600 inds. larvae stocked separately in each set of Tanks-A and Tanks-B, experiments' treatment of LZFL (Tanks-A) recorded a higher total survival (537 inds.), than FFFL (Tanks-B) that recorded a total survival of 330 inds. The LZFL had a higher survival rate (89%) than FFFL (55%), while FFFL had a higher mortality rate (45%) than the LZFL (10.5%). There were varied exhibition of significant difference by the various indices data analyzed. With respect to stocked larvae (600 inds.), LZFL total survival (537 inds.) compared to FFFL's (330 inds.), did not show no significant difference (P>0.05). However, with respect to the stocked larvae (600 inds.), LZFL total morality (63) compared to FFFL's (270) showed significant difference (P≤0.05); LZFL survival rates (%) compared to FFFL's and LZFL mortality rate (%) compared to FFFL's, also exhibited significant difference (P≤0.05) when compared against each other. The larvae survival rate (%) and mortality rate values are plotted as pie-charts in Figs. 12 and 13.

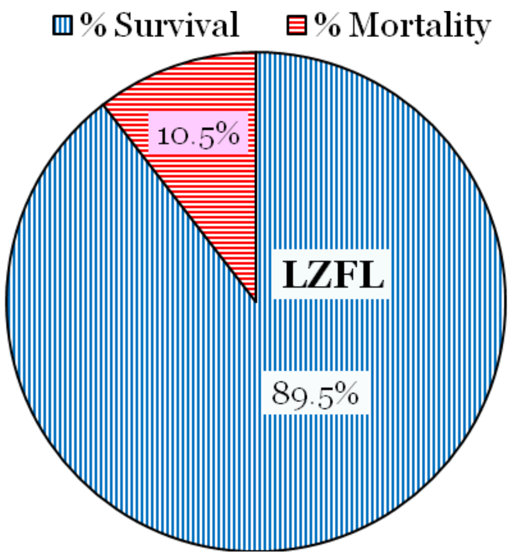

Figure 12: LZFL survival and mortality rate (%)

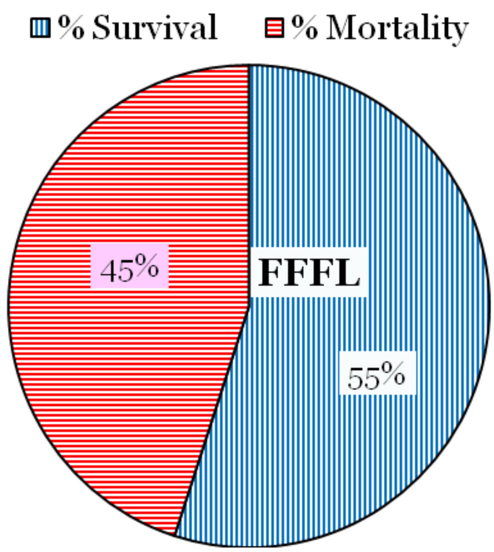

Figure 13: FFFL survival and mortality rate (%)

Several previous investigations reports averred that fish larvae reared on LZD attained creditable survival rate, Olurin and Oluwo (2010); Okunsebor (2014). The report of this investigation demonstrates that LZFL attained higher survival rate, (89.5%,) compared to FFFL (55%) survival rate. Consequently, MSZD is more supportive of a higher survival-rate, than FFD. This study finding corroborates previous reports of the studies of Adeyemo *et al.*, 1994; Ovie *et al.* (1997); Amali and Solomon (2001); Ovie and Ovie (2002) that averred from comparative study of growth and survival rate performance of African catfish species reared on freshwater LZD, *Artemia* and FFD demonstrated that better growth and survival rate outcome were obtained in larvae fed LZD.

Freshwater Natural-live-fish-food (zooplankton) or LZD, hatched *Artemia*-cysts, dried-decapsulated-*Artemia*, boiled-chicken-egg, grinded-dried-fish-powder, blood-meal, (Pandey, 2013) and varieties of formulated-feeds have severally been tried on rearing post yolk-larvae (Ovie *et al.,* 1997; Okogwu *et al.,* 2006; Arimoro *et al.,* 2008), with little or no dependable successes. Freshwater fish species are known to spawn freely in the natural habitat, but with slow growth and lower rate of survival, owing to natural hazards, Viveen *et al.* (1985). The successes achieved through induced fish breeding are truncated by high rate of mortality, usually recorded at the early days of their life, Lavens and Sorgeloose (1996). These deficiencies marred by retard growth and low rate of survival is anchored on many factors, among which insufficient and inappropriate food, ineffective feeding regimes and unhealthy water quality, stands prominent (Huisman, 1976; Madu *et al.,* 1990; Eya, 2003).

Researchers that have previously investigated the effectiveness of LZD, had severally focused on the use of monospecies zooplankton, such as *Brachionus* sp., *Moina* sp., and many other monospecies of rotifers, cladocerans and copepods on rearing fish larvae, but obtained results that were unsustainable and acquired procedures that were not easily transferable, owing to the complexities of the procedural mechanisms, (Ovie *et al.,* 1997). However, a cue from natural occurrence shows that a mixture of natural-live-fish-foods (mixed-species-zooplankton) will offer a more effective diet, being that it provides a wider spectrum of nutrients to the fish larvae, (Rumsey, 1994). Additionally, the mass production of MSZ for fish larvae rearing involves an easier and more realistic technique to Aquaculturists in tropical countries, particularly Africans, when compared to the complex procedures involved in monospecies-zooplankton propagation, (Obhahie *et al.,* 2025).

The relatively lower survival rate FFFL likely resulted from the CO_2 produced during metabolism of uneaten formulated-feed, faeces and dead fish larvae degeneration and their resultant lowering of DO, pH and increasing the BOD of the culture media (Marinou *et al.,* 2020; Kahami *et al.*, 2023). It could infer from this study that FFFL lower growth and survival rate, relative lower SGR and higher cost of procuring FFD will increase cost of production and minimize the Aquaculturists' profit. The low performance of FFD is attributed to its nature of immobility, contrary to zooplankton that are moving and creating current that induces stimulus, a behaviour which enhances their being encountered, seen and ingested by fish larvae, (Lavens and Sorgeloose, 1996).

Conclusion

Findings of this study are that: [1]LMSZD is suitable for fish larvae rearing. [2]LMSZD achieved a higher growth and survival rate than FFD. [3]LMSZD has the potentials of being favourable larvae first exogenous diet compared to *Artemia* and other FFDs. [4]The use of LMSZD and stale/algal water promotes high water quality that requires no-use of aeration. [5]LMSZD produces low CO_2, no humic acids and no carbonic acid concentration, making water quality management easy. [6]LMSZD promotes pH stability, high DO, low BOD, rapid larvae growth, no fish-kill or mass-death.

Affirmations

Participation and Publication Consent

The authors gave their consent to participate in this research project and hereby verify that the research report and manuscript is original and it's neither being considered nor already published by any other journal or elsewhere. They agreed that the manuscript be submitted for publication.

Data Accessibility

Data generated in this research project, analyzed and reported in this manuscript are available and can be accessed through the corresponding author.

Conflict of Interests

The Authors affirm that there are no-conflict of financial/other interests as regards this research experiments, preparation of manuscript nor publication of this article.

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دراسة مقارنة لتأثيرات النظام الغذائي للعوالق الحيوانية المختلطة الأنواع والأعلاف المصنعة على المعايير الفيزيائية والكيميائية ومعدلات النمو والبقاء ليرقات سمكة *Clarias gariepinus*

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المستخلص

تم تقييم تحليل مقارن لتأثيرات نظام العوالق الحيوانية الحي المختلط (LMSZD) ونظام العلف المُصنّع (FFD) على المعايير الفيزيائية والكيميائية لوسط الزراعة، ونمو يرقات سمكة *Clarias gariepinus* ومعدل بقائها لمدة 15 يوماً. أُجريت التجربة في ستة أحواض بلاستيكية سعة 30 لتراً، في ثلاث نسخ (مكررات)، عُرفت بالخزانين "أ" و"ب". زُوّد كل حوض بـ 200 يرقة من نوع "إندستريال" في مرحلة ما بعد صفار البيض، بعمر ثلاثة أيام، وبمتوسط وزن وطول ابتدائيين 0.0128 غ و0.65 سم على التوالي. وُضعت اليرقات التي تتغذى على العوالق الحيوانية الحية (LZFL) في الخزان "أ"، بينما وُضعت اليرقات التي تتغذى على العلف المُصنّع (FFFL) في الخزان "ب". قُدّمت اليرقات مرتين يومياً. أُجري تحليل للمعايير الفيزيائية والكيميائية على مدار يومين، وكانت القيم المتوسطة التراكمية المسجلة في الخزانين (أ) و(ب)، على التوالي، هي: درجة الحرارة (24.24، 23.88°م)، والاس الهيدروجيني (7.29، 6.96)، والتوصيل الكهربائي (263.84، 276.7 ميكروثانية/سم²)، والقلوية الكلية (74.99، 93.45 جزء في المليون)، وإجمالي المواد الصلبة الذائبة (127.79، 138.8 جزء في المليون)، والأوكسجين المذاب (7.02، 5.08 جزء في المليون)، والطلب الحيوي للأوكسجين (1.08، 1.77 جزء في المليون)، وثاني أوكسيد الكاربون الحر (239.14، 11.08 جزء في المليون). كانت معايير النمو لكل من LZFL وFFFL على التوالي، هي زيادة الطول (1.20، 1.00سم)، وزيادة الوزن (0.1755، 0.1456غم)، ومعدل النمو النوعي [SGR] (%) حيث بلغ 17.92، 16.78. أما معدلات البقاء (%) فقد بلغت 89.50، 55.00، بينما بلغ معامل الحالة 2.77 (%) [K]، 3.53 لكل من LZFL وFFFL على التوالي. لم يُلاحظ فرقٌ معنويٌ في الطلب الحيوي للأوكسجين (BOD)، ودرجة الحرارة، والرقم الهيدروجيني (pH)، وثاني أوكسيد الكاربون ($P>0.05$). أظهرت قيم EC، وTA، وTDS، وDO فرقاً معنوياً عند $P\leq0.05$. أظهرت قيم متوسطات مؤشرات النمو ارتفاعاً تدريجياً يومياً في كلا المعاملتين. حافظت LZFL على متوسط قيم أعلى من FFFL طوال التجارب. أظهر كلٌّ من مؤشري نمو LZFL وFFFL فرقاً معنوياً ($P\leq0.05$).

الكلمات المفتاحية: يرقات *Clarias gariepinus*، الأعلاف المصنعة، العوالق الحيوانية الحية المختلطة الأنواع، المعايير الفيزيائية والكيميائية، معدل النمو والبقاء.