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Absorption of Food Along the Guts of *Parachanna obscura* and *Clarias gariepinus*

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Abstract: The knowledge of feeding habit and absorption of food in the gut of fish is important for fish farmers to boost their production and meet the ever increasing demand for man consumption. The carbohydrate, protein and lipid contents of the food ingested and their absorption in the intestine of *Parachanna obscura* and *Clarias gareipinus* inhabiting Ogbese River in Ekiti State were investigated. For *Parachanna obscura*, total protein of the ingested food was 64.54%, total carbohydrate 20.20% while the total lipid in the stomach content was 6.12% of organic matter. The total percentages of the food absorbed were 76.4% protein, 35.9% carbohydrate and 25.2% lipid. For *Clarias gariepinus*, total protein of the ingested food was 60.87%, total carbohydrate 30.42% while total lipid in the stomach content was 3.30% of organic matter. The total percentages of the food absorbed were 68.0% protein, 45.8% carbohydrate and 24.5% lipid. In both fish species the absorption of protein, carbohydrate and lipid occurred mostly in the fore-gut (the first one-third of the intestine). In *Parachanna obscura*, the foregut had the highest percentage absorption (59% protein, 24% carbohydrate and 15% lipid), while the hindgut had the lowest percentage absorption (4% protein, 4.6% carbohydrate and 3.3% lipid). In *Clarias gariepinus*, the foregut had the highest percentage absorption (41% protein, 34% carbohydrate and 14% lipid) while the hindgut had the lowest percentage absorption (4.1% protein, 3.6% carbohydrate and 3.3% lipid). The nutrients contents (protein, carbohydrate and lipid) of the food in *Parachanna obscura* were significantly different (P>0.05) from the nutrients (protein, carbohydrate and lipid) in the food of *Clarias gariepinus*. This will provide base-line information useful in artificial food formulation and culture of suitable live organisms for the species during culture of either species.

Keywords: Fish, Absorption, Food, Gut, Protein, Carbohydrate, Fat

Introduction

Feeding is the process of taking in food; Food can be defined as any substance consumed to provide nutritional support for the body (Rabanal *et al*., 2004). Digestion is the process of modifying and/or hydrolyzing feed and food polymers into molecules and elements that can be absorbed across the intestinal wall (Portella and Dabrowski, 2008). Absorption is the process of assimilating food substance into the cells, tissues and organs in the body of fish (Peter *et al*., 2004). Knowledge about what fish eats aids in understanding digestion and absorption in their gut (Platell and Polter, 2001). Some fish species feed on dead items (scavengers), others on living material, some feed solely on micro- organisms, others on larger plants and animals and some are opportunistic eating whatever they can find and they undergo different types of digestion of food. Basically, fishes are classified into herbivores, omnivores and carnivores based on the nature of food taken. The morphology of the digestive apparatus is an adaptation to their food and feeding habits (Russo *et al*.,

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2007). These three classes are defined as follows; Herbivorous fish is a group of fishes that eat plant materials. Example include tilapia (*Oreochromis niloticus),* parrot fish (*Chlocucus microzhinos*), gold fish (*Carassium auratus*), surgeon fish (*Acanthurus lineatus*) etc. Carnivorous fishes are fishes which feed majorly on flesh. Example of these fishes include tiger fish (*Hydrocynus vittatus*), African pike (*Hepsetus odoe*), cuttle fish (*Polpsus bimaculatus*), white shark (*Carcharodon carchucians*) etc. Omnivorous fishes are fishes that can eat flesh and plant materials, example include angel fish (*Pterophylum leopoldi*), tiger barbs (*Puntigrus tetrazona*), carp (*Cyprinus carpio*), (*Ichtalacus punctatus*) (Amber, 2013).

Food absorption is known to vary with fish species. Bligh and Dyer (1959) reported that gold fish *Chlocucus microzhinos* absorbed 60% of carbohydrate, 79% of protein and also 40% of lipid thus loosing 40%, 20% and 60% of carbohydrate, protein and lipid respectively. *Oreochromis mossambicus* assimilated 63% organic matter, 77% protein and 63% carbohydrate in its food implying that 23-27% was lost (Bowen, 1981). *Tilapia rendalli* assimilated 63-70% of the dry weight in the apical segments of *Ceratophyllum demersum* thus losing 30-37% (Caulton, 1978). *Oreochromis aureus* assimilated about 55% and 77% of carbon in green and blue green algae, thus loosing 45% and 33% (Tanaka *et al*., 1981). Also a similar research was carried out by Moriarty (1973) and he reported that *Oreochromis niloticus* assimilated about 50% of carbon in green algae and 80% of blue green algae thus loosing 50% and 20% respectively. *Sarotherondon galilaleus* absorbed about 88%, 78%, 84% and 37% of the carbohydrate, protein, lipid and crude fiber respectively in its diet thus losing 12-63% (Akintunde, 1982). Brunson (1998) fed *Clarias gariepinus* with conventional feedstuffs of groundnut cake and maize. He reported that about 68% of carbohydrate, 52% of protein, 38% of lipid was absorbed in the intestine thus losing 32%, 48% and 62%f carbohydrate, protein and lipid respectively. In *Heterotis niloticus* about 65% of protein, 40% carbohydrate and 78% lipid consumed were absorbed thus 22-60% was lost (Ugwumba, 1996). *Hepsetus odoe* absorbed about 72% of protein, 63% of carbohydrate and 51% of lipid thus losing 28% of protein, 37% of carbohydrate and 49% of lipid (Idowu, 2011)

