Sahel Journal of Life Sciences FUDMA (SAJOLS)
June 2025 Vol. 3(2): 211-221
ISSN: 3027-0456 (Print)
ISSN: 1595-5915 (Online)
DOI: *https://doi.org/10.33003/sajols-2025-0302-26*

Research Article

Comparative Analysis of Organic and Inorganic Fertilizers Effects on Zooplankton Population Dynamics and Physicochemical Parameters of Culture-Media

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ABSTRACT
Efficacy of inorganic (NPK 15:15:15 and Urea) and organic (poultry-droppings) fertilizers in culturing freshwater mixed-species-zooplankton were appraised for 6 weeks, using two tanks designated Tank-A and Tank-B, treated with inorganic and organic fertilizers respectively. Mixed-species-zooplankton were obtained from the wild, nursed in indoor aquaria and used to inoculate outdoor concrete tanks for zooplankton mass-production. Physicochemical parameters cumulative-mean obtained in Tank-A and Tank-B respectively were temperature [^{0}C] (25.19; 24.99), pH (7.38; 7.40), electrical-conductivity (EC) [$^{\mu s}/_{cm}$] (443.66; 387.16) and transparency [cm] (25.34; 24.66), other values (in ppm) were, total-dissolved-solids (TDS), (191.1; 209.68), total-alkalinity [TA] (108.1; 150.98), dissolved-oxygen [DO] (7.80; 5.66), BOD (2.23; 2.42), free-CO_2 (23.0; 31.0), Nitrate (4.62; 3.57), Phosphate (2.47; 2.15) and Potassium (11.49; 10.28). Three zooplankton taxa; Rotifera, Cladocera and Copepoda comprising 15 species were identified. Population density average-mean in Tank-A and Tank-B respectively were combined mixed-species-zooplankton (440 inds.ml^{-1}; 389 inds.ml^{-1}), Rotifera (208; 188 inds.ml^{-1}), Cladocera (129; 110 inds.ml^{-1}), and Copepoda (103; 91 inds.ml^{-1}). Population percentage distribution in Tank-A and Tank-B were Rotifera (47.37; 48.26%), Cladocera (29.28; 28.32%) and Copepoda (23.35; 23.42%) respectively. Temperature, pH, BOD and Phosphate had no significant difference ($P < 0.05$), while TDS, EC, TA, DO, CO_2, Transparency, Nitrate and Potassium showed significant differences ($P < 0.05$). Zooplankton population density also showed significant differences ($P < 0.05$) between the values of Tank-A against Tank-B. However, the over-all performance of both fertilizers and zooplankton response were within the optimum ranges for simulated aquatic environments' requirements for zooplankton mass-production.

Keywords: Formulated-feed; Inorganic-organic-fertilizers; Mixed-species-zooplankton; Physicochemical-parameters; Population-dynamics

Citation: Obhahie, A.I., Oyewumi, J.O. & Agbon, A.O. (2025). Comparative Analysis of Organic and Inorganic Fertilizers Effects on Zooplankton Population Dynamics and Physicochemical Parameters of Culture-Media. *Sahel Journal of Life Sciences FUDMA*, 3(2): 211-221. DOI: *https://doi.org/10.33003/sajols-2025-030222-26*

INTRODUCTION

Zooplankton are organism that are drifted by lotic waters and floats on lentic water body. Zooplankton sizes range from tenth of millimeter to four millimeter, (Eya, 2003; Shulz, 2012). They serve important role in food-chain and food-web through serving as a link between lower trophic and higher trophic level organisms, (Shulz, 2012; wikiwand, 2025). Freshwater zooplankton has the potential of replacing *Artemia* and artificial feeds in fresh-water fish breeding, (Oladele and Omitogun, 2016; Ekelemu and Nwabueze, 2010). Zooplankton can serve as biological monitoring agents as regards toxicology and aquatic ecosystems' reaction to climate change, owing to their abundance and species diversity, due to the fact that they have short lifecycles that generally spans within weeks, (wikiwand, 2025; Shulz, 2012; Mackas and Beaugrand, 2010). They are able to provide adequate protein needed for growth and proper development of several species of fish larvae, (Ovie and Ovie, 2002; Amali and Solomon, 2001; Lubzens *et al*. 2001).

Zooplankton are categorized based on their lifecycle and size. On the basis of life-cycle, they are classified into holozooplankton (i.e. zooplankton that live their entire lifecycle as plankton) and merozooplankton (i.e. living part of their life as plankton before metamor-phosing into either nekton, sessile or benthic living), (Shiffert, 2020; wikiwand, 2025), while based on size, they are classified as picozooplankton (2µm), nanozooplankton (2 - 20µm), microzooplankton (20 - 200µm) and mesozooplankton (0.2 - 20 mm). Among the larger size of zooplankton are the mesozooplankton, which are dominated by copepods, while the preceding size are the microzooplankton which are mostly rotifers and cladocerans, (wikiwand, 2025; Shulz, 2012; Eya, 2003; Schwoerbel, 1970).

Zooplankton feed on fresh-sprout bacterio-plankton, phytoplankton, organic-detritus or prey on smaller animals depending on species, (Shulz, 2012; Eya, 2003). They are present and wildly distributed over the water-body column, being mostly abundant where food is available. Zooplankton biomass and species composition in ponds and shallow water fluctuates depending on interrelating driving force that may include polymixis, condition of weather, change in water level, food/feeding management and nutrients load, (Shulz, 2012; Borics *et al*. 2000). Studies have shown that quality and quantity of zooplankton abundance varies from one location to another under the same environment and within the same ecological conditions, (Bhuiyan *et al*. 2008). Season, physicochemical parameters, such as soil, water-movement and biological factors affects zooplankton distribution and abundance, (Davis *et al*. 2009).

Owing to the driving force and factors affecting zooplankton availability and abundance, there is need for managed simulated environment, suitable for mass production of zooplankton to meet the need of freshwater fish breeder, (Eya, 2003; Shulz, 2012). The commonly cultured zooplankton group for commercial finfish and shellfish rearing are rotifera, cladocera and copepoda, (Shulz, 2012; Eya, 2003).

Freshwater fish species spawns freely in the wild, but with low survival rate, as a result of climatic and biological setbacks, (Okogwu *et al*. 2006). The achievement made by induced fish breeding under managed hatchery is lost through high mortality rate at early days of fry-life (Okogwu *et al*. 2006). Fish larvae poor growth and high mortality rates have been traced to several factors, among which inappropriate, inadequate, lack of suitable food and poor water quality predominates, (Eya, 2003; Okogwu *et al*. 2006; Obhahie, 2022). Thus, comprehension of managed production of freshwater zooplankton will be of great assistance to freshwater fisheries industry in Africa and particularly in Nigeria, (Okunsebor, 2014; Ekelemu and Nwabueze, 2010).

Neonate fish larvae are fragile, minute, immature, have tiny mouth size, undeveloped chemoreceptors, eyes and digestive system that limit their proper food choice and intake at the point of exogenous first-feeding stage, (Lavens and Sorgeloose, 1996). The nutritional value of formulated feed is inadequate to supply the required nutrients for fish larva, when compared to natural fish food that from studies has shown the potential to meet the necessary nutritional requirement, (Okunsebor, 2014). These qualities inform Aquaculturists' selection criteria for suitable fish larva diet, (Figure 1[adapted from: Lavens and Sorgeloose, 1996]).

