Polyculture Of *Heteroclarias / Tilapia* Under Different Feeding Regimes

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ABSTRACT: Triplicate Treatments of *Heteroclarias* and Nile Tilapia (*Oreochromis niloticus*) fingerlings in a semi-intensive polyculture system, were fed for twelve weeks on Pigeon pea meal, Bambara groundnut meal and coppen floating feed. They were fed at 3% body weight and were used as the control treatment. Growth performance and Physiochemical Parameters were measured weekly. Results showed that the treatment fed with coppen had the best growth performance; mean weight gain (2.23g) and (1.13g) for *Heteroclarias* and Tilapia, while the treatments fed with substitutes, showed appreciable growth performance with Pigeon pea meal having a final mean weight gain of (1.16g) and (0.74g) and Bambara nut coming last with (0.92)g and (0.97g) respectively. There was significant difference (P>0.05) between the feed types on the growth of the fish. [New York Science Journal 2010;3(10):42-57]. (ISSN: 1554-0200).

Key Words: Bambara groundnut, coppen feed, *Heteroclarias* and Nile Tilapia (*Oreochromis niloticus*).

INTRODUCTION AND LITERATURE REVIEW

Fish farming has become a worldwide practice and has been for years. This is the growing and cultivation of different species of fish including other aquatic animals for various purposes such as, feeding, decoration, ornamental and for advanced research .This branch of Agriculture has become very important being that they are good sources of protein, vitamins, oils etc (Bard *et. al*., 1976).

Fish farming also known as Aquaculture plays a major role in Agriculture in Africa and especially in Nigeria. This could be practiced in either their natural habitat or by artificial methods, most especially to boost fish productivity in Nigeria and the world as a whole. Artificial fish farming could be carried out with the use of ponds, tanks and aquariums, making available facilities which will enhance fish growth .The art of artificial fish farming may perhaps encourage research and studies on the various species of fishes with the aim of improving growth yield, prevention of diseases, improved quantities and other areas of study. (Bard *et.al.*, 1976). In the review of Ita, (1998), it was stated that early fish farmers in Nigeria raised their fish in burrow pits, abandoned minefields and in earthen ponds on extensive production system. The introduction of concrete tanks allows for manageable pond size and modification of the environment through a water flow-through system and supplementary feeding thus allowing for higher fish yield. The advent of the indoor water re-circulatory system (WRS) has ushered in a new prospect for aquaculture. The introduction of WRS has created a turning point in the production of catfish in Nigeria.

The story of aquaculture in Nigeria is essentially the story of catfish culture and the hope of fish supply in Nigeria hangs on its development and culture. Recent trends all over the world, point to a decline in landing from capture fisheries, an indicator that fish stocks have approached or even exceeded the point of maximum sustainable yield. Aquaculture therefore remains the only viable alternative for increasing fish production in order to meet the protein need of the people. It was observed that of the over 30,000MT of various freshwater and brackish water fish species caught in the year 2000, catfishes were more abundant next to Tilapias. FAO (1993) reported that 27,488MT of catfishes produced in 1990 were consumed locally. This implies that there is still great need for higher production for both local and international markets. In aquaculture, fish require adequate food supply in the right proportions and with proper nutritional contents needed for growth, energy, reproduction, movement, and other activities which they carry out.

According to Hepher (1990), fish yield and profitability per pond area of a culture unit depends, to a large extent, on the amount of the supplementary feed used. Weatherly and Gill, (1977) stated that fish meal is commonly used in feed formulation to supplement the high cost of protein in culture diets due to its nutritive value. Due to the increase in fresh water farming in Nigeria and globally, there could be intense competition for fish meal and fish oil (FAO 1997and Naylor *et al.* 2000), hence, the need for alternative source of protein to replace fish meal without reducing the quality of the feed. Though animal by-products e.g. blood meal, hydrolysed feather meal, bone meal and some plant proteins are good alternatives, they are less expensive and have differences. The excess amino acids may contain some anti nutritional factors that may impair proper fish growth (Rodrigu ***et. al***., 1996, Sinthyehu ***et.al***., 1996, Fagbenro1999, Salaro ***et. al***, 2000 and Francis ***et. al***., 2001). However, these meals can be mixed up in certain proportions to produce balanced nutritional and economic diets (Eyo and Olatunde, 1996, Mukhopadhyay and Ray, 1999 and Mbahinzireki, ***et. al***., 2000). Wee and Shu (1989) stated that a balanced fish feed formulation at present, demands a cost effective replacement to supply the needed dietary protein. These ingredients, which are usually, trash to man, contain high quality protein, energy calories, amino acids and so on.

As an alternative to fishmeal, plant products, such as soya beans, oil seedcakes and groundnut cakes have been evaluated as fish feed ingredients. Omoregie and Ogbemudia (1993) advised that it will be more economical to utilize plant protein and accept a reduced growth rate of aquatic animal than feeding fish meal at high cost. According to Ayinla (1986), the essential nutrient requirements of fish are protein, carbohydrates, oils vitamins, minerals, salt and fibre. Rumsey (1993) reported that fish feed accounts for a major part (30-70%) of the total operational cost of an average fish farm. Warm water fishes require protein in their diets (Lim and Dominy, 1993).

According to Lim and Dominy (1991), the animal protein particularly fish meal is traditionally considered the major ingredient of fish feed. According to Lim and Dominy (1993) , Rumsey(1993), fish meal supply was likely to decline between 1900MT AND 2000MT and this could no longer meet the demand of the expanding fish feed industry. Therefore, the need to find suitable replacement to fish meal in fish feeds is of great importance. However, the uses of high plants protein in fish diets have poor feed efficiency compared to fish meal containing diets. (Lim and Dominy, 1993).

It is therefore necessary to seek cost effective, yet nutritionally balanced and adequate replacement to supplement dietary animal protein based diets. An obvious approach involves the utilization of ingredients of plant origin, which include the of use bambara nut, lima beans and pigeon pea as non-conventional feed stuffs as fish feed for *Oreochromis niloticus* and *Heteroclarias sp* in a polyculture.

Due to limitations encountered in extensive fish farming, it is necessary to approach artificial means of growing fish; these could be either intensive or semi-intensive. This is the use of concrete ponds and aquariums. To ensure consistent production of more than one species of fish in a specific period, the practice of polyculture is highly encouraged. The major preliminary condition in setting up a polyculture system is to identify an ideal stocking ratio which takes into consideration the intensity of specie interaction and utilization of different ecological strata, and a better valorisation of the renewable resources of the water body (Billad, 1980).

Numerous combinations of fish species in polyculture systems have been used throughout the world (Delmundo, 1980; Shroeder, 1980; Edwards ***et. al***., 1989).

The yearnings of farmers and scientists to have a farmed catfish that combines the fast growth traits of *Heterobranchus spp* and early maturing traits of *C. gariepinus* led to the development of a hybrid *'Heteroclarias' spp*. The technology was widely accepted as it gave 58% internal rate of return (IRR) on investment **(**Faturoti *et. al*., 1986**)**. Popma (1978) stated that the positive effect of *Tilapia* polycultured with predatory fish species is an additional source of food for the latter represented by *Tilapia* larvae.

Wilson and Hilhn (1981) stated that in a Catfish/*Tilapia* polyculture system, stocking of *Tilapia* at densities equal to or greater than 25% of the weight of stocked catfishes in high density tanks are not advisable.

In the last few years, increased interests in aquaculture and polyculture has been witnessed due to spurred interests of many people in fish farming, and this will continue to play an important role in meeting the demand for fish **(**FAO, 2003**)**. Most production in Nigeria is realized from pond based tanks and water re-circulatory culture systems using polyculture farming techniques.

Artificial feeding of fish has many known advantages which include enhancement of high stocking density especially in polyculture system resulting in high yield, promotion of growth and enables the farmer to observe the behaviour of his fish during feeding in order to detect any abnormality (Schoonbee and Prinsloo, 1988). Unlike in the past when fish depends on natural food in the pond, the production of fish feed is becoming popular with each passing day in the country.

Aquaculture in Africa is a relatively new industry and is not practiced on a wide scale. Fish pond culture in sub-Saharan Africa started in Kenya in 1924 and later spread to other parts of the continent (Huisman, 1986 and Jackson *et. al.*, 1982). FAO (1998) stated that, fish supplies over 50% of the total animal protein consumed in developing countries and less so in developed countries. However, in Nigeria fish constitutes 40% of animal protein intake (Olatunde, 1989).

Aquaculture in Nigeria has turned a new leaf, in that it has become wide scale since the FAO introduced modern aquaculture and aquaculture technology into the system. Cultivable fish species include *Tilapia*, Clariid cat fishes and exotic Carps (Balarin and Hatton, 1979; Van den Boscche and Bernacsek, 1990) which are facilitated with the acquisition of induced breeding technology.

In Nigeria today, aquaculture practices, seeks to improve fish yield and fish productivity. Its benefits range from rural development income generation, farm sustainability as well as reduction in vulnerability. This practice also makes use of land which is considered unsuitable for agriculture such as swamps or saline areas. Anyila (1991) stated that, over 9,570 of all fish protein consumed in Nigeria comes from the wild. Eyo (2001) reported that since aquatic resources are finite although renewable, every effort should be made towards increased fish production through improved resource management and conservation and also intensive aquaculture practices.

Currently, aquaculture production in Nigeria has witnessed slow pace of development. Aquaculture contributes only about 25000MT of fish annually which is about 69% of domestic fish production, whereas the projected requirement for fish products by the year 2000 was 4million MT (Ita, 1998). Nigeria has high potentials in aquaculture which is hardly tapped. Ayinla, (1998) stated that aquaculture provided food of high animal protein, generated income and employment thereby promoting the socio-economic development of Nigerians. Fish production when combined with improved inland fisheries management to eliminate fish importation and earn substantial foreign exchange.

The demand for protein raises as the population increases hence, the need to invest on animals and fish species that can reproduce and grow rapidly. Examples of these are *Oreochromis niloticus* which are of great importance to subsistence fish farmers in Africa and Asia (Bardach *et. al*., 1999), clariid fish species, carps and *Heterotis niloticus. Tilapia* is a good candidate of aquaculture because of its growth rate and productivity ability (prolific in nature). According to Teshima *et al.* (1986), Oreochromis niloticus is one of the fastest growing members of the *Tilapia* family and thrives well under culture condition throughout most farms in Nigeria. *Heteroclarias* are in high demand by most farmers due to their hardness and fast growth. There seeds are, however, not readily available to meet the needs of large scale fish farmers because unlike tilapia, they do not readily reproduce in capacity, even when they do, the survival rate of the fry is so slow that the fingerling produced from a given size of a pond may not be sufficient to restock the pond.

Nile *Tilapia (Oreochromis niloticus)* is the most predominantly cultured species among the cichlid family (Roderick, 1997). It exhibits qualities that include fast growth, efficient use of feed and resistance to disease (Lovell, 1989). Thus, the aim of this study was to evaluate the effects of soaked copra meal as a replacement for soybean meal on growth performance, nutrient utilization, digestibility and hepato-somatic index of Nile *Tilapia* (*Oreochromis niloticus)*
fingerlings.

The protein requirement for fish has shown to vary not only with species of fish but also with life stages. Hence, the determination of protein requirement for maximum growth of any species is a logical first step to development of a cost-effective feed for the fish.

There are several works on the determination of optimal protein requirements for *Tilapia*. Winfree and Stickney (1981); recommended 34% protein for *Tilapia aurea* of 7.5g body weight while Jauncey (1982) found 40% crude protein to be optimal for *Sarotherodon mossambicus* of 2g body weight in aquaria. Sheaf and Huang (1989) reported 24% protein for hybrid *Tilapia* fry reared in sea water. Omoniyi (1997) reported 30%crude protein as being optimal for food growth of *Sarotherodon galilaeus* fry reared in concrete tanks.

Solomon *et al.* (1996) found that the best growth performance and food utilization parameters for mud fish were attained at 40% crude protein level when the fishes were fed with different levels of protein.

Balogun *et al.* (1992) also summarized the gross protein requiment of *Clarias gariepinus* as follows: fingerlings to juveniles require 37.5% protein, juvenile to adult require 35.5% protein.

Solomon *et .al.* ,(1996) said that there is a wide array of food and feed stuff that are suitable for fish feeding and there quality is primarily assessed on their nutrient composition such as protein levels.

Heteroclarias are omnivorous feeding on insects and fish material more than any other food item. Changes in food composition and feeding habits of fish in relation to the size and age of the fish and season are biological phenomena which are common to many species of fish in the tropics and temperate areas of the world. The success of *Heteroclarias* can be attributed to its ability to colonize the variety of habitués created by the formation of the lake (Olatunde, 1997) and its ability to utilize a wide range of food.

Legendre *et.al.*, (1991)**,** in his investigation of the food preferences of the commercial fishes of Lake Volta, noted that, *Heteroclarias* feed mainly on insects and fish material. Edwards *et. al.,* (1989) stated that food plays a very important role in the husbandry of animals, including fish. The fish under culture receive their nutrient and energy required for the maintenance of life and growth from food eaten. Foods supplied to the cultured fish are of two types; natural feeds and artificial feeds. The artificial feeds play a vital role in intensive aquaculture, where the objective is to produce optimum density of fish per unit area of water.

Much conventional protein feed stuff such as fish meal, soybean meal and groundnut cake used in fish diet formulations in Nigeria are scarce and expensive. Lim and Dominy (1989) stated that, the high cost and availability has made it imperative to source for an alternative. Animal sources like fish meal, blood meal and plant products like soybean, groundnut cake, Bambara nuts have been used in the past as good source of protein to formulate fish feed (Eyo, 1995). However, their demand for consumption by man and in formulating other animal feeds might affect their availability for fish formulation (Eyo, 1995**)**. Hence the need to look into other available plant protein sources for possible use in fish feed formulation.

Plant materials have progressively been analyzed for fish feed formulation and their limitation due to inferior protein content have been evaluated (Ddevandra 1985). Ufodike *et .al.,* (2006), carried out a research on the utility of pear seed, mango seed, and bean seed coat in fish production and he observed that the superiority of protein in the fish meal (58.58+-0.7%) showed that animal tissue generally contained more protein than plant tissue such as rice bran (8.7%), cassava leaves (7%), plantain peels (9.14%), sun flower seed (12.3%), (Halver 1960, Gohl 1981, and Millikin 1982).

In order to reduce the cost of a balanced fish diet, locally available ingredients such as agricultural by-products and plant proteins should be included in the diet or substituted for expensive animal plant protein sources. Bambara groundnut (Bam-nut) is a leguminous plant similar to the common groundnut/peanut (*Vigna unguilata*). It is found in abundance in the south eastern part of Nigeria and is commonly known as Okpa. Like the groundnut, it is grown for its underground seeds (Ashenafi and Busse, 1991). The seeds may be eaten raw when immature but the hard mature seeds need to be roasted or boiled to produce sweet and pleasant tasting meal. The seed contains 14-24% protein, about 60% carbohydrate, and it is higher in essential amino acids, methionine than most other grain legumes. (Brough *et. al*.,1993). It contains 6-12 % oil, which is lesser than the amount in peanuts. Bambara groundnut, though underutilized African legume, has global availability especially in hostile tropical environments (Linneman, 1997). Bam-nut is one of the indigenous grains of sub-Saharan Africa, favoured in terms of nutritional value and tolerance to adverse environmental conditions. It is the third most important legume after groundnut and cowpea. Despite these, its full economic significance has not been determined (FAO, 2003).

Bambara groundnut (*Vigna subterranean* (L.) *Verdc*) is a legume grown mainly in the Middle Belt region and Enugu State of Nigeria (Doku and Karikari, 1971). Bambara groundnut seed has been reported to contain 14-24% crude protein (Rachie and Roberts, 1974; Evans *et. al*., 1975; Temple and Aliyu, 1994; Olomu, 1995). The protein of the nut is of high biological value (FAO, 1982; Olomu, 1995), with a high amount of lysine (6.60%) and 1.30% methionine (Poulter, 1981; Temple and Aliyu, 1994). According to Ezuoke (2003), bambara groundnut is not an oily seed since it contains only about 6% of ether extract. It contains moderate amounts of calcium and iron, though poor in phosphorus and with fairly high contents of thiamine, riboflavin, niacin and carotene, but very low in ascorbic acid (Oyenuga, 1968). It also contains minimum amount of trypsin and chymotrypsin inhibitors (Doku and Karikari, 1971).

Bambara nut (*Vigna subterranea* (L) Verde syn. *Voandzeia subterranea* (L) Thours) is stigmatized a poor man's crop. The most important limitations to utilization of this crop are the anti nutritional factors and storage induced defects that demand high fuel in puts for food preparation (Ezeuoke, 2003). The nutritional potentials of the crop were documented. Oyenuga, (1968) reported that it is richer than groundnuts in essential amino acids such as isoleucine, leucine, lysine, methionine, phenylalanine, threonine and valine.

The need to substitute fishmeal in animal feed has necessitated the use of plant derived feedstuffs. Legume seeds have been highly favourable because of their rich protein composition, energy and, mineral content and widespread distribution in the tropics. However, only few of these plant proteins have been utilized and investigated (Tacon and Jackson 1985; Webster ***et. al***., 1992;, Ogunji and Wirth 2001).

Pigeon pea [*Cajanus cajan* (L.) Millsp.] Is one of the oldest food crops and ranks fifth in importance among edible legumes of the world (Morton 1976; Salunkhe *et. al*. 1986). Pigeon pea grows well in tropical and sub-tropical environments extending between 30deg.N and 30deg.S latitude with a temperature range of 20° to 40°C (Sinha, 1977). It is widely grown in about 14 countries in over 4 million ha. The major producers of pigeon pea in the world are as follows; India, followed by Uganda, Tanzania, Kenya, Malawi, Ethiopia, and Mozambique in Africa; the Dominican Republic, Puerto Rica, and the West Indies in the Caribbean region and Latin America; Burma, Thailand, Indonesia, and the Philippines in Asia; and Australia (Sinha, 1977). Several countries in Africa (in the central, western, and southern regions), North America, Central America, and South America have been identified as potential areas for pigeon pea production. In Nigeria's south western region, it is commonly called Otili. Pigeon pea is used for food, feed, and fuel. Pigeon pea produces more nitrogen from plant biomass per unit area of land than many other legumes although it usually produces fewer nodules than legumes (Onim 1987). Pigeon pea can fix about 70 kg N/ha per season by symbiosis until the mid-pod-fill stage. This is around 88% of the total nitrogen content of the plant at that stage of growth. Pigeon pea has been used as a green manure crop. It grows well even in soils with a low phosphorus level. The plant is remarkably hardy to both low temperatures (as low as 5° to 10°C) and high temperatures (up to 40°C) and, thus, is an ideal crop to fit into cropping systems of in many parts of the world (Sinha, 1977). Pigeon pea is normally grown as an annual shrub, but is a perennial in which plants may grow for several years and develop into small trees. It gives additional yield after the first harvest if sufficient moisture is available, and it has great flexibility in a wide range of cropping systems. The crop has a wide range of maturity (80 to 250 days) and time to maturity is greatly affected by temperature and photoperiod. Thus, there exist maturity types of pigeon pea for many different cropping systems. Pigeon pea is a rich source of proteins, carbohydrates, and certain minerals. The protein content of commonly grown pigeon pea cultivars ranges between 17.9 and 24.3 g/100 g (Salunkhe ***et.al***., 1986) for whole grain samples, and between 21.1 and 28.1 g/100 g for split seed. Wild species of pigeon pea have been found to be a very promising source of high-protein and several high-protein genotypes have been developed with a protein content as high as 32.5% (Singh ***et.al***., 1990). These high-protein genotypes contain protein content on average by nearly 20% higher than the normal genotypes (Saxena ***et.al.***. 1987; Reddy ***et.al***., 1979). The high-protein genotypes also contain significantly higher (about 25%) sulphur-containing amino acids, namely methionine and cystine (Singh ***et.al***., 1990). Pigeon pea seeds contain about 57.3 to 58.7% carbohydrate, 1.2 to 8.1% crude fiber, and 0.6 to 3.8% lipids (Sinha, 1977). Pigeon pea is a good source of dietary minerals such as calcium, phosphorus, magnesium, iron, sulphur, and potassium. It is also a good source of soluble vitamins, especially thiamin, riboflavin, niacin, and choline.

Pigeon pea is most widely eaten in the form of split seeds and used in this way; it contains protein with an amino acid profile similar to that of soybean (Singh ***et.al***., 1990). Green pods and green seeds are also consumed as a vegetable. Vegetable pigeon pea types are important in Central America as well as in Western and Eastern Africa, where green peas are consumed as soups, etc. (Morton, 1976). The presences of anti nutritional factors in these legumes have limited their widespread usage and direct incorporation into animal feeds. Pigeon pea (*Cajanus cajan*) seed is one of the tropical legume seeds that has been scarcely used in fish feed production in spite of its crude protein and energy profile. Like other legume seeds, its nutritive value is masked by the occurrence of anti nutritional factors, example trypsin inhibitors haemaglutinin and saponin (Grimaud, 1988; Francis ***et.al***., 2001). Svobodova ***et.al***., (1991) opined that ichthyo-haematology would be useful in the assessment of suitability of feeds and feed mixture, evaluation of fish conditions, determination of toxic effect of substances as well as diagnosis of disease. The removal of anti-nutritional factors in pigeon pea using different processing methods is important to make it safe for use in fish feed production. Different processing methods have been devised to remove or reduce the concentration of these factors. Wee and Wang (1987) demonstrated this glaring inadequacy in the weight loss of experimental fish. Hence there is a need to combine other feed ingredients with plant protein materials. *Phaseolus vulgaris* (bean seed coat) could be incorporated into the diet of rainbow trout, Ufodike and Matty (1984) without compromising protein digestibility, provided carbohydrate in the diet is sufficient. Ufodike *et al.,* (2006) also revealed that, bean coat, a by- product of bean pudding (moi moi) as a potential protein supplement.

According to Harpaz *et. al,*. (2001), protein requirements for optimal growth and feeding of juvenile fishes usually range from 35-55%depending on species Olvera (1990) stated that, typical herbivores such as tilapia require dietary protein between 30-35%. In contrast carnivores require 40-45% dietary protein.

According to Takeuchi *et.al.,* (1990), low protein digestibility has been reported in fish fed high carbohydrate diets. Stickney (1979) and Watanabe (1988) noted that nutrient digestibility in fish is linear relationship to the increasing levels of dietary protein consumed.

Ofejukwu *et. al.,* (2003) showed that 20% sesame cake can be used with 30% fish meal in the diet of juvenile *Oreochromis niloticus.* The extent to which nutrients, particularly protein are utilized by fish is regulated by an interplay of dietary and environmental factors which include energy content of the diet (Garling and Wilson, 1976). Jauncey (1981) indicated that, growth was proportional to the amount of protein in the diet of juvenile *Sarotherodon mossambicus.* Faturoti *et. al.,* (1986) reported that the optimum protein content of diets for juvenile *Clarias lazera* was 40%.

Shephard (1988) stated that difference in growth increments between monoculture of one species and polyculture of several species within the same period. However one specie might affect the environment to improve the growth condition for the other specie i.e. C = (a-b)/a.

Legendre *et. al.,* (1991) reported that hybrid morphology was intermediate to that of the parents and had a faster growth performance. Pan and Zheng (1986) mentioned that intraspecific hybridization of fish hlariasas been considered to combine valuable traits from two or more species to obtain hybrids that exceed both parents' species (Naevadal, 1987).

Individual specie could be used as a predator for recruitment control under different stocking ratios (Bedawi, 1985). Guerrero *et. al*., (1979) found out that the production of a Tilapia monoculture system was lower than in polyculture with Macrobrachium. Dunseth and Bayne (1978) observed that, the highest stocking ratio (*C. managuense*: *T. aurea* 1: 4 and 1:8) had a huge yield but lower individual weight gain. Vivien *et. al.,* (1985) recommended an initial stocking weight of 1-3g for catfish and 5-15g for *Tilapia.*

Cruz, 1980 stated that the Nile *Tilapia* (*Oreochromis niloticus*) generally is ideal for polyculture trials because it does not affect the growth and production of other species.

Feed and feeding of catfishes in grow outs ponds are perhaps the most documented in literature. Various efforts have been made to establish the crude protein and amino acid requirement of *Clarias gariepinus.* Ayinla (1988) recommended 35% and 40% crude protein (Cp) for raising table size and brood stock respectively. Of the 10 essential amino acids (EAA) required by warm water fish species, only 3 EAAs studied have been documented and these are arginnie, methionine and lysine. In order to formulate and compound aqua feeds that will meet the nutrient requirements of the catfish at affordable cost, several conventional and non-conventional animal by-products and plant residues have been tested to substitute or replace fishmeal. Feeding development has moved from the use of single ingredient, broadcasting un-pelleted meal to pelleting and in fact the use of pelleted floating feed which has made a big difference to aquaculture development in Nigeria as *Clarias gariepinus* is being raised to maturity within six months.

MATERIALS AND METHODS

AQUARIUMS AND TREATMENTS

Tilapia and *Heteroclarias* were transported from Ajima farms, Kuje, Abuja (FCT) in plastic bowls with well oxygenated water at 5pm-6pm to avoid mortality due to high temperature. They were assigned randomly into 3 replicate aquaria at 15 fingerlings per treatment, designed as one (stocking ratio) by two (specie combination factorial). Stocking ratio was 1:2 *Heteroclarias/Tilapia.*

Three glass aquaria each having a dimension of 1.165m^2 was used in the experiments under laboratory condition. The aquaria are facilities of the Department of Biological Science, University of Abuja. There were 3 treatments with the same stocking density. Each of their aquaria was stocked with 5 *Heteroclarias* fingerlings and 10 *Tilapias* respectively. The fingerlings stocked in each aquarium are of the same sizes to avoid cannibalism. Dechlorinated tap water was used. No prophylactic treatment was given before acclimatization. The fingerlings were acclimatized for seven days and fed experimental floating diets at 2% body weight. The aquaria were well aerated. At the end of acclimatization period, the fishes were starved for 24 hours to empty their gut content and prepare them for experimental feed. This also helps to make the fish hungry and thus receptive to the new diet. Before randomly stocking the fish, the initial total length (cm) of individual fish and mean weight of the fish was recorded before placing them in the rearing containers. The aquariums were covered with mosquito net to prevent fingerlings from jumping out, intrusion of insects and other foreign bodies (Lizards, geckos, etc). All experimental tanks were cleaned daily by scrubbing, siphoning accumulated waste and disinfecting with 3ml/L Potassium permanganate and rinse with clean water.

FEEDING AND MEASUREMENT

Coppen feeds for aquaculture (floating diet) containing 42% crude protein, 13% crude fat, 1.9% crude fibre and 8.9% ash was used as control feed for the first treatment (Tank C) which serves as control Treatment, boiled Bambara groundnut containing 22% crude protein, 10.09% lipid, 3.51% crude fibre and 11.60% ash for third treatment (Tank B), boiled Pigeon pea (*Cajanus cajan*) containing 25.2% crude protein, 8.9% lipid, 6.9% moisture and 14.0% ash in third treatment (Tank A) was used. The fingerlings were fed 3% of their body weight twice daily, morning (8am-9am) and evening (5pm-6pm). Samplings of fish for weight and length measurement were initially done with a scoop net. However due to difficulties in collecting the fish with the net, the water volume was reduced with a rubber siphon before the fishes were collected with a scoop net. Fish weight (g) was taken using a top loading balance (model: Ohaus precisin plus). The fingerlings were weighed in groups once a week. The standard length of the fish was taken to the nearest cm with the aid of a measuring board. This was done once a week. Depleted water was replaced with fresh water to an effective depth of 20cm after each cleaning.

EXPERIMENTAL FISH FEED:

Bambara groundnut meal (*Vigna subterranean*) and Pigeon pea meal *(Cajanus cajan*) are the experimental feed stuff used to formulate the diets for the feeding trial.

Bambara groundnut meal *(Vigna subterranean):*

- Fish meal: 1cup
- Boiled Bambara nuts: 1cup
- Corn flour: 2cups
- Vegetable oil: 1teaspoon
- Vitamin and mineral premix:1/4 of a teaspoon

Pigeon pea meal *(Cajanus cajan)*

- Fish meal: 1cup
- Boiled Pigeon peas: 1cup
- Corn flour: 2cups
- Vegetable oil: 1 teaspoon
- Vitamin and Mineral premix:1/4 of a teaspoon

PHYSIOCHEMICAL PARAMETERS:

Both surface water temperature and atmospheric temperature were read daily to the nearest ^{o}C with the aid of mercury in glass thermometer. Dissolved oxygen was determined once a week by titration with 0.1 NAOH and the azide modification of the Winkler method (American Public Health Association 1976). Ammonia (NH_3) was determined by a spectrophotometer, using the phenolhydrochrorite method (Stirling, 1985). pH was determined with the aid of digital pH meter. Nitrite was determined as described by (APHA, 1990).

FOOD UTILIZATION PARAMETERS:

Specific growth rate {SGR}: This was calculated from data on changes of the body weight over the given time intervals according to the method of Brown (1957) as follows;

$$SGR\% = \frac{\text{Ln } W_2 - \text{Ln } W_1 \times 100}{T-t}$$

Where; W1 is the initial weight (gram at time t).
W2 is the final weight (gram at time T) (Brown, 1957).

Food conversion ratio:-

$$FCR = \frac{\text{Weight of food consumed per fortnight (g)}}{\text{Weight gained by fish per fortnight (g)}}$$

Weight gain (g)

Weight gain (g) is calculated as the difference between the initial and final mean weight values of the fish in the aquarium.

$$\text{Weight gain (\%)} = \frac{\text{Final weight}}{\text{Initial weight}} \times 100$$

Survival rate {SR}:-

The survival rate, SR was calculated as total fish number harvested / total fish number stocked expressed in percentage.

$$\text{Survival (\%)} = \frac{\text{Number of fish harvested}}{\text{Number of fish stocked}} \times 100$$

Relative weight gain:-

$$\text{Relative weight gain (RWG)} = \frac{W_2 - W_1}{W_1} \times 100$$

Mean growth rate{MGR}:- This was computed using the standard equation:

$$MGR = \frac{W_2 - W_1 \times 100}{0.5(W1.W2)}$$

Where: W_1= Initial weight

W_2 = Final weight

t = Period of experiment in days.

0.5= constant

Percentage weight gain (%WG):- This is expressed by the equation:

$$\% WG = \frac{Wt - Wo}{Wo} \times 100$$

Where: Wo = Initial weight and Wt = Weight at time t.

STATISTICAL ANALYSIS:-

1. Analysis of the growth data using analysis of variance (ANOVA).
2. Minimum significant difference.

RESULTS

Results of physiochemical parameters for the three treatments (A, B and C)are presented in Appendix 3, 6 and 9 while the production parameters for the three treatments are given in Appendix 1, 2, 4, 5, 7 and 8 respectively.

As shown in Appendix 3, 6 and 9, the atmospheric temperature throughout the study period varied between 24.5^{o}C to 28.5^{o}C but highest water temperature occurred in the eighth week of the experiment.

Treatment A, B and C recorded the highest concentration of dissolved oxygen at 5.8mg/ml and 6.94mg/ml while the lowest reading, ranged between 3.66mg/ml and 3.47mg/ml were obtained for treatment A between the eleventh and twelfth weeks of the study period. pH values measurement of the three treatments had more or less similar readings which ranged between 7.0 and 8.2 (Appendix 3, 6 and 9). Ammonia concentration throughout the study period also had more or less similar readings for the treatments which ranged between 0.01mg/ml and 2.03mg/ml. (Appendix 3, 6 and 9). Nitrite concentrations were more or less similar in all three treatments between 0.001mg/ml and 0.06mg/ml (Appendix 3, 6 and 9).

The various production parameters in the three treatments show that Treatment C for *Heteroclarias* had the highest mean weight gain, specific growth rate and mean growth rate. Values ranged between 0.20g and 2.23g for the mean weight gain, 1.25cm and 5.32cm for the specific growth rate, and between 0.06 and 2.50 for the mean growth rate respectively. While the lowest values were obtained from Treatment B, 0.72g for mean weight gain, 1.72g for specific growth rate and 0.005 for mean growth rate (Appendix 4). Meanwhile the various production parameters for the each treatments of *Tilapia* showed that treatment C had the highest mean weight gain of 1.13g, also the highest specific growth rate of 2.37 and the highest mean growth rate was also at 0.06 (Appendix 8). At the end of the study period Treatment C also had the highest survival rate (98.33%) compared to Treatment A and B each having survival rates of (93.33%) and (85.00%) for the *Heteroclarias*. Treatment A had the highest survival rate of (92.50%), while treatment B and C each had survival rates of (87.5%) and (84.17%) for *Tilapia*.

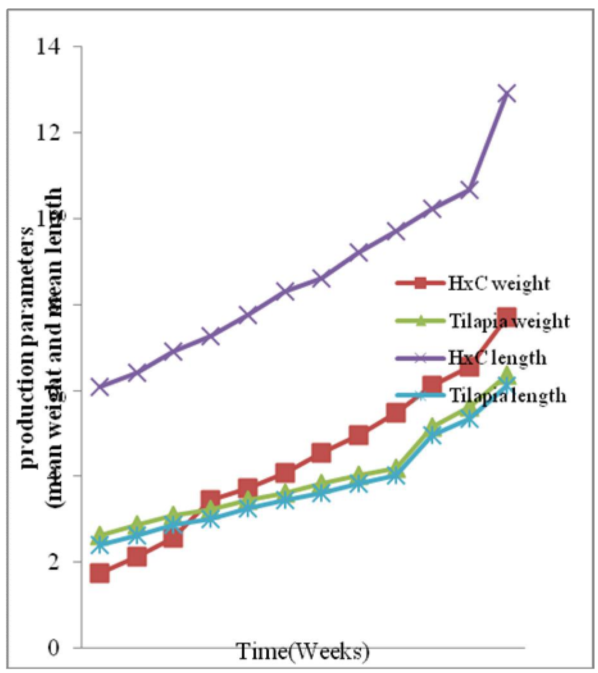

Figure 1- Growth Rate for Treatment A (1:2) HxC/*Tilapia*

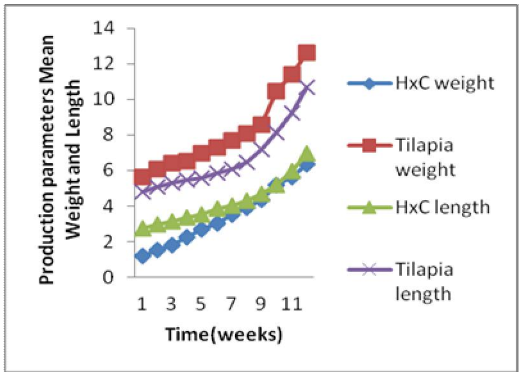

Figure 2- Growth Rate for treatment B (1:2) HxC/ *Tilapia*

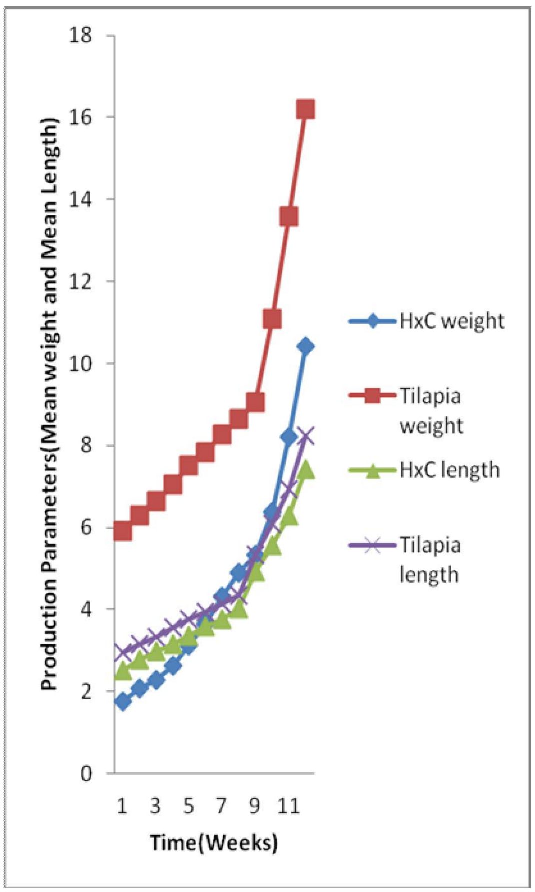

Figure 3- Growth Rate for Treatment C (1:2) HxC/*Tilapia*

DISCUSSION, CONCLUSION AND RECOMMENDATIONS

The water temperature and atmospheric temperature of the three treatments recorded during the experimental period ranged from 24.3°C- 28.5°C, 24.0°C- 28.5°C and 24.0°C-28.0°C respectively (Appendix 3, 6 and 9). The temperature readings in all the treatments above were within the same range which is tolerable for Clariid fish culture as recommended by Swann *et.al.* (1990). The pH of the treatments were within the range of 7.0- 8.3 which is alkaline and agrees with earlier report by Boyd and Licktkoppler (1979). These results also showed that the pH ranges fall within the tolerable range of 6.0-9.0 ideal for tropical fish culture although high level may have had an effect on some other water quality parameters (Akinwole and Faturoti, 2006) .Tropical fish generally require moderate temperature between 25°C-32°C. According to Adeniji and Ovie (1990), an ideal water condition is necessary for the growth of fish since its entire life processes are dependent on quality of its environments. Other water quality parameters such measured such as Dissolved oxygen, Nitrite, and Ammonia were at their tolerable ranges. Throughout the period, the nitrite level remained between 0.01mg/ml and 0.06mg/ml, with treatment B having the lowest reading of 0.01mg/ml and treatment A and C having the highest value of 0.06mg/ml. Presence of nitrifying bacteria, which are naturally slow growers, enhances higher nitrite levels greater than 0.06mg/ml. These are toxic for Clariid fish culture (Federal Ministry of Environment, 2006).

Ammonia content in all three treatments was at optimum range between 0.01mg/l to 2.03mg/ l and the highest level was recorded 2.03mg/l while the lowest level was recorded as 0.20mg/l for treatment A. At the end of the experimental period, ammonia was recorded in high concentrations; this was due to increase in biomass. These although were at a tolerable range. Eding and Kamstra (2001) stated that values less than 8.8mg/l are tolerable.

Dissolved oxygen concentration reduced gradually weekly during the period of the experiment. It fell as low as 3.64mg/l in Treatment (Appendix 9). This is below the optimum level of dissolved oxygen for good growth. These low levels could be as a result of metabolism of fish in the tank or/and bacteria decomposing organic material like debris in the water and underutilized feed which may cause disease or death.

The values for the production parameters for the three Treatments' A, B and C each at stocking densities of 1:2 *Heteroclarias/Tilapia* show the final mean weight gain of Treatment C (2.23g) which surpassed that of Treatments' A and B at (1.16g) and (0.92g). Also the final length of Treatment C

(2.60cm) surpassed that of treatments' A (2.25cm) and B (1.16cm) for *Heteroclarias* respectively (Appendix 1, 4 and 7). As for *Tilapia*, the final mean weight gain recorded highest for Treatment C (1.13g) while Treatments A and B recorded each (0.74g) and (0.97g) respectively. Also, the highest mean length gain was recorded for Treatment B at (1.41cm) while Treatments A and C recorded each (0.76cm) and (1.29cm). The difference in the mean weight gain and mean length gain of the three treatments shows the difference in composition and nutritive value of the different feed given to each fish treatment.

The specific growth rate of Treatment C (5.32) at the end of the experimental period exceeded that of Treatments' A (2.33) and Treatment B (1.72) for *Heteroclarias*, meanwhile, the highest for *Tilapia* was from Treatment C (2.37) while Treatment A was (2.15) and Treatment B was (1.76) respectively. The food conversion efficiency was also higher in Treatment C at (37.0) while Treatments' A and B recorded (3.57) and (2.71) for *Heteroclarias*, while *Tilapia* recorded for same parameter, Treatment C was (9.06) while for A (2.77) and B (3.33) respectively. The highest mortality occurred among *Tilapia* in all the treatments, this was due to stress caused by overcrowding, handling and the reduced oxygen levels towards the end of the production period.

The replacement of fish meal based diets with pigeon pea (*Cajanus cajan*) and Bambara nut (*Vigna Subterranean L.*) at 50% was found to be suiting with good results especially for *Tilapia* (Jackson *et.al.*, 1982). Plant materials have progressively been analyzed for fish feed formulation and their limitation due to inferior protein content have been evaluated, (Devandra, 1985). This observation is been in consonance with the result of the present study in which the protein content of *Cajanus cajan* and *Vigna subterranean L.* was 25.2% and 22%.

The superiority of protein in the fish meal (58.58%) showed that animal tissue generally contained more protein than plant tissue such as rice bran (8.7%), cassava leaves (7%), Plantain peels (9.14%), and sun flower seeds (12.3%), Halver 1960, Gohl 1981, and Milikin 1982) demonstrated this glaring inadequacy in the weight loss of their experimental fish. Hence, the need to combine other feed ingredients with plant protein materials as those used in this study has long been demonstrated in some literature (Cho *et. al*., 1985, Ufodike *et al*., 1990, Stickney *et. al*., 1996, Hossain and Shikha, 1996). Unlike coppen which has a crude protein content of 42% which is suitable for the optimum growth of Clariid fish. From the result of this study, the growth was proportional to the amount of protein in the diet. This has been confirmed by previous studies on fish protein e.g 41.68 to 42.92% for grass carp fry (*Ctenopharyngodon idella*) (Dabrowski, 1977). These tallies with the results recorded in the present study which identifies the floating feed coppen as that which produced fish with the better performance. This was as a result of the high protein content of the feed compared to the values for the production parameters of treatments fed Bambara nut meal and Pigeon pea meal each having lower protein contents.

The effect of the production parameters on the productivity of *Heteroclarias* and *Tilapia* was statistically analyzed using one-way and two-way ANOVA.

The analysis showed no significant difference in all the production parameters (P>0.05) except for Food Conversion Efficiency which had a significant difference (P<0.05) for *Heteroclarias* from Treatment C (control), while for *Tilapia*, there was no significant difference in all the production parameters (P>0.05).

The Two- way analysis showed that the Mean weight gain of the three treatments had no significant difference (P>0.05) while the Mean Weight and Food Conversion Efficiency of the three Treatments showed significant difference (P<0.05).

In conclusion, this experiment has demonstrated that there was palpable result in the growth performance of *Heteroclarias* and *Tilapia* under polyculture being fed with Bambara nut meal (*Vigna subterranean L.*) and Pigeon pea meal (*Cajanus cajan*) at 50 % inclusion and substitution of fish meal. Although the best quality and growth performance based on the production parameters were observed in Treatment C (*Heteroclarias* and *Tilapia* fed coppen floating feed) this contains a high level of protein for optimal growth of fish. Not withstanding, these can be used as a substitute for fish meal at certain proportions and should be encouraged.

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