Cat fish (*Clarias gariepinus*) is an omnivorous fresh water fish. It is a popular delicacy in Nigeria. It is a prominent culture species because of its fast growth rate and resistance to diseases and stress factors like over stocking and poor water quality (Olojo *et al*., 2005). It is named cat fish because they possess prominent barbels which resemble cat's whiskers. It has slender body (Ahmed, 2013). The Snake head fish, (*Parachanna obscura*) is a medium sized carnivorous fish that has an elongated shape tapered at both ends and is covered with circular scales (cycloid). The adult fish feed primarily on other fish up to half their size while juveniles feed on insect larvae, prawns, copepods and insects (Fiogbe, 2013).

Studies on food and feeding habit of *Clarias gariepinus* showed that it feeds mostly on zooplanktons (Ameigheme, 2005; Adeyemi, 2009). *Parachanna obscura* is a carnivorous fish. Studies conducted on food and feeding habits of *Parachanna obscura* in cross River state Nigeria between February and April 2009 revealed that the species feed mostly on food from animal origin (George *et al*., 2009). The type and length of a fish gut is a function of the type of food it consumes (Elliott and Bellwood, 2003; Idowu, 2011).

The quantity and the quality of food given to different types of fish have a drastic effect on how these foods are absorbed in their gut (Abowei and Ekubo, 2011). The amount of food given to fish determines the amount of food in the stomach of fish which is prior to how these nutrients are absorbed.

Fish is known to be the commonest and readily available source of protein in the diets of Nigerians which is mostly consumed compared to the other sources of protein such as cow and goat. This encourages artificial rearing of fish in order to meet its increasing demand. Therefore, it is necessary to have the knowledge of the food, feeding habit as well as absorption of food and nutritional requirements for optimum growth of fish. This will help in the formulation of fish feed by fish farmers to boost their production of fish, meet the demand for man consumption and subsequently boost the economy.

Materials and Methods

Study Area

Ogbese River flows from Ekiti State through Ogbese town in Akure North Local Government Area, Ondo State. It has an annual rainfall of about 1600 mm to 2100 mm, which covers the month of April to October and drainage area of 2039 km. the mean daily maximum temperature range from 30°C to 35°C while the mean daily minimum temperature range from 21°C to 26°C (Philips, 1996; Bord, 2013). Ogbese River also serves as source of water supply to the neighboring rural communities. The River is used for irrigation of farm lands and as a means of livelihood for local fishermen. Artisanal fishery is also practiced at the River using traps, set and cast nets, hook and line. Species of fish in the River include *Tilapia zillii, Sarotherodon niloticus, Clarias gariepinus, Hepsetus odoe, Parachanna obscura* etc (Adewumi *et al*., 2014).

Collection of Fish Samples

A total number of 88 *Clarias gariepinus* and 74 *Parachanna obscura* samples were collected from fishermen between June 2017 and September 2017. These samples were collected on weekly basis (1-3 times a week based on the availability of the fish samples) from the landing centers of fishermen. They were brought to the department of Zoology and Environmental Biology Laboratory for analysis.

Analysis of Samples

In the laboratory, the total length, the standard length (beginning from snout to the end of caudal peduncle) (Schineider, 1990) were taken to the nearest 0.1 cm by the use of a measuring board. The weight of individual fish samples was taken with an electronic weighing balance to the nearest 0.1 g.

Analysis of Stomach Contents

The fish was dissected with a pair of pointed scissors. The stomach was removed by slitting the fish from the throat to anus. The fullness of stomach was noted and classified as full, three- quarter full, half- full, one quarter full or empty stomach.

Chemical Composition and Energy Level of Stomach Contents, Intestinal Contents and Feacal samples

After the length of the gastro intestinal tract was cut into sections of stomach, foregut, mid gut and hindgut, the contents of the sections i.e., stomach, fore, mid and hind gut were then emptied into a Petri dish. Samples of contents of the stomach and various sections of the intestine (foregut, midgut, and hindgut) and feaces were dried at 70°C for 24 h. Feacal samples were obtained by pressing slightly the anal region of each specimen. The moisture free samples were grounded in a mortal and sealed in small dry envelope and kept properly prior to proximate analysis.

The method of Kaushik and Hynes (1968) was employed to extract protein from the dried samples. Extraction was carried out for 48h at room temperature with 0.1 m sodium hydroxide (NaOH), purified by precipitation with Trichloroacetic Acid (TCA) and quantified by Miller's (1959) modification of Lowry's assay, as described by Clark (1983). Carbohydrates in the sample were determined by a colorimetric technique using acid orcinol reagent. Lipids were quantified by the rapid total lipid extraction method of Bligh and Dyer (1959). Energy content of each sample was determined by measuring the amount of heat released during combustion of the sample using a Gallenkamp Ballistic Bomb Calorimeter following the procedure in the Calorimeter manual. The results were expressed as kcal/g.

Absorption of Food along the Gut

In calculating percentage absorption of ingested food, the percentage of each nutrient component in the stomach was regarded as the amount ingested while the percentage in feaces was regarded as the amount egested. The difference between the amounts in the various sections of the intestine relative to the amount in the stomach was attributed to absorption in the various sections of the intestines. Percentage absorption was calculated for protein, carbohydrate and lipid.

Statistical Analysis

The minimum, maximum and mean value of total length, standard length, intestinal length and weight of both *Parachanna obscura* and *Clarias gariepinus* were determined. Correlated coefficients of nutrients were determined from the two species studied to know if these are significantly different from each other or not using ANOVA with Duncan Multiple Range Test (DMRT).

Results

Proximate Analysis of Stomach and Intestinal Contents

The nutrients composition of food ingested by both fish species i.e., *Parachanna obscura* and *Clarias gariepinus* and percentage absorption in their gut are presented in Table 1a and 2a respectively. Average weight of *Parachanna obscura* is 291.48 g and for *Clarias gariepinus* it is 321.82 g. Average standard lengths is 26.41 cm for *Parachanna obscura* and 30.43 cm for *Clarias gariepinus*. For *Parachanna obscura* the mean intestinal length is 60.3% of total length of the body while for *Clarias gariepinus* it's 89.3% of total length of the body.

Total protein in the stomach content of *Parachanna obscura* is 64.54%, total carbohydrate is 20.20%, total lipid is 6.12% and total ash is 7.00%, total moisture content is 2.14%. Fiber was not detected in the stomach and the value of Energy is 2.96kcal/g in the stomach organic matter as shown in Table 1a. While in *Clarias gariepinus*, total protein in the stomach is 60.87%, total carbohydrate is 30.42% and total lipid is 3.30%, total ash is 3.00%, total moisture content is 2.41%. Fiber was not detected in the stomach and the value of Energy is 2.83kcal/g in the stomach organic matter as shown in Table 2a.

Absorption of Food

As the food progressed from the stomach of *Parachanna obscura* through various sections of the intestine, the amount of protein, carbohydrate and lipid decreased until it finally became feaces as presented in Table 1b above. By the time the food became feaces, total of 76.4% protein, 35.9% carbohydrate and 25.2% lipid had been absorbed (Table 1b). The foregut had the highest percentage absorption (59% protein, 24% carbohydrate and 15% lipid) followed by midgut (14%

protein, 7% carbohydrate and 7% lipid), while the hindgut had the lowest (4% protein, 4.6% carbohydrate and 3.3% lipid). So also, as food progressed from the stomach of *Clarias gariepinus* through various sections of intestine i.e., foregut, midgut and hindgut, the amount of protein, carbohydrate and lipid decreased until it finally became feaces (Table 2b). By the time the food became feaces, total of 68.0% protein, 45.8% carbohydrate and 24.5% lipid had been absorbed (Table 2b).

The foregut had the highest percentage absorption (41% protein, 34% carbohydrate and 14% lipid) followed by midgut (23.2% protein, 7.9% carbohydrate and 7.3% lipid), while the hindgut had the lowest percentage absorption (4.1% protein, 3.6% carbohydrate and 3.3% lipid). Absorption of protein is the highest followed by carbohydrate then lipid. This statement is true for both fish species.

The comparisons of the nutrients in the two species were tabled out in Table 3. Protein, carbohydrate, lipid, fiber and energy were found to be significantly different in both species, which were marked by different superscript. i.e. *Parachanna obscura* nutrients are significantly different from *Clarias gariepinus* nutrients (Table 3). Moreover for other nutrients like ash and moisture content they are not significantly different. For *Parachanna obscura*, ash value is 36.40a and for *Clarias gariepinus* 32.16a and moisture content value for both fish species 8.80c and 9.49c for *Parachanna obscura* and *Clarias gariepinus* respectively. The results were marked by similar superscript.

Table 1a: Proximate Composition of food of *Parachanna obscura* collected from Ogbese River

Parameters measured	Stomach	Foregut	Midgut	Hindgut	Feaces
%Ash	7.00	40.92	46.53	48.15	49.75
%Moisture content	2.14	7.65	9.85	9.98	14.38
% Crude Protein	64.54	26.80	17.78	15.22	12.02
% Fat	6.12	5.22	4.78	4.58	2.57
% Fibre	Nd	4.09	7.19	9.12	10.98
% Carbohydrate	20.20	15.32	13.87	12.95	10.30
Energy	2.96	2.08	2.87	4.10	3.93

Nd = Not detected

Table 1b: Rate of absorption of Protein, Carbohydrate and lipid in the gut of *Parachanna obscura* during the period of study

Nutrients	Foregut	Midