Compative study of the growth index of Clariidfish frys fed first food diets of Artemia, Whole Egg and Commercial feed

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Abstract - A feeding trial was conducted on the comparison of the growth index of clariidfish frys fed on artemia, whole egg and commercial diets. The frys used for the experiment were obtained from spawning in which a total number of 450 frys were used. The frys were allocated to three experimental treatments T1 (artermia), T2 (Whole egg) and T3 (commercial feed powder) replicated 3 times which consisted of 50 frys per replicate in a completely randomized design. The result indicated that artemia had the best recorded length gain, weight gain and survival while the least result was recorded in whole egg. Artenia and whole egg increased in weight by 12 and 88% on weeks 2 and 3 compared to 11 and 89% of commercial feed. The FCR was best with artemia on wek1 at 20% followed by commercial feed at 27 % and worst with whole egg at 28%, however, it was better with commercial feed and whole egg on week 2 at 34% compared to artemia at 37%. It is concluded that diet of animal origin is best suited for first feeding of C. gariepinus frys.

I. INTRODUCTION

The effect of natural feeds on the growth and survival rate of frys has not been exhaustively investigated. For this reason, the present study will determine the best in terms of easy accessibility of the three diets: artemia, whole egg and commercial feed powder for the growth of *Clarias gariepinus* frys. Artemia is a genus of aquatic crustaceans also known as brine shrimp. It appears to be the only genus in the family Artemiidae. Their populations are found worldwide in inland saltwater lakes, but not in oceans. They are able to avoid cohabiting with most types of predators, such as fish, by their ability to live in waters of very high salinity (up to 25%), (Grageda et al., 2003; Gabriel et al., 2007). The ability of the Artemia to produce dormant eggs, known as cysts, has led to extensive use of Artemia in aquaculture. The cysts may be stored for long periods and hatched on demand to provide a convenient form of live feed for larval fish and crustaceans, (Grageda et al., 2003). Nauplii of the brine shrimp Artemia constitute the most widely used food item, and over 2000 tonnes of dry Artemia cysts are marketed worldwide annually. Fish farm owners search for a cost-effective, easy to use, and available food that is preferred by the fish. From cysts, brine shrimp nauplii can readily be used to feed fish and crustacean larvae just after one-day incubation. Instar I (the nauplii that just hatched and with large yolk reserves in their body) and instar II nauplii (the nauplii after first moult and with functional digestive tracts) are more widely used in aquaculture, because they are easy for operation, rich in nutrients, and small, which makes them suitable for feeding fish and crustacean larvae live or after drying, Eding *et al.,* 2002.Artemia are widely utilized as partial or sole feed by over 85% of cultured marine animals (Grageda et al., 2003).

Poultry egg contains enough nutrients to hatch a chick, so it is considered a complete food. The yolk also provides all or most of the minerals, vitamin A and thiamine. Albumen is an important reservoir for water, essential ions and protein, the latter forming 99% of the dry matter of albumen and also having useful anti-microbial properties (Li *et al.,* 2004).

Commercial fish diets are manufactured as either extruded (floating or buoyant) or pressure-pelleted (sinking) feeds. Both floating and sinking feed can produce satisfactory growth, but some fish species prefer floating, others sinking. Shrimp, for example, will not accept a floating feed, but most fish species can be trained to accept a floating pellet. Extruded feeds are more expensive due to the higher manufacturing costs. Usually, it is advantageous to feed a floating (extruded) feed because the farmer can directly observe the feeding intensity of his fish and adjust feeding rates accordingly. Determining whether feeding rates are too low or too high is important in maximizing fish growth and feed use efficiency, Kottelat, 2001. Commercially Produced Feeds Prepared or artificial feeds can be either complete or supplemental. Complete diets supply all the ingredients (protein, carbohydrates, fats, vitamins, and minerals) necessary for the optimal growth and health of the fish. Most fish farmers use complete diets, typically made up of the following components and percentage ranges: protein, 18-50 percent; lipids, 10-25 percent; carbohydrate, 15-20 percent, Kovac *et al,* (2000). The nutritional content of the feed depends on what species of fish is being cultured and at what life stage. When fish are reared in high-density indoor systems or confined in cages and cannot forage freely on natural food (e.g., algae, aquatic plants, aquatic invertebrates, etc.), they must be provided a complete diet. In contrast, supplemental (i.e., incomplete or partial) diets are intended only to help support the natural food normally available to fish in ponds or outdoor raceways, Lim et al., (2001). Supplemental diets do not contain a full complement of vitamins or minerals but are typically used to help fortify the naturally available diet with extra protein, carbohydrate, and/or lipids. Fish feeds prepared with plant protein (e.g., soybean meal) are typically low in methionine. Meanwhile, fish feeds manufactured with bacterial or yeast proteins are often deficient in both methionine and lysine, Ayuba *et al.,* (2013). Therefore, these amino acids must be supplemented to diets when these sources of proteins are used to replace fishmeal. It is important to know and provide the dietary protein and specific amino acid requirements of each fish species to promote optimal growth and health. Protein is the most expensive component of fish feed, it is important to accurately determine the protein requirements for each species and life stage cultured. Proteins are formed by linkages of individual amino acids. Although more than 200 amino acids occur in nature, only about 20 amino acids are common of these, 10 are essential (indispensable) amino acids that cannot be synthesized by fish. The 10 essential amino acids that must be supplied by the diet are methionine, arginine, threonine, tryptophan, histidine, isoleucine, lysine, leucine, valine, and phenylalanine. Out of these, lysine and methionine are often the first limiting amino acids, (Ng, 2002). Fish feeds prepared with plant protein (e.g., soybean meal) are typically low in methionine. Meanwhile, fish feeds manufactured with bacterial or yeast proteins are often deficient in both methionine and lysine. Therefore, these amino acids must be supplemented to diets when these sources of proteins are used to replace fishmeal. It is important to know and provide the dietary protein and specific amino acid requirements of each fish species to promote optimal growth and health. Protein levels in aquaculture feeds generally average 30 to 35 percent for shrimp, 28-32 percent for catfish, 35-40 percent for tilapia, 38-42 percent for hybrid striped bass, and 40-45 percent for trout and other marine finfish. In general, protein requirements are typically lower for herbivorous fish (plant-eating) and omnivorous fish (plant and animal eaters) than they are for carnivorous (flesh-eating) fish. Protein requirements are higher for fish reared in high-density systems (e.g., recirculating aquaculture) compared to low-density culture (e.g., ponds). Protein requirements are generally higher for smaller as well as early life stage fish, (Ng, 2002). As fish grow larger, their protein requirements usually decrease. Protein requirements also vary with rearing environment, water temperature, and water quality, as well as the genetic composition and feeding rates of the fish. Protein is used for fish growth if adequate levels of fats and carbohydrates (energy) are present in the diet. If not, the more expensive protein can be used for energy and life support rather than growth. Proteins are composed of carbon (50 percent), nitrogen (16 percent), oxygen (21.5 percent), and hydrogen (6.5 percent), and other elements (6.0 percent). Fish are capable of using a high-protein diet, but as much as 65 percent of the protein can be lost to the environment. Most nitrogen is excreted as ammonia (NH_3) from the gills of fish, and only 10 percent is excreted as solid wastes. Eutrophication (nutrient enrichment) of surface waters due to excess nitrogen from fish farm effluents can be a significant water quality concern for fish farmers, (Sorensen, 2003). Appropriate feeds, feeding strategies, and waste management practices are essential to protect downstream water quality.

Clarias gariepinus is indigenous to the inland waters of much of Africa and they are also endemic in Asia Minor in countries such as Israel, Syria and the south of Turkey. *C. gariepinus* has been widely introduced to other parts of the world including the Netherlands, Hungary, much of South-East Asia and East Asia. This species can be cultivated in areas with a tropical climate, areas with access to geothermal waters or with the use of heated recirculating water systems. It is a hardy fish that can be densely stocked in low oxygen waters making it ideal for culture in areas with a limited water supply, (Senanan *et al.*, 2004). Its air-breathing ability, high fecundity, fast growth rate, resistance to disease and high feed conversion efficiency makes *C. gariepinus* the freshwater species with the widest latitudinal range in the world. The objectives of this study were; to compare the growth performance of *Clarias gariepinus* fries, fed with artermia, egg yolk and commercial feed powder; compare the survival rate of *Clarias gariepinus* frys, feed artermia, whole egg and commercial feed powder; to ensure that the lack of fish seed of Clarias gariepinus, which is a delight to most fish farmers and consumers become a thing of the past.

II. MATERIALS AND METHODS

2.1 Experimental Site and fish

The study was carried out at Purity Farms, Emene, Enugu State, Nigeria. This location lies between latitude of $6^0$50'N and Longitude of 6.458^0N – 7.551^0E.The average day time temperature is 26^oC and the night time temperature is 20^oC with a mean elevation of 450m above sea level and an annual rainfall of 1800mm to 2100mm (Anikwe et al., 2007). The fries used for this experiment were obtained from spawning of matured broodstock purchased from Purity fish farm in Enugu State, Nigeria. The female gravid broodstock was injected, by the next day the female was ready to shed its eggs, the female was gently carried into a plastic container waiting to be pressed to shed eggs. During that period the male broodstock of 1kg was assembled for sacrifice. A matured male was sacrificed to obtain the milt for fertilization of the eggs. One male to one female of equal weight.The milt was obtained 15 to 25 minutes before stripping of the female eggs. The gut of the male fish was cut open with a surgical blade to expose the two lobe testis. The testis were removed carefully and dried with a blotting paper. Small incisions were made at the tip of the testis and the milt was squeezed out and washed into a container that is dry with a 0.9% saline solution. The stripping of the female continued until trace of blood was seen. Eggs were collected in a clean bowl. Preparation of the Incubation trough method was used in this research with the flow through system. The source of water was from a bore hole. The over head tank let in water into the incubator and excess water was allowed to leave the incubator via the outlet pipe. The eggs obtained from female specimen were fertilized by the milt obtained from the male. The milt obtained was poured into the bowl containing the stripped eggs and was shaken slightly to ensure proper mixing. Later, this was poured into the incubation system which was well aerated and temperature 27^0 – 28^0C was maintained. The hatchings commenced after 12hrs and was completed after 24hrs. After hatching, the newly hatchlings were selected from the spawning tank. A total number of 450 frys were obtained from the tank.

2.2 Experimental Design and Procedure

The three (3) experimental diets used for the experiment were artemia (Diet 1), egg (Diet 2) and commercial feed powder (Diet 3). The fish were reared in 9 tanks with a water holding capacity of seventy five liters (75L). Each tank was washed thoroughly with detergents, filled to 2/3 (50 liters) capacity and stocked with fifty frys of Clarias gariepinus and covered with ½ inch mesh sized polyethelene netting material to prevent fish from leaping out and attack on the fish by predatory animals. Aeration was provided in the water tanks through air stones using aquarium water pumps. The design of the experiment was a completely randomized design with three (3) treatments and three (3) replications. Treatment 1 (T_1) comprised of artemia, Treatment 2 comprised egg (T_2) and Treatment 3 comprised commercial feed powder, coppens to be precise (T_3). Each experimental treatment was replicated three (3) times. All the feeds were administered manually three times daily between 8:00 and 18:00hr. The experiment lasted for 4 weeks. The commercial feed powder, egg and artemia that were used for the experiment, were purchased from a Ogbete Main Market, Enugu. The egg used for the experiment was broken into a bowl and mixture comprising of the albumen and yolk was gotten by beating them in a neat bowl. The mixture was microwaved and then allowed to cool. Then the egg was blended and dried in the microwave. The egg was sieved to fine grains and used for feeding of the experimental frys.

2.3 Statistical Analysis

Data collected were analyzed using Statistical Package for Social Sciences (SPSS) computer package, version 20.0 and subjected to one-way analysis of variance (ANOVA). Observed difference in means values of parameter were tested for significance (at $p < 0.05$) with means separation using Duncan Multiple Range Test (DMRT).

III. RESULTS

The results obtained from the experiment were presented in the table and figures as shown below.

Table 1: Weight of experimental frys

Parameters	Week 1	Week 2	Week 3
Artermia	0.0010 ± 0.00000^a	0.0180 ± 0.00252^b	0.2250 ± 0.06084^c
Whole Egg	0.0010 ± 0.00000^a	0.0270 ± 0.00115^b	0.1517 ± 0.00551^c
Commercial Feed	0.0010 ± 0.00000^a	0.0237 ± 0.00186^b	0.2147 ± 0.00240^c

Parameters in the same row with same superscript are not significantly different

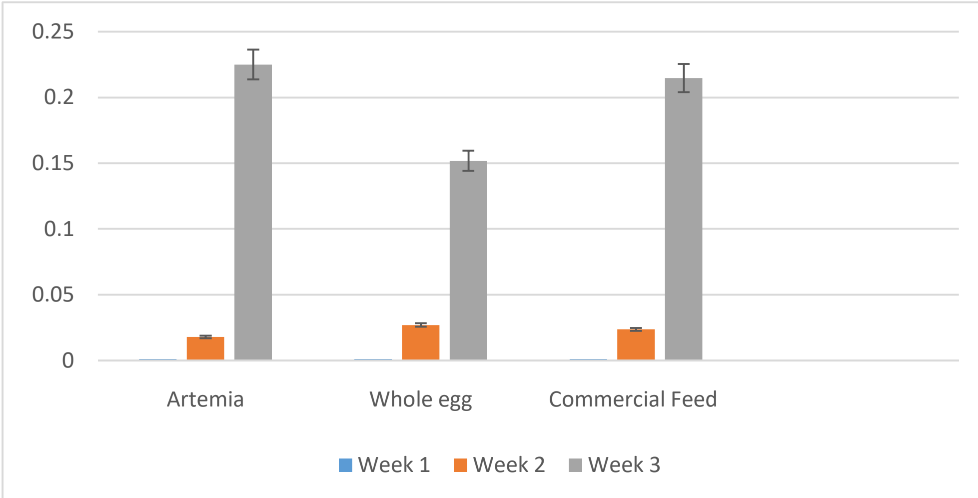


Figure .1: weight among treatments

It can be deduced from the above table that the frys fed with artermia recorded the best weight when compared to commercial feed and whole egg. Artemia had the highest result (0.2250 ± 0.06084g) due to better water quality and more favorable rearing conditions while whole egg had the lowest result because the treatment experienced reduced water quality caused by the diet. Therefore, significant differences ($P < 0.05$) existed among the treatment groups.

Table 2: Length gain (cm)

Parameters	Week 1	Week 2	Week 3
Artermia	0.6333 ± 0.06667^{a}	1.0667 ±0.03333^{b}	2.2333 ±0.08819^{c}
Whole egg	0.6667 ±0.03333^{a}	0.9667 ±0.13333^{b}	1.9000 ±0.11547^{c}
Commercial Feed	0.6667 ±0.03333^{a}	1.1000 ±0.05774^{b}	2.1000 ±0.05774^{c}

Parameters in the same row with same superscript are not significantly different

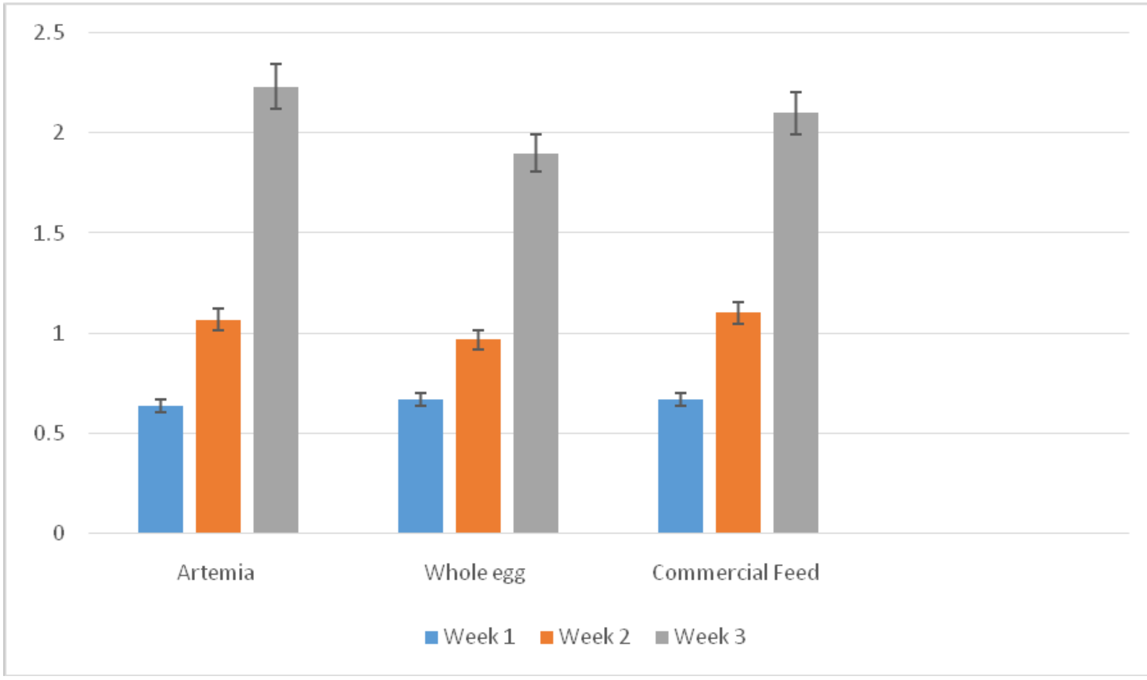


Figure .2: length

The highest length gain was recorded in artemia (2.2333 ±.08819cm) in week 3. The lowest was recorded in whole egg. Significant differences existed among the treatments ($p > 0.05$).

Table 3: Weight gain

Parameters	Week 1	Week 2	Week 3
Artemia	.00	0.0260 ±.00115[a]	0.1980 ±.00458[b]
Whole egg	.00	0.0170 ±.00252[a]	0.1343 ±.05768[b]
Commercial Feed	.00	0.0227 ±.00186[a]	0.1910 ±.00058[b]

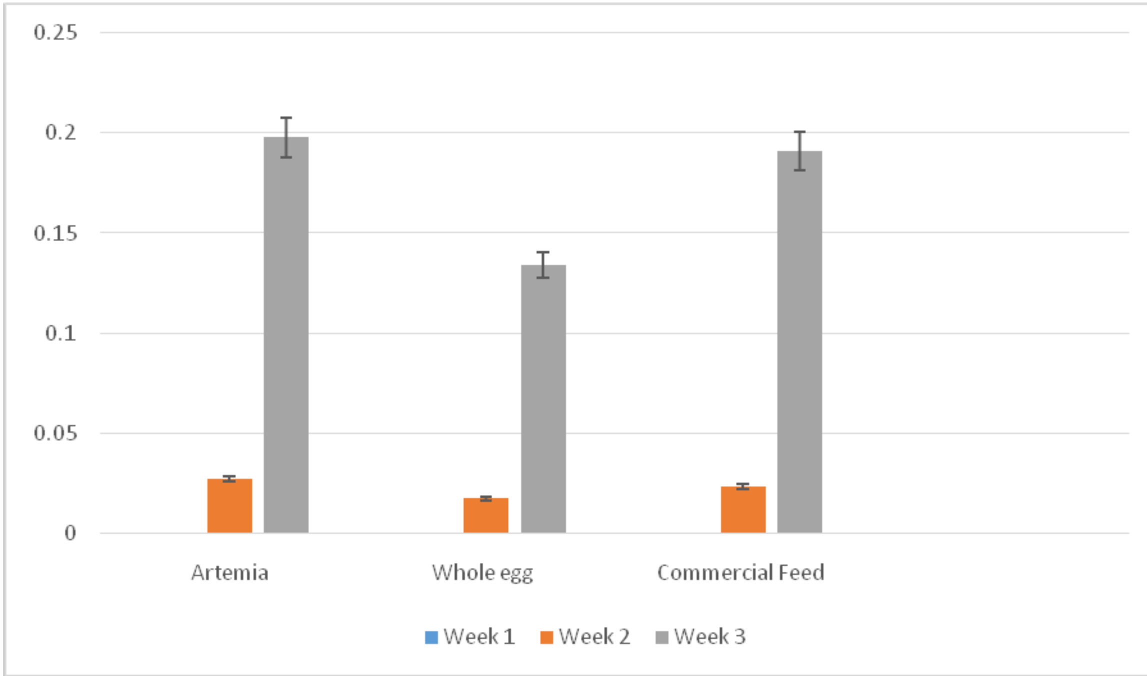


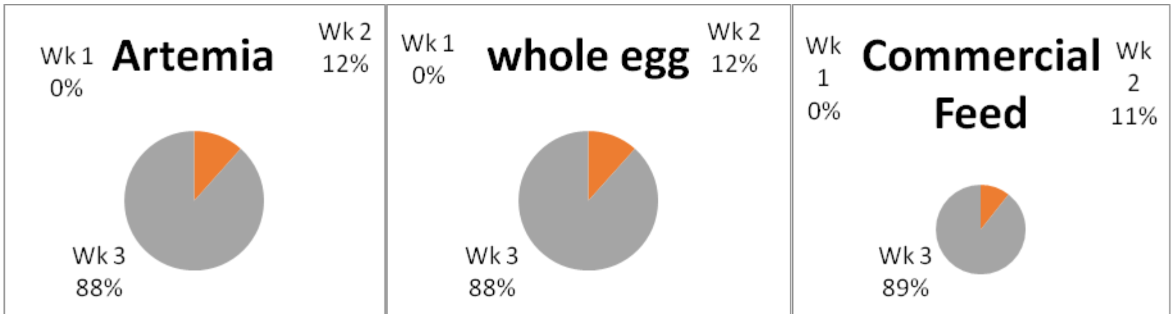
Figure 3: weight gain

There was no significant difference among the treatments ($p > 0.05$) in week 1 and week 2 but there was significance difference ($p < 0.05$) in week 3. The highest weight gain was recorded in week 3 in diet (2) which is artermia.

Table 4: Feed Conversion Ratio (FCR)

Parameters	Week 1	Week 2	Week 3
Artemia	.0143 ±.00667[a]	.0267 ±.00033[b]	.0310 [c] ±.01258[c]
Whole egg	.0600	.0743 ±.00088[a]	.0810 [b] ±.01258[c]
Commercial Feed	.0500 [a]	.0640 ±.00058[b]	.0723 [c] ±.00876[c]

Parameters in the same row with same superscript are not significantly different wg



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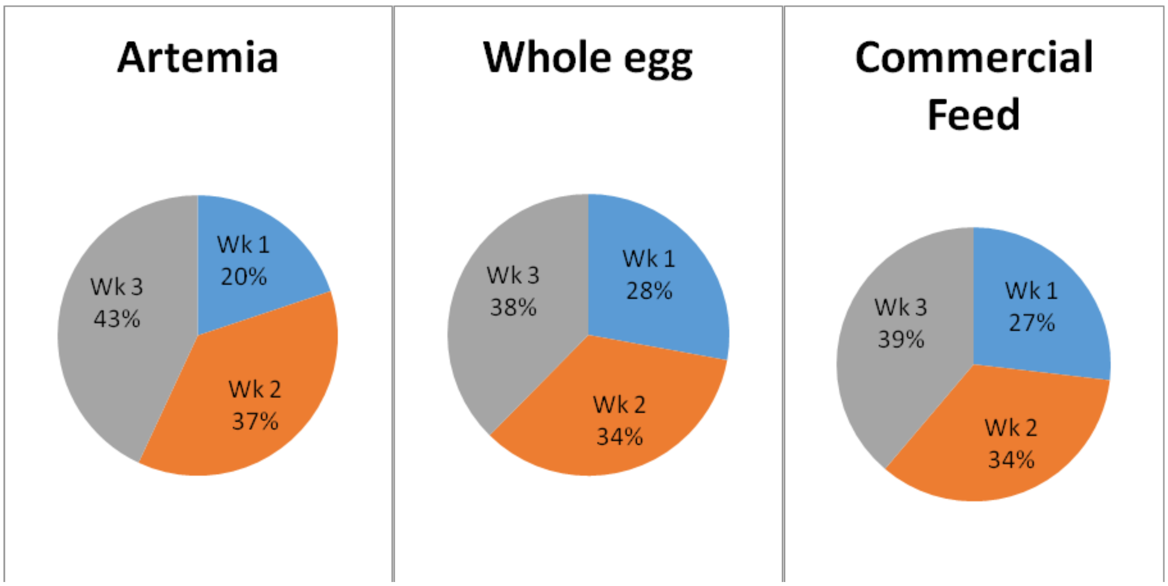

Key Wg=weight gain, fcr= food conversion ratio

Artenia and whole egg increased in weight by 12 and 88% on weeks 2 and 3 compared to 11 and 89% of commercial feed. The FCR was best with artemia on wek1 at 20% followed by commercial feed at 27 % and worst with whole egg at 28%, however, it was better with commercial feed and whole egg on week 2 at 34% compared to artemia at 37%.

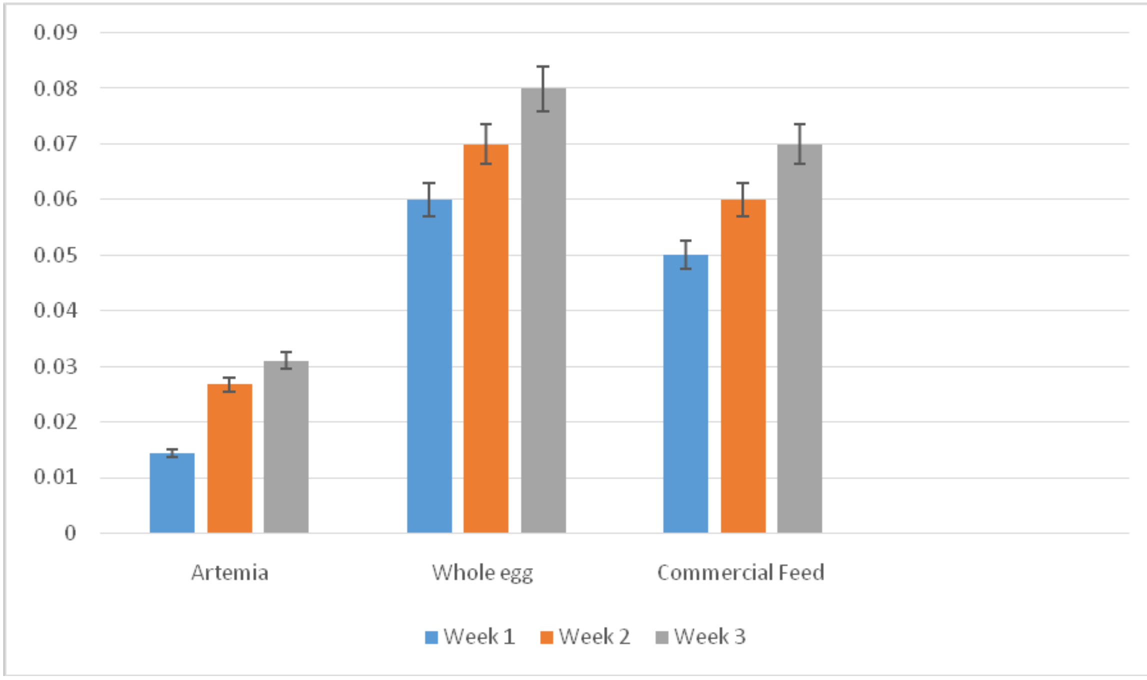

Figure 4: feed conversion ratio among treatments

The best feed conversion ratio was recorded in week 1 in diet (2) which is artermia. The feed conversion ratio (FCR) in all the treatment displayed significant difference among the treatments ($p < 0.05$).

Table 5: Survival

Parameters	Week 1	Week 2	Week 3
Artermia	94.6667 ± 4.66667	96.6667 ± 4.66667	98.6667 ± 4.66667
Whole egg	89.3333 ± 6.35959	84.6667 ± 4.66667	73.3333 ± 4.05518
Commercial Feed	90.0000 ± 4.16333	92.0000 ± 3.05505	94.6667 ± 2.90593

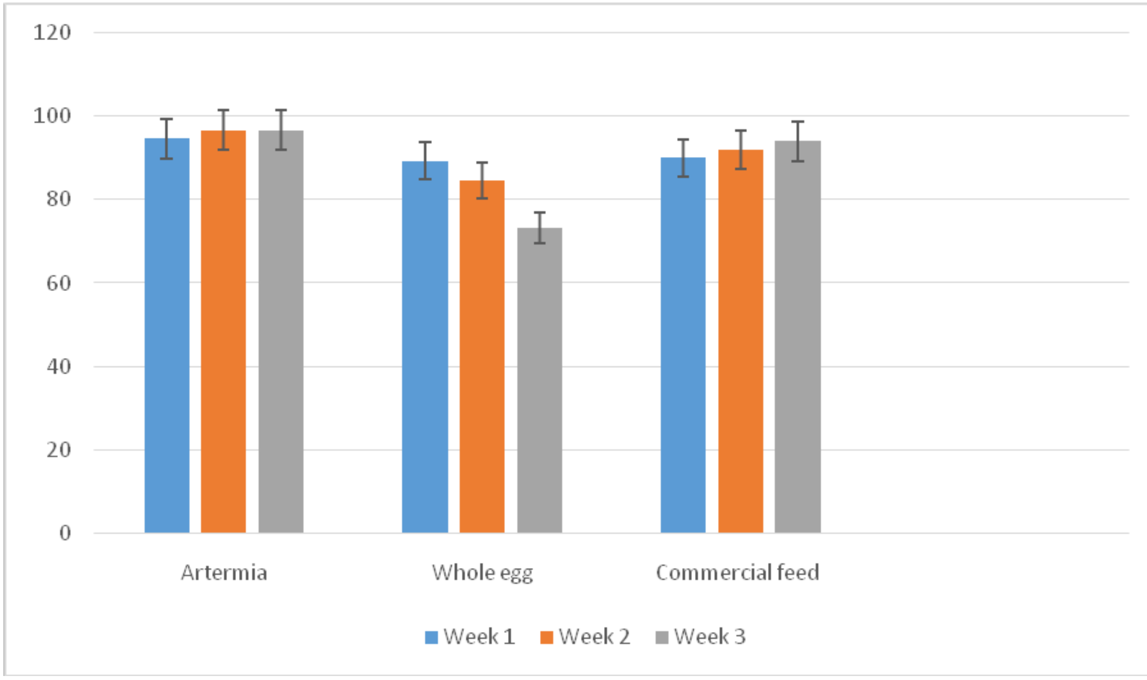

Figure 5: survival among treatments

The treatment with the highest survival recorded was artermia (98.6667 ± 4.66667), followed by commercial feed and then whole egg. The survival rate displayed by the treatments showed that, there is no significant difference among all the treatments ($p > 0.05$).

IV. DISCUSSION

The African catfish *Clarias gariepinus* is a major warm water species in Africa (Ghana, Ethiopia, Egypt, Mali and Nigeria). Its culture has received considerable attention since the early 1970 and 1980s but the industry remains relatively undeveloped largely due to dependence on aquatic products from capture fisheries. Currently, due to decline in most of the capture fisheries and increased demand for protein of aquatic products, the need for an alternative source, particularly from aquaculture is growing (Adewumi and Olaleye, 2011) to augment fish supply from the capture fisheries. The importance of aquaculture; in improving the diet of the people, generating employment in rural areas and in conserving foreign exchange; through import substitution, has increased in recent years. For aquaculture industry to thrive, apart from development of adequate manpower, there is need to research and develop various inputs of production, such as feed. The need for feed development for various life stages of fish is becoming increasingly urgent. Fish production is made practically impossible without the supply or availability of fish seeds (Grageda et al., 2003). For many fish species, the larval period is considered critical in the life history. The transition from endogenous to exogenous feeding is a critical event in the life of a fish. Great losses are sustained in the hatchery, noted (Girri *et al.,* 2002), as fry weans over from yolk absorption to exogenous feeding. It is generally acknowledged that the farmer's choice of food during the first few days of hatching is critical to larval survival. Hitherto, the reliance has been on importation of encapsulated *Artemia*. However, in recent years, Nigerian fish culturists have made use of several materials to rear the larvae of *Clarias gariepinus* (Adewumi and Olaleye, 2011). Success of larval rearing depends mainly on the availability of suitable diets that are readily consumed, efficiently digested and provides the required nutrients to support good growth and health (Lavens and Sorgeloos, 2000). One of the major obstacles confronting the development of aquaculture industry is availability of affordable and high-quality fish feed (FAO, 2006). Fish growth and survival rate depend on the kind of feed, feeding frequency, feed intake and the fish's ability to absorb the nutrients. Starter feeds are important in the growth of African catfish (*C. gariepinus)* larvae. Live feeds such as *Artemia*, rotifers, copepods, *cladocerans* have been employed with successful outcomes in feeding most fry of *C. gariepinus* (Ali, 2001). Although *Artemia nauplii* and decapsulated cysts have long been used successfully in starter feeds of most fish fry (Aliu and Ofoche 2001), their increasing cost and especially the current rise in adulterated *Artemia,* is a major constraint to most fish farmers especially in West Africa. The use of artificial feeds alone is also not encouraging, as it tends to pollute the aquatic environment of the fish hatchlings. As a result, there is the need to find alternative feed or a combination, for fish fry. Attempts have also been made to use inert diets solely or in combination with live food for fish larvae rearing (Lubzens and Zhora, 2003).

Awaiss and Kestemont (2008), investigated the use of formulated diet as a starter diet for *C. batrachus*, in which they recorded a level of success but their choice of ingredients (fish meal, baker's yeast, powdered milk, whole egg, boiled chicken egg yolk, cod liver oil, agar, vitamin premix, mineral premix, attractant amongst others) were very expensive which was not different from the high cost of *Artemia.* Growth and survival data are powerful tools for understanding the effects of both live and manufactured diets on first-feeding fish larvae (Mwanja, *et al,* 2006). No perfectly suitable larval diet has yet been developed, especially to meet our demand in Nigeria. This work therefore is focused on the search for an efficient and effective feed for fish fry. Nutrition in aquaculture plays a very important role in the production of high quality and marketable fishes. The success of fish farming since its increment contribute to maximal production efficiency, reduced food waste and improved water quality, (Ngugi *et al.,*2011). High cost of feed has been a major problem to fish farmers in Nigeria. This high cost constitutes up to 70% of recurrent cost of the most intensive fish farm ventures which negates the economic viability of the farm when cheaper alternatives are not available (FAO, 2007). Artificial feed is usually expensive because the conventional feed ingredients compete for its consumption by humans and livestock. There is need to identify, explore and utilize cheaper non-conventional feeds which are not only easily available and attracts less competition. Based on affordable cost, ready availability and provision of crude protein, zooplanktons were reported to posses immense potential for fish feed production, (Ngugi *et al.,* 2011).

Frys tend to prefer diet of fine particle size. Some workers have recorded positive results with artemia especially in fish larval culture (Grageda et al., 2008) which also corroborated with the present study. Artermia are reported to be of better nutritional value (higher essential fatty acids) compared to other fish foods. The whole egg gave the least performance in terms of weight gain, length gain and survival. Various reasons adduced for its poor performance include poor water quality caused by the diet, (Grageda et al., 2008).

V. CONCLUSION

Starter feed are important in the growth of African catfish *C. gariepinus* fry. Taking into account the growth and survival data one would conclude that African catfish *C. gariepinus* fry larvae/fry can be reared by providing artermia as starter feed for the first one week followed by whole egg and commercial feed after the initial one week period. The study recommends the use of artermia as the starter diet for African catfish *C. gariepinus* larvae. Artermia should not be used to feed larvae of fish beyond one week.

REFERENCES

[1] Adewumi A and Olaleye VF, (2011). Catfish culture in Nigeria: progress, prospects and problems. *African Journal of Agricultural Research.* 6(6):1281- 1285.

[2] Ali MZ, (2001). Dietary protein and energy interactions in African catfish (*Clarias gariepinus*).Ph.D thesis, Institute of Aquaculture, University of Stirling, Stirling Scotland, UK; pp. 217

[3] Aliu BS and Ofoche NI, (2001). Assessment of plantain peels in the diets of African catfish (*Heterobranchus* x *Clarias gariepinus*) hybrid juvenile. *Nigerian Journal of Applied Science,* 19: 45 – 48.

[4] Anikwe MAN, Mbah CN, Ezeaku PI, Onyia VN, (2007). *Tillage and plastic mulch effects on soil properties and growth and yield of cocoyam (Colocasia esculenta) on an Ultisol in southeastern Nigeria.* Soil Tillage Res. 93, 264 272. doi:http://dx.doi.org/10.1016/j.still.2006.04.007.

[5] Awaiss A. and Kestemont P. (2008). Feeding sequence (Branchionus and dry diet) on survival, growth and biochemical composition ofAfrican catfish, (*Clarias gariepinus*, Burchell Pisces: Clariidae) larvae. *Journal of Aquacultural Research.*29: 731–741.

[6] Ayuba, V.O. and Iorkohol, E.K. (2013) ximate Composition of Some Commercial Fish Feeds Sold in Nige Journal of Fisheries and Aquatic Science, 8, pp. 248-252, doi: 10.3923/jfas.2013.248.252

[7] Eding EH, Schneider O, Ouwerkerk ENJ, Klapwijk A, Verreth JAJ, Aarnink AJA, 2002. The effect of fish biomass and denitrification on the energy balance in African catfish farms. In: Proceedings of the Third International Conference on Recirculating Aquaculture, Virginia, USA, 20-23 July, 2000. US Department of Agriculture, Virginia Polytechnic Institute and State University, USA

[8] FAO. (2006). Food and Agriculture Organisation. Regional Review on Aquaculture Development in Sub-Saharan Africa. FAO. Fisheries Circular No. 1017/4. Rome, Italy, pp. 93.

[9] Food and Agriculture Organization (FAO). (2007). Aquaculture production 1986- 1995.FAO Fish .Circ. No.815 (FIDID/815- Rev.9), FAO, Rome, Italy.

[10] Gabriel, U. U., Akinrotimi, O. A., Bekibebe, D. O. and Anyanwu, P. E. (2007). Locally produced fish feed: Potentials for aquaculture development in sub-Saharan Africa. *Africa Journal of Agriculture Research*, 2(2):287-295.

[11] Grageda MVC, Kotani T, Sakara Y, Hagiwara A (2008). Effects of feeding copepod and Artemia on early growth and behavior of the self fertilizing fish, Rivulus marmoratus , under laboratory conditions. Aquaculture, 281: 100-105.

[12] Girri, S. S, Sahoo, S. K, Sahu, A. K, Mohanty, S. N, Mohanty, P.K. and Ayyapan, S. (2002). Larval survival and growth in *Wallagoattu* (Bloch and Schneider): Effect of light, photoperiod and feeding regimes. *Aquaculture*,213:157-161.

[13] Kottelat M, 2001. Fishes of Laos. Colombo, Sri Lanka: WHT Publications Ltd., 198 pp

[14] Kovács B, Egedi S, Bártfai R, Orbán L, 2000. Male-specific DNA markers from African catfish (Clarias gariepinus). Genetica, 110(3):267-276

[15] Lavens, P. and Sorgeloos, P., (2000). The history, present status and prospects of the availability of *Artemia* cystsfor aquaculture.*Aquaculture*, 181: 397–403.

[16] Li MH, Robinson EH, Manning BB, Bosworth BG (2004) Effect of dietary protein concentration on production characteristics of pond-raised channel catfish fed once daily or once every other day to satiation. North American Journal of Aquaculture 66: 184-190. 15.

[17] Lim PhaikKin, Boey PengLim, Ng WingKeong, (2001). Dietary palm oil level affects growth performance, protein retention and tissue vitamin E concentration of African catfish, Clarias gariepinus. Aquaculture, 202(1/2):101-112

[18] Lubzens E and Zmora O (2003).Production and nutritional values of rotifers. In: Live feeds in marine aquaculture (ed. L.A. McEvoy. pp17-64. Blackwell Publishing. Oxford, UK.

[19] Mwanja, W.W., Akol. A., Abubaker. L., Mwanja,M., Msuku, B.S. and Bugenyi, F. (2006). Status and impact of rural aquaculture practice onthe Lake Victoria basin wetlands. *African Journal of Ecology,* 45:165-174.

[20] Ng WK, (2002). The nutrient requirements of clariid catfishes. Aqua Feed International, 5:14-18

[21] Ngugi C, Chepkirui-Bolt V, Bowman J, Oyoo-Okoth E, Rasowo J, Mugo-Bundi and Cherop L. (2011). Growth performance, survival, feed utilization and nutrient utilization of African catfish (*Clarias gariepinus*) larvae co-fed *Artemia* and micro-diet containing freshwater atyid shrimp (*Caridina nilotica*) during weaning. *Aquaculture Nutrition.*17: 82 – 89.

[22] Senanan W, Kapuscinski AR, Na-Nakorn U, Miller LM, (2004). Genetic impacts of hybrid catfish farming (Clarias macrocephalus x C. gariepinus) on native catfish populations in central Thailand. Aquaculture, 235:167-184

[23] Sogbesan OA, Ugwumba AAA, (2006). Effects of different dietary replacement of fish meal with earthworm (*Hyperrodrilus euryaulos,* clausen, 1914: Oligocheata: Eudrilidae) meal in the diet of Heterobranchus 125

[24] Sorensen M. (2003) Nutritional and Physical Quality of Fish Feeds Extruded at Various Temperatures, [PhD Thesis], Department of Animal Science, Agricultural University of Norway, Norway.