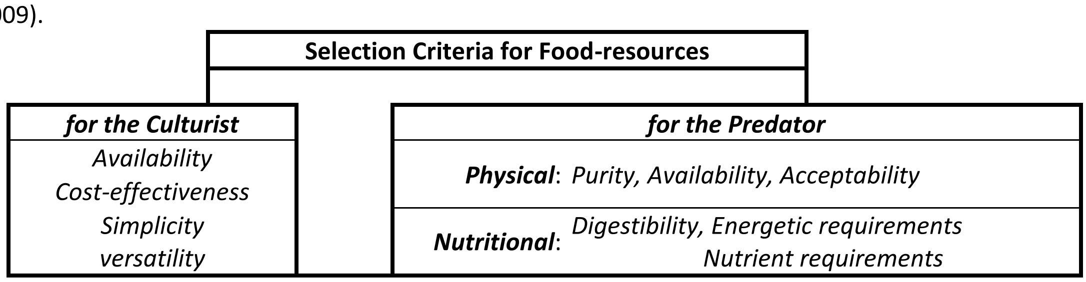


Figure 1: **Criteria for fish larva food selection**

Common culturable zooplankton for freshwater fish larvae are, Rotifera (e.g. *Brachionus* sp.), Cladocera (e.g. *Moina* spp.) and copepod (e.g. *Cyclopod* spp.). Freshwater zooplankton maintains a life-span of about four weeks in the freshwater habitat, (Delbare and Dhert, 1996; Eya, 2003; Shulz, 2012), and can be easily mass produced, harvested and use for freshwater larval culture (Ajah, 2010; Shulz, 2012)

Fertilization of zooplankton culture tank is a common practice for establishing adequate quantities and qualities of zooplankton production for fish. The applied fertilizer could be inorganic or organic based. Inorganic fertilizers commonly applied are those that have components of nitrate (N) phosphorus (P) and potassium (K) or Urea (Boyd and Massaut, 1999; Obhahie, 2022; Eya, 2003). While organic fertilizers commonly applied could be sourced from wide range of animals' faeces or sourced from plants (Knud-Hansen, 1998). Suitable organic fertilizers should have low carbon-nitrogen ratio and fine particle size to allow rapid decomposition, (Geiger and Turner, 1990).

The assertion behind culture fertilization is to provide nutrients for phytoplankton increase production, which will in-turn favour increase of zooplankton population that feed on phytoplankton. Effect of fertilizers application on the quality and quantity of zooplankton culture is determined by the relative composition of zooplankton species in a particular culture pond. Rotifera, Cladocera and Copepod, species are commonly used zooplankton for fish larvae rearing. Their age at maturity, rate of egg production and quantity of eggs produced is affected by their food quality and quantity, (Eya, 2003). Thus, inorganic and organic fertilizers are applied to increase phytoplankton production that in-turn provides essential nutrient to enhance productivity of zooplankton which eventually serve as food for fish larvae, (Young and Flickinger, 1988; Boyd and Massaut, 1999; Obhahie, 2022).

MATERIALS AND METHODS

Study Area Description

The experiment was carried out in concrete tanks situated at the Hatchery in the Department of Animal and Environmental Biology, Federal University Oye-Ekiti, (FUOYE), main campus, phase II, Oye-Ekiti, Nigeria. Water sampling for physicochemical parameters and zooplankton analysis was carried-out in 6 weeks, spanning through October to December. The culture concrete tanks were designed to accommodate 1,200 litres (L) of water, but were filled to a volume of 1,000 L. The culture tanks were filled with water from borehole. The Hatchery has perimeter fence for safety and prevention from intruders.

Concrete Tanks Preparation

Two tanks designated Tank-A and Tank-B were used for the experiment. The tanks were checked for firmness and leakages by letting water into them and observed for 24 hours and drained. Noticed leakages were mended and thereafter water was let-in and left for some days for curing to be carried-out.

Concrete Tanks Curing

Tank curing was achieved by letting in water, in addition with fertilizer for rapidity. The tanks were left uninterrupted for some days, except for interval stirring to enhance nutrient circulation, until algae and insects' larvae were noticed in the tanks, indicating the tanks' ability to support life.

Zooplankton Culture Tanks Fertilization, Maintenance and Management

Fertilization of tanks for algae production was carried out by adding 20 g each of inorganic fertilizers, (NPK-15:15:15 and Urea) to Tank-A and addition of 200 g of organic fertilizer, (dried-pure poultry-droppings) to Tank-B. The inorganic fertilizers were applied via direct dissolution into Tank-A, while the organic fertilizer was dissolved in water, sieved and the solute poured into culture Tank-B. The tanks were left undisturbed, except for regulated stirring for nutrient circulation. When phytoplankton bloom was adjudged well established and rich enough to sustain zooplankton mass production, the culture tanks media were inoculated with nursed mixed-species-zooplankton samples. Culture media were renewed weekly by addition of prepared fertilizers. Zooplankton culture media were sometimes slightly drained and refilled with water in-order to cut-back excess fertilizer and achieve optimum phytoplankton bloom, in accordance to Eya, (2003); Arimoro, (2006); Obhahie, 2022.

Wild-zooplankton Collection, Nursing and Culture Tanks Inoculation

Wild mixed-species-zooplankton samples were collected from lentic ponds at Itaji, Oye, Ekiti State, with the aid of 50µm mesh-size plankton net and poured into a plastic-bucket until 10 L samples was collected and transported to Hatchery at FUOYE, where it was filtered with 1mm mesh-size net and introduced (at 5 L each) into two 30 L plastic-aquaria, tagged Tank-A and Tank-B, containing algae culture media obtained from concrete Tank-A and Tank-B respectively. The wild-zooplankton samples were nursed, for acclimatization and mass multiplication in the plastic-aquaria for about a week before being gradually used to inoculate the concrete culture tanks containing 1,000 L of water, in accordance to the methods described by Eya (2003) and Obhahie, (2022), while some were reserved in the plastic-aquaria culture for continuous close range culture and multiplication. Zooplankton samples collection was done in accordance to Goswami, (2004).

Wild and Cultured Zooplankton Sample Qualitative and Quantitative Analysis

A portion of the filtered wild-zooplankton sample was transferred into a 100 ml bottle and preserved with 5% formaldehyde, while the larger portion was used to inoculate the plastic-aquaria zooplankton nursing culture media.

Zooplankton samples were harvested from the concrete tanks culture media 3 times a week in 10 L plastic bucket and filtered. A portion of it was transferred into a 100 ml bottle and preserved with 5% formaldehyde, while the remaining larger portion was used to feed fish larvae. The preserved zooplankton samples were examined with microscope to ascertain the qualitative and quantitative nature of its composition. Zooplankton samples collection was carried-out in accordance to Goswami, (2004).

Zooplankton samples identification was carried out by examining about 25 ml of the preserved sample. A drop (1 ml) of the sample was made on counting-chamber, placed on an electric-light-microscope and examined using two magnifications of x40 (to obtain a general view of the species composition) and x100 (to ascertain species identification). Zooplankton identification and enumeration was done in accordance to Jeje and Fernando, (1986), Shiel, (1995) and Goswami, (2004).

Physicochemical Parameters

Water samples were obtained from culture tanks 3 times per week and analyzed for physicochemical parameters, which includes Temperature, pH, Total Dissolved Solids (TDS), Electrical Conductivity (EC), Transparency, Total Alkalinity (TA), Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Free Carbon Dioxide (CO_2), Nitrate (N), Phosphate (P) and Potassium (K). Temperature, pH, TDS and EC were determined with the aid of Digital-Multiple-Parameters-Tester (DMPT). Transparency was determined with Secchi-disc. TA, BOD, Free CO_2 and DO were analyzed by titrimetric method, in accordance to APHA, *et al*. (2017). Nitrate (N) and Phosphate (P) were determined with Spectrophoto-meter, while Potassium (K) was determined by atomic Absorption Spectrophotometer (AAS).

Data Analysis

The physicochemical parameters and zooplankton species population densities data were analyzed using the descriptive statistics to obtain mean (M) and standard deviation (SD), while analysis of variance (ANOVA): t-Test: Paired Two Sample for Means at 95% confidence level were used to determine the significant difference among means. The effect of types of fertilizers on zooplankton species population density and physicochemical parameters values are as presented in column-chart figures.

RESULTS

Physicochemical Parameters

Table 1 records zooplankton culture media physicochemical parameters obtained in Tank-A. Column 1 – 6 contains the weekly mean ($\bar{x}$) and standard deviation (SD/±) of the 12 parameters, while column 7 bears Week 1 – 6 cumulative mean and SD.

Table 2 recorded the zooplankton culture media physicochemical parameters obtained in Tank-B. Column 1 – 6 contains the weekly mean ($\bar{x}$) and standard deviation (SD/±) of the 12 parameters, while Week 1 – 6 cumulative mean and SD are recorded in column 7.

The mean values of Tank-A and Tank-B are plotted in column-chart (figures 2 – 13). The physicochemical parameters mean values fluctuated slightly. Tank-A recorded slightly higher mean values in temperature, EC, transparency, DO, nitrate, phosphate and potassium, while Tank-B had higher mean values in pH, TDS, TA, BOD and CO_2.

Temperature, pH, BOD and Phosphate exhibited no significant difference ($P < 0.05$) between their values in Tank-A against Tank-B, while the values of TDS, EC, TA, DO, CO_2, Transparency, Nitrate and Potassium had significant differences ($P < 0.05$) between their value in Tank-A against Tank-B.

Table 1: Physicochemical Parameters' Mean and Standard Deviation in Tank A

Parameters	WEEK 1	WEEK 2	WEEK 3	WEEK 4	WEEK 5	WEEK 6	WEEK 1 - 6
Temperature (^{0}c)	26.54±0.53	25.53±0.42	25.57±0.47	24.65±0.94	24.67±1.25	25.52±0.41	25.19±0.48
pH	7.02±0.11	7.06±0.63	7.27±0.43	7.37±0.41	7.57±0.44	7.65±0.35	7.38±0.24
EC (µs/cm)	394.2±21.16	412.3±22.34	462.5±24.52	455.4±13.79	422.8±24.97	465.3±23.25	443.66±24.4
Transparency (cm)	28.52±0.52	26.54±0.52	24.56±0.54	25.58±1.48	23.92±0.72	26.08±1.07	25.34±1.08
TDS (ppm)	138.2±23.97	152.8±34.75	173.7±26.53	195.2±27.31	220.3±24.18	213.5±32.36	191.1±28.02
TA (ppm)	78.50±23.56	96.50±19.54	88.5±22.51	139.4±22.53	112.7±16.62	103.4±15.65	108.1±19.63
DO (ppm)	6.51±0.12	7.34±0.12	8.52±0.41	6.76±0.58	7.58±0.46	8.78±0.62	7.80±0.84
BOD (ppm)	1.06±0.29	1.55±0.23	2.83±0.38	1.65±0.64	2.28±0.36	2.85±0.32	2.23±0.62
Free CO2 (ppm)	11.00±1.41	18.00±1.42	31.50±2.12	26.50±0.71	20.50±0.71	18.50±0.71	23.00±5.83
Nitrate (ppm)	4.25±0.35	3.65±0.23	4.25±0.45	4.85±0.33	5.64±0.32	4.72±0.22	4.62±0.74
Phosphate(ppm)	1.51±0.25	1.85±0.02	2.12±0.04	3.31±0.05	3.55±0.02	2.03±0.43	2.47±0.66
Potassium (ppm)	10.36±2.03	10.57±2.01	11.51±2.12	10.67±1.08	13.77±1.03	10.92±1.03	11.49±1.33

Table 2: Physicochemical Parameters' Mean and Standard Deviation in Tank B

Parameters	WEEK 1	WEEK 2	WEEK 3	WEEK 4	WEEK 5	WEEK 6	WEEK 1 - 6
Temperature (^{0}c)	25.35±0.52	24.95±0.42	25.15±0.33	24.33±0.27	25.35±0.25	25.17±0.23	24.99±0.40
pH	7.17±0.13	7.14±0.23	7.23±0.15	7.44±0.33	7.47±0.46	7.72±0.63	7.40±0.23
EC (µs/cm)	374.1±1 4.25	386.6±23.43	396.7±25.61	383.9±21.88	364.4±14.16	404.2±22.34	387.16±15.09
Transparency (cm)	27.53±0.53	25.55±0.56	24.57±0.52	24.59±0.47	24.15±0.45	24.38±1.86	24.66±0.53
TDS (ppm)	148.1±32.86	167.2±24.64	186.1±35.42	206.1±33.29	248.6±26.27	240.4±27.45	209.68±37.76
TA (ppm)	127.5±24.55	147.5±13.53	167.5±23.52	168.3±23.54	149.3±23.37	142.3±22.54	154.98±12.07
DO (ppm)	4.45±0.22	4.92±0.21	5.88±0.43	5.82±0.52	6.42±0.24	5.26±0.62	5.66±0.58
BOD (ppm)	1.25±0.22	1.75±0.26	2.15±0.53	2.02±0.53	3.02±0.49	3.17±0.88	2.42±0.63
Free CO2 (ppm)	19.00±1.41	25.50±0.71	36.50±2.12	33.50±0.71	31.00±1.41	28.50±2.50	31.00±4.27
Nitrate (ppm)	3.60±0.25	3.10±0.35	3.51±0.15	3.75±0.43	3.95±0.64	3.52±0.12	3.57±0.32
Phosphate(ppm)	1.05±0.33	1.73±0.01	2.02±0.05	2.32±0.02	2.82±0.03	1.85±0.13	2.15±0.44
Potassium (ppm)	8.35±0.15	8.59±1.02	10.72±1.09	9.94±2.05	11.72±1.02	10.45±1.06	10.28±1.15

Abbreviations: EC [Electrical Conductivity]; Total Dissolved Solids (TDS); TA [Total Alkalinity]; BOD [Biochemical Oxygen Demand]; CO_2 [Free Carbon Dioxide]; DO [Dissolved Oxygen]

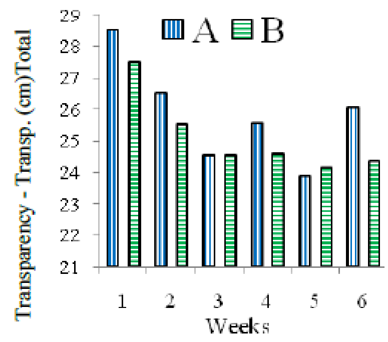


Fig. 5: Weekly Transparency range

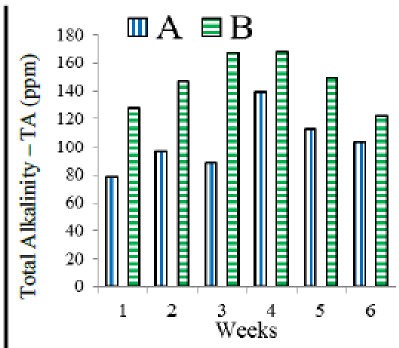


Fig. 6: Weekly T. Alkalinity conc.

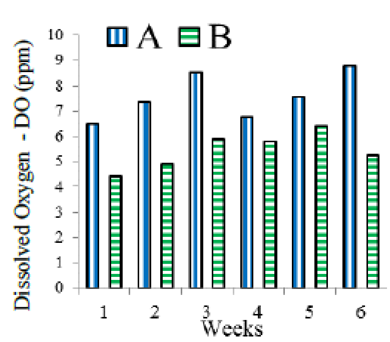


Fig. 7: Weekly DO concentration

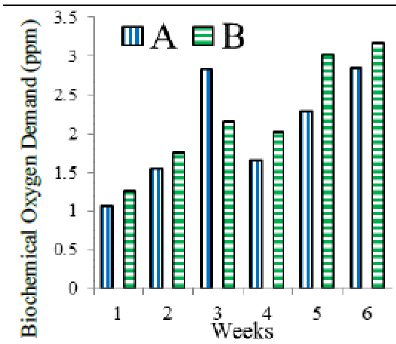


Fig. 8: Weekly BOD range

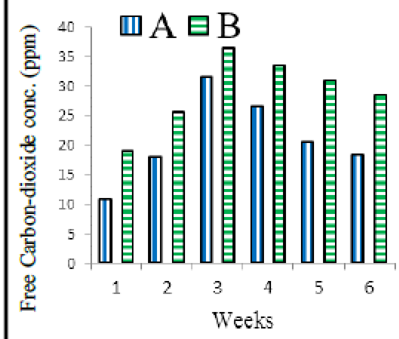


Fig. 9: Weekly free CO_2 conc.

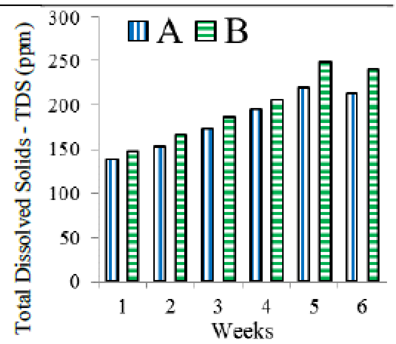


Fig. 10: Weekly TDS concentration

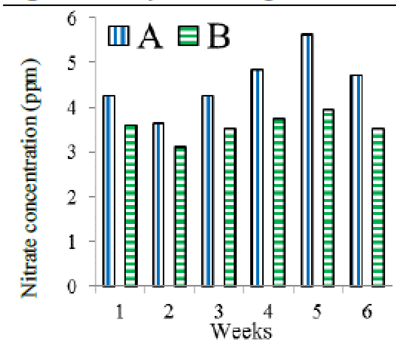


Fig. 11: Weekly Nitrate conc.

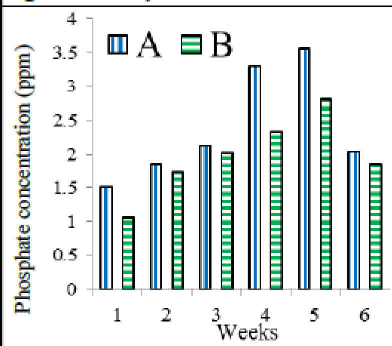


Fig. 12: Weekly Phosphate conc.

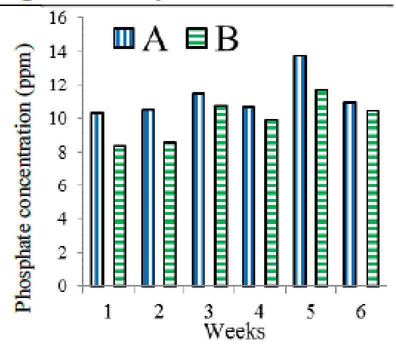


Fig. 13: Weekly Potassium conc.

Zooplankton Population Density

Three zooplankton taxa, Rotifera, Cladocera and Copepoda comprising 15 species were identified. Table 3, column 1 -12, row 1 -3 shows the weekly zooplankton taxa popula-tion mean obtained from samples analysis and presented in column-chart, figures 14, 15 and 16.

Table 3, row 4 (Total) shows week 1 – 6 total collective mean ($\bar{x}$) of mixed-species-zooplankton population densities that are presented in column-chart in Figure 17. The population density mean-values-total of mixed-species-zooplankton obtained from Tank-A and Tank-B, in each Week 1 - 6 were 432 and 388 inds.ml^{-1}; 427 and 399 inds.ml^{-1}; 451 and 401 inds.ml^{-1}; 438 and 391 inds.ml^{-1}; 447 and 365 inds.ml^{-1}; 437 and 389 inds.ml^{-1} respectively.

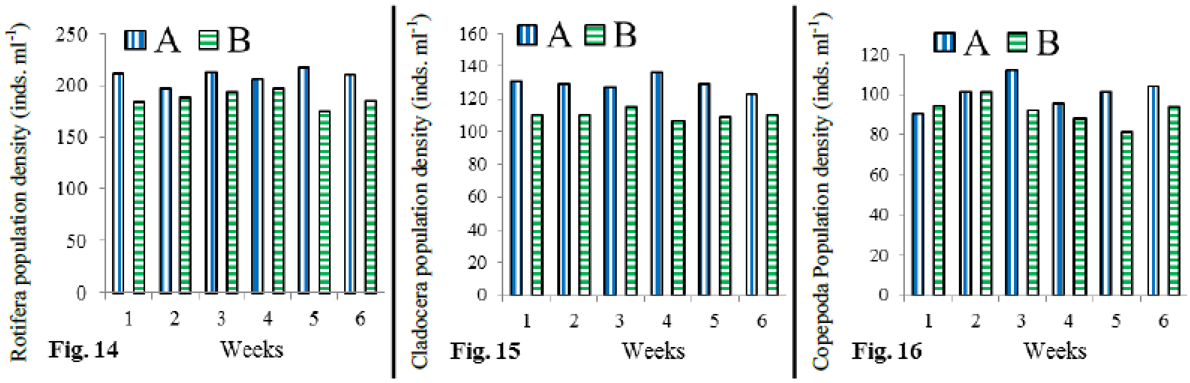
Table 3, columns 13 and 14, shows week 1 – 6 cumulative mean ($\bar{x}$) of mixed-species-zooplankton population densities, which are plotted in Figure 18. The population density mean values of zooplankton varied-taxa reared in Tank-A and Tank-B were, Rotifera (208.4 and 188.7 inds.ml^{-1}), Cladocera (128.8 and 110.2 inds.ml^{-1}) and Copepoda (102.7 and 91.14 inds.ml^{-1}) respectively, and its represented with column-chart by Figure 18

Columns 15 and 16 of Table 3, recorded collective average week 1 – 6 zooplankton taxa percentage (%) mean population distribution that are plotted in Figure 19. The obtained population percentage distribution in Tank-A and Tank-B were Rotifera (47.37; 48.26%), Cladocera (29.28; 28.32%) and Copepoda (23.35; 23.42%) respectively.

The t-test: paired two sample for means statistical analysis of the zooplankton population density showed that there was significant differences (P < 0.05) between the value obtained from Tank-A when compared to those obtained from Tank-B.

Table 3: Zooplankton Taxa Population Density Mean and Percentage in Tank-A and Tank-B (inds.ml^{-1})

Zooplankton	Week 1		Week 2		Week 3		Week 4		Week 5		Week 6		Wk 1 - 6 ($\bar{x}$)		Wk 1 - 6 (%)	
Taxa	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
Rotifer	211	184	197	188	212	194	206	197	217	175	210	185	208.4	187.8	47.37	48.26
Cladocera	131	110	129	110	127	115	136	107	129	109	123	110	128.8	110.2	29.28	28.32
Copepoda	90.3	94.3	101	101	112	92.2	95.7	87.7	101	80.8	104	93.6	102.7	91.14	23.35	23.42
Total	432	388	427	399	451	401	438	391	447	365	437	389	440	389	100.0	100.0



Figs. 14 - 16: Population density of Rotifera (14), Cladocera (15), Copepoda (16) reared on inorganic (A) and organic (B) fertilizers

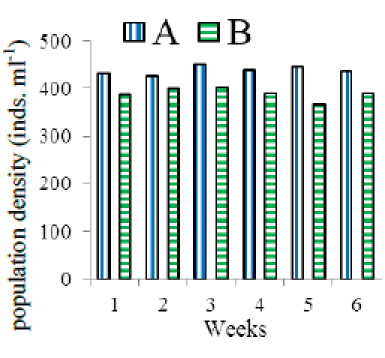


Fig. 17: Daily mean Population density of mixed-species-zooplankton.

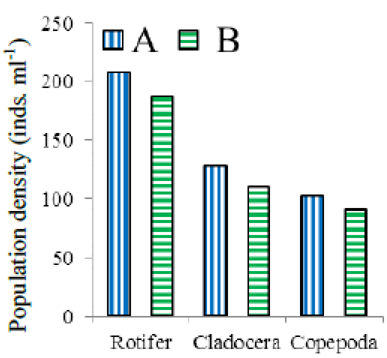


Fig. 18: Daily average mean population density of zooplankton varied-taxa.

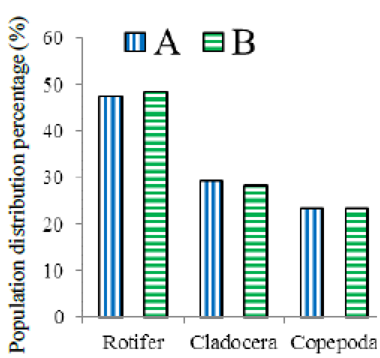


Fig. 19: Zooplankton taxa percentage (%) mean population distributior

DISCUSSION

Inorganic and organic fertilizers are commonly used in zooplankton culture to enhance algal blooms that in-turn serve as source nutrients to zooplankton, (Boyd and Massaut, 1999; Shulz, 2012; Ekelemu and Nwabueze, 2010). Inorganic fertilizer favours higher population density of zooplankton (Mosha *et al*. 2016) owing to its immediate release of nutrients, (Boyd and Massaut, 1999). Organic fertilizers may in contrast promote excessive phytoplankton blooms that could potentially affect water quality, survival, abundance and composition of zooplankton, (Boyd and Massaut, 1999). Commendable improvements were reported in inorganic and organic fertilizers treated zooplankton production tanks when compared to unfertilized culture (Mosha *et al*. 2016; Boyd, 1982). Organic fertilizer application have been reported to have creditable results on zooplankton culture, being that they are proficient in supplying the required nutrients necessary for zooplankton mass production (Orji and Chibugwu, 2010).

The zooplankton culture media physicochemical parameters obtained in Tank-A fluctuated slightly against that of Tank-B. The mean values obtained were within suitable range for tropical freshwater zooplankton production in simulated aquatic environments, when evaluated with previous works carried-out by Orji and Chibugwu, (2010), Akodogbo *et al*. (2014), Mosha *et al*. (2016), Yakubu *et al*. 2018) and several other Scientists.

The temperature mean ranges were 24.65 – 26.54^{0}C in Tank-A and 24.33 – 25.35 in Tank-B. These mean values are within the required limits for zooplankton optimum multiplication, (Arimoro and Ofojekwu, 2004), being that at a temperature below 20^{0}C the rate of zooplankton multiplication decreases in culture ponds, (Kim, 1972). The general temperature of the experiment's vicinity is within 24 – 27^{0}C range, which is appropriate for outdoor zooplankton culture, (Ludwig, 1993; Mosha *et al*. 2016).

The pH values were alkaline, ranging from 7.02 – 7.65 in Tank-A and 7.14 – 7.72 in Tank-B, which are consistent with previous studies, (Islam *et al*. 2000; Oladele and Omitogun 2016). Research reports earmarked the optimum zooplankton culture average pH requirement to be within 6.5 – 8.5 pH range, (Eya, 2003; El-Naggar *et al*. 2008), which aligns with the result of this investigation.

Naturally transparency tends to be inverse to TDS, same tendency was observed in this investigation. The Tank-A and Tank-B highest transparency mean (28.52 and 27.53cm) coincided with the lowest TDS mean (138.2 and 148.1 ppm) in week 1, equally, transparency lowest mean (23.92 and 24.15 cm) coincided with TDS highest mean (220.3 and 248.6 ppm) at week 5, in Tank-A and Tank-B respectively. This gradual increase in TDS (turbidity) and inverse corresponding decrease of transparency is as a result of phytoplankton and zooplankton population density proliferation within the period, (Reid and Wood, 1976; Adeniji *et al*. 1997; Azionu *et al*. 2001).

The EC started with its lowest mean values (394.2 and 374.1 µs/cm) at week 1, in both tanks. The highest values (465.3 and 404.2 µs/cm) were achieved in week 6 in Tank-A and Tank-B respectively. There were gradual mean values rise from week 1 to week 3, followed by a gradual decline and a sharp increase in weeks 6. This model of EC behaviour may have been influenced by the pH and alkalinity content of the culture media, being that EC, pH and alkalinity exhibits interwoven relationship, (Akindele, 2013; Ovie *et al*. 2001; Azionu *et al*. 2001).

The total alkalinity (TA) lowest mean (78.5 and 127.5 ppm) were recorded in week 1, in both tanks and the maximum mean (139.4 and 168.3 ppm) were obtained at week 4 in both tanks, followed by decreasing fluctuations in weeks 5 and 6. These decreasing trends may have been influenced by the regimes of fertilizer renewal of the culture media, (Arimoro, 2006). The TA mean values obtained in this investigation were within the natural, 40 – 41.5 ppm recorded by Ovie *et al*. (2001) at Dadin Kowa and Kiri reservoirs and the fertilized, 60 – 340 ppm obtained by El-Naggar *et al*. (2008) in an experiment conducted in earthen ponds.

Dissolved oxygen (DO) lowest mean (4.45 ppm) was recorded in Tank-B at week 1. This could be attributed to the high unutilized organic nutrients from manure at the start of the experiment. As algal bloom proliferates, the DO also improved, reaching its Tank-B maximum (6.42 ppm) at week 5. Tank-A DO lowest mean (6.51 ppm) was recorded in week 1, and it gradually improved to reach its maximum (8.78 ppm) at week 6. This improvement in DO could be attributed to the gradual algal bloom, (Boyd and Massaut, 1999; Eya, 2003).

Tank-A and Tank-B respective BOD lowest mean (1.06 and 1.25 ppm) were recorded in at week 1. This could be attributed to the relatively low and reduced metabolism at the start of work, but as algal bloom increased, metabolism also increased, thereby increasing the BOD gradually to its maximum (2.85 and 3.17 ppm) at week 6, in Tank-A and Tank-B respectively. The gradual increase of BOD, from week1 – 6 is most probably connected to the gradual accumulation of detritus resulting from increased metabolism, (Ovie *et al*. 2001; Azionu *et al*. 2001; Boyd and Massaut, 1999; Eya, 2003; Obhahie *et al*. 2007).

The free-carbon-dioxide (CO_2) lowest mean values (11.00 and 19.00 ppm) were obtained at week 1, in Tank-A and Tank-B respectively. The maximum mean values (31.50 and 36.50 ppm) were recorded at week 3 in Tank-A and Tank-B respectively, followed by a gradual decline and steady increase in weeks 4, 5 and 6.

These patterns of CO_2 behaviour could be associated with organic components gradual build-up and decline in the culture tank, in like manner as the occurrence of organic effluents build-up in water-bodies, (Boyd and Massaut, 1999; Obhahie *et al*. 2007). CO_2 is phytoplankton source of nutrient and its level in ponds exhibits diurnal fluctuation, being highest in the morning and experiencing gradual depreciation as the day progresses owing to the process of photosynthesis of phytoplankton, (Hargreaves and Brunson, 1996).

The experiment started with a moderate mean value of Nitrate (N) of 4.25 and 3.60 ppm, Phosphate (P) of 1.51 and 1.05 ppm and Potassium (K) of 10.36 and 8.35 ppm, at week 1, and a gradual mean values increase culminating at week 5 with maximum mean value of N of 5.64 and 3.95 ppm, P of 3.55 and 2.82 ppm and K of 13.77 and 11.72 ppm, in Tank-A and Tank-B respectively. Week 6 experienced a slight mean values decrease.

NPK are mainly sourced from fertilizers. The regular supply of these nutrients was maintained by periodical renewal, carried-out either weekly or as determined by their available concentration in the culture media. There were situations when the culture media have to be slightly drained and refilled with water in-order to cut back the amount of fertilizer content in it, so as to achieve acceptable nutrient limits and optimum phytoplankton bloom for zooplankton consumption, (Boyd and Massaut, 1999; Eya, 2003; Arimoro, 2006).

The fertilizers reduction was based on deleterious algae bloom and density of zooplankton in the culture tanks and care was taken not to over-fertilize the media, being that algae not consumed beyond a certain period degrades, increasing the level of ammonia, BOD and CO_2, while inhibiting the dissolved oxygen and pH level in the culture media, (Arimoro, 2006; Eya, 2003; Hargreaves and Brunson, 1996; Boyd, 1982). This research report revealed that inorganic and organic fertilizers culture media physicochemical parameters values were within the optimum ranges for simulated aquaculture ecosystems notwithstanding the occurrence of significant difference observed.

Three zooplankton taxa, comprising Rotifera, Cladocera and Copepoda, made-up of 15 species were identified in the culture media samples analysed from both Tank-A and Tank-B. The species composition distributions were 6 species of Rotifera, 5 species of Cladocera and 4 species of Copepoda. Quantitatively and qualitative dominance of the 3 zooplankton taxa were, Rotifera > Cladocera < Copepoda in both tanks.

The cumulative population density mean for week 1 – 6 in Tank-A and Tank-B respectively were 440 inds.ml^{-1} and 389 inds.ml^{-1} (Table 3, column 13 and 14). At taxa level, the mean population density of Rotifera was 208.4 inds.ml^{-1}, Cladocera was 128.8 inds.ml^{-1}, and Copepoda was 102.7 inds.ml^{-1} in Tank-A. Recorded in Tank-B were Rotifera, 187.8 inds.ml^{-1}, Cladocera, 110.2 inds.ml^{-1} and Copepoda 91.14 inds.ml^{-1}. The population density distribution percentage by taxa in Tank-A and Tank-B respectively were Rotifera, 47.37 and 48.26 %, Cladocera, 29.28 and 28.32 %, while Copepoda is – 23.35 and 23.42%.

Result of this research indicated that inorganic fertilizer have more concentrations of nutrients and favoured higher phytoplankton abundance, thus more zooplankton productivity, when compared to organic fertilizer, (Kumar *et al*. 2014; Boyd, 1982). These findings corroborated with Mosha *et al*. (2016) that reported a significant higher abundance of natural-fish-food in inorganic fertilizer treated tanks when compared to organic fertilizer treated tanks. Young and Flickinger, (1988) also reported enhanced zooplankton proliferation with application of inorganic fertilizer in zooplankton production for largemouth bass fingerlings production. Zooplankton high abundance was likely due to adequate availability of nutrients in culture media, (Boyd and Massaut, 1999; Guangjun 2013.

As in this experiment, earlier works reported Rotifera to be a common dominant zooplankton group in fertilized ponds, (Kumar, *et al*. 2014). Similarly, cladocerans and copepod nauplii exhibited significant higher population densities in ponds fertilized with inorganic fertilizer than ponds fertilized with organic fertilizer, (Mischke and Zimba, 2004).

Rotifera, Cladocera and Copepoda were relatively more abundant in this investigation than those reported by Rajalakshmi *et al*. (2012) and Oladele and Omitogun, (2016), but less abundant than the 562 inds.ml^{-1} reported by Arimoro and Ofojekwu, (2004), between 400 and 1,347 inds.ml^{-1} reported by Lubzens *et al*. (1995) and the 1,000 inds.ml^{-1} reported Kim, (1972), although their report was basically on Rotifera culture. Zooplankton size has been shown to determine their population density, Kim, (1972) reported 100 inds.ml^{-1} for larger *Brachionus calyciflorus* and 1,000 inds.ml^{-1} for tiny *Filinia longiseta* in similar ponds and culture condition. However the over-all performance of both fertilizers and zooplankton response in this investigation were within the optimum ranges for simulated aquatic environments required for zooplankton mass production.

CONCLUSION

This research experiment report indicates that inorganic fertilizer (Tank-A) resulted to relatively higher zooplankton population abundance when compared to the organic fertilizer (Tank-B). There is significant difference ($P < 0.05$) between the values of Tank-A against Tank-B. The average population density values of culture Tank-A (440 inds.ml^{-1}) and Tank-B (389 inds.ml^{-1}) are within the optimum range of managed zooplankton culture tank.

Notwith-standing cost of inorganic fertilizers, small-holder farmers can procure and use them, being that relatively little quantity is required. Fish breeders are advised to utilize either or both inorganic and organic fertilizers. The zooplankton culture techniques applied in this study has the potential for Nigeria, in that it encourages the utilization of animal manure.

Acknowledgments
The authors are grateful to the Departments of Animal and Environmental Biology, Federal University Oye-Ekiti and Delta State University, Abraka, Nigeria for providing the facilities used in this research experiments. [2]Tertiary Education Trust Fund, Academic Staff Training and Development (TETFund AST and D) for providing the required funds.

REFERENCES

Adeniji, H. A., Mbagwu, I. G. and Ovie, S. I. (1997). Primary production and biological limnology of Tiga lake, Kano State, after the introduction of Freshwater Clupeids. *In*: *NIFFR Annual Report*. Pp 12 – 17. ISSN 0331 – 9296

Ajah, P. O. (2010). Mass culture of Rotifera (*Brachionus quadridentatus* [Hermann, 1783], using three different algal species. *African Journal of Food Science*, Vol. **4**(3) Pp. 80-85, http://www.academicjournals.org/ajfs

Akindele, E. O. (2013). Relationships between the physicochemical water parameters and zooplankton fauna of Tiga lake, Kano, Nigeria. *Bayero Journal of Pure and Applied Sciences*, 6(1): 95 – 100

Akodogbo, H. H., Bonou, C. A. and Fiogbe, E. D. (2014). Effect of pig dung fertilizer on zooplankton production. *Journal of Applied Biosciences* 84:7665 - 7673. ISSN 1997–5902. www.m.elewa.org. http://dx.doi.org/10.4314/jab.v84i1.7

Amali, E. I. and Solomon, S. G. (2001). "Growth and survival of first feeding larvae of *Clarias gariepinus* fed live and preserved zooplankton. *Journal of Aquatic Science* 16: 29-32.

APHA – American Public Health Association, AWWA – American Water Works Associa-tion, Water Pollution Control Federation (WPCF). (2017). Standard Methods for the Examination of Water and Wastewater 23rd Edition, APHA, AWWA, WPCF, New York. *www.aphabooksstore.org;* Visit *www.standardmethods.org* - ISSN 55-1979

Arimoro, F. O. (2006). Culture of the freshwater rotifer, *Brachionus calyciflorus*, and its application in fish larviculture technology. *African Journal of Biotechnology*. 5 (7), Pp. 536 - 541, http://www.academicjournals.org/AJB ISSN 1684–5315

Arimoro, F. O. and Ofojekwu, P. C. (2004). Some aspects of the culture, population dynamics reproductive rates of the freshwater rotifer, *B. calyciflorus* fed selected diets. *J. Aquatic Sci*. 19(2): 95-98.

Azionu, B. C., Ovie, S. I. and Adigun, B. (2001). Successional pattern of the plankton community of the integrated poultry-fish reservoir and the adjoining newly constructed reservoir in NIFFR Estate, New Bussa. *In*: *NIFFR Annual Report* (2000). Pp 9 – 12. ISSN 0331 – 9296

Bhuiyan, A. S., Islam, M. T., and Shsrmeen, R. (2008). Occurrence and abundance of some copepods in a fish pond in Rajshahi, Bangladesh in relation to the physic-chemical conditions. *Journal of Bioscience*, 16: 115-119.

Borics, G., Grigorzky, I., Szabo, S. and Padisak, J. (2000). Phytoplankton associations in a small hypertrophic fish pond in the east Hungary during a change from bottom-up to top-down control. *Hydrobiologia,* 424(1-3): 79-90.

Boyd, C. E.and Massaut, L. (1999). Risks associated with the use of chemicals in pond aquaculture. *Aquacultural Engineering*. 20: 113-132.

Boyd, C.E., (1982). Water quality management for pond fish culture. Elseiver Publishers, pp.249

Davis, O. A., Abowei, J. F. N. and Otene, B. B. (2009). Seasonal abundance and distribution of plankton of Minichinda stream, Niger Delta, Nigeria. *American Journal of Science Research*, 2(2): 20-30.

Delbare, D. and Dhert, P. (1996). *Cladocerans*, *Nematodes* and *Trichophora* Larvae. In: Lavens, P. and Soegeloose, P. (ed.); Manual on the production and use of live food in aquaculture. FAO *Fisheries Technical Paper* 361, Rome, Pp 283 – 295.

Ekelemu, J. K. and Nwabueze, A. A. (2010). Comparative studies on zooplankton production using different types of organic manure. *In*: *Proceedings of 25th Annual Conference Fisheries Society of Nigeria* (FISON), Lagos, Nigeria. ISSN: 1117-3149

El-Naggar, G. O., Ibrahim, N. A. and Abou-Zead, M. Y. (2008). Influence of fertilizers' types and stocking density on water quality and growth performance of Nile Tilapia – African Catfish in polyculture system. *8th International Symposium on Tilapia in Aquaculture*. WorldFish Center, Regional Center for Africa and West Asia, Abbassa, Abou-Hammad, Sharkia, Egypt. *Email: g.naggar@cgiarorg*

Eya, J. C. (2003). Zooplankton production/water quality management. *In: Farmer-to- Farmer Program*; Manual prepared for Winrock International. Funded by the U. S. Agency for International Development

Geiger, J. G. and Turner, C. J. (1990). Pond fertilization and zooplankton management techniques for production of fingerling striped bass and hybrid striped bass. In Culture and Propagation of Striped Bass and its Hybrids.

Goswami, S. C. (2004). Zooplankton methodology, collection and identification - a field manual. In: Dhargalkar, V.K. and Verlecar, X.N., (Ed.). National Institute of Oceanography, Dona Paula, Goa. Financial Support, Ministry of Environment & Forests, New Delhi

Guangjun, L. V. (2013). Structure and diversity of zooplankton communities in four reservoirs with varying nutrient composition in the Yangtze River Basin, China. Southwest University, Rongchong, China

Hargreaves, J. and Brunson, M. (1996). Carbon Dioxide in Fish Ponds. Southern Regional Aquaculture Center (SRAC) Publication. No. 468. https://aquaculture.ca.uky.edu/files /srac_468_carbon_dioxide_in_fish_ponds.pdf (Retrieved 05 – 06 – 2025).

Islam, M. N., Khan, T. A., and Bhuiyan, A. S. (2000). Ecology and Seasonal abundance of some zooplankton of a pond in Rajshahi. Univ. J. Zool. Rajshahi Univ.19: 25-32.

Jeje, C. Y. and Fernando, C. F. (1986). A practical guide to the identification of Nigerian zooplankton (Cladocera, Copepoda and Rotifera). KLRI Publ., New Bussa, 742 Pp.

Kim, I. B. (1972). Mass production of rotifers for the culture of fish and some shrimp Larvae. *Bulletin of Korean Fisheries Society*. 5: 45 – 49.

Knud-Hansen, C. F. (1998). Pond Fertilization: Ecological Approach and Practical Application. Pond Dynamics/ Aquaculture Collaborative Research Support Program. Oregon State University, Corvallis,125 pp.

Kumar, S. D., Kumar, S. P., Kumar, V. U. and Anbuganapathi, G. (2014). Efficacy of biofertilizer enriched flower waste vermin-compost on production and growth of primary producers and freshwater aquarium fishes Global Veterinaria 13: 215-220.

Lavens, P. and Soegeloose, P. (1996). Manual on the production and use of live food in aquaculture. FAO *Fisheries Technical Paper* 361, Rome, Pp 283 – 295.

Lubzens, E., Gibson, O., Zmora, O. and Sukenik, A. (1995). Potential advantages of frozen algae (*Nannochloropsis*) for rotifer (*Brachionus plicatilis*) culture. *Aquaculture*. 133: 295 – 309.

Lubzens, E., Zmora, O. and Barr, Y. (2001). Biotechnology and aquaculture of rotifer. *Hydrobiologia*. 446/447: 337 – 353.

Ludwig, G. M. (1993). Effects of Trichlorfon, Fenthion, and Diflubenzuron on the zooplankton community and on the production of the reciprocal-cross hybrid stripped bass fry in culture ponds. *Aquaculture*. 110: 301-319.

Mackas, D. L. and Beaugrand, G. (2010). Comparisons of zooplankton time series. *Journal of Marine Systems*, Impact of climate variability on marine ecosystems: A comparative approach.79 (3): 286 – 304. (https://search.worldcat.org/issn/0924-7963)

Mischke, C. C. and Zimba, P. V. (2004). Plankton community responses in earthen channel catfish nursery ponds under various fertilization regimes. *Aquaculture* 233: 219-235.

Mosha, S. S., Kang'ombe, J. Jere, W. and Madalla, N. (2016). Effect of organic and inorganic fertilizers on natural food composition and performance of African Catfish (*Clarias gariepinus*) fry produced under artificial propagation. *J. Aquac. Res. & Development*. 7(8): 441. doi:10.4172/2155-9546.1000441. ISSN: 2155-9546

Obhahie, A. I. (2022). Fish fry nutrition, *In*: *Aquafeed production, economics and health impact in fish management*. Akintomide, T. O., (ed.). OAK Ventures publishing, FRN, Nigeria. ISBN 978-978-51961-5-3. Pp 23 - 37.

Obhahie, A. I., Ugwaka, K. A., Ugwu, L. L. C. and Adesiyan, F. A. (2007). Effects of industrial effluents and municipal wastes on water conductivity and total dissolved solids, sulphate and phosphate ions concentration of Ogba River, Benin City, Nigeria. *Journal of Fisheries International*. 2(4): 277 - 283. *Medwellonline © Medwell Journals*

Okogwu, O. I., Obhahie, A. I., Hamzat, M. and Ovie, S. I. (2006). Growth and survival of Heterobranchus bidorsalis and a hybrid catfish, *Clarias anguillaris* X *Heterobranchus bidorsalis* Larval Reared on Live *Moina micrura. Scietia African* 5(2): 127 – 132.

Okunsebor, S. A. (2014). Culture of Zooplankton (Brachionus calyciflorus, Moina micrura and Daphnia pulex), as Live Food for Heterobranchus bidorsalis Hatchlings. Ph.D. Thesis in the Department of Zoology, University of Jos, Jos, Nigeria.

Oladele, A. H. and Omitogun, O. G. (2016). Raising zooplankton as a substitute for Artemia for feeding the larval and fry stages of African catfish (*Clarias gariepinus*). Livestock Research for Rural Development. 28 (10): Pp 11

Orji, R. C. A. and Chibugwu, K. (2010). Effect of organic fertilizers on zooplankton production. *Journal of Agriculture and Food Sciences*. 8(2): 43 – 48. ISSN 1597 – 1074. *www.imsu-jafs-info*

Ovie, S. I. and Ovie, S. O. (2002). Fish-larval rearing: the effect of pure/Multispecies Zooplankton and artificial diet on the growth and survival of *Clarias anguillaris* (Linnaeus, 1758) larvae. *Journal of Aquatic Sciences* 17(1): 69 – 73. Published by Nigeria Association for Aquatic Sciences

Ovie, S. I., Adepoju, F. and Ajayi, O. (2001). Limnological stock assessment, productivity and potential fish yield of Dadin Kowa and Kiri reservoirs. *In*: *NIFFR Annual Report* (2000). Pp 9 – 12. ISSN 0331 – 9296

Rajalakshmi, M., Ramasubramanian, V. and Priyadarisini, V. B. (2012). Mass Culture of Zooplankton, *Ceriodaphnia cornuta* on Animal Excreta. *Madras Agric. J.*, 99 (10-12): 867-870, https://doi.org/10.29321/MAJ.10.100214

Reid, G. K. and Wood, R. D. (1976).Ecology of Inland water and Estuaries. 2nd Edn. 231pp.

Schwoerbel, J. (1970). Methods for the investigation of the open water zone of standing waters (pelagial). *In: Methods of hydrobiology (Freshwater Biology)*. Schwoerbel, J. (ed.). Pergamon Press, Oxford * London * Toronto *Sydney * Braunschweig

Shiel, R. J. (1995). A guide to identification of rotifers, cladocerans and copepods from Australian inland waters. Co-op. Res. Ctr. for Freshwater Ecology, Murray-Darling Freshwater Res. Ctr., Ellis Street, Thurgoona, Albury, NSW 2640

Shiffert, M. (2020). *Water drop plankton study*. Marine Extension and Georgia Sea Grant University of Georgia. *gacoast.uga.edu*

Shulz, K. (2012). Limnology - Zooplankton Diversity and Ecology. Kim Shulz YouTube video production, for State University of New York College of Environmental Science and Forestry (SUNY ESF). ESFTV. *https://esftv. limnology-zooplankton ecology and diversity. YouTube* (Retrieved 05 – 06 – 2025).

Wikiwand, (2025). Zooplankton-Wikiwand. *https://www.wikiwand.com/en/article/ zooplankton*. Retrieved 05 – 06 – 2025.

Yakubu, A. F., Adams, T. E., Olaji, E. D., Adebote, E. E and Okabe, O. R. (2018). Effect of inorganic fertilization on the zooplankton production in fresh water pond. *International Journal of Environment, Agriculture and Biotechnology* (IJEAB), 3(6): 2126 – 2130. *http://dx.doi.org/10.22161/ijeab/3.6.22* ISSN: 2456-1878. *www.ijeab.com*

Young, C. H. and Flickinger, S. A. (1988). Zooplankton production and pond fertilization for largemouth bass fingerling production. *In: Proceedings of Annual Conference of Southeast Association of Fisheries and Wildlife Agencies* (SEAFWA), 42: 66 – 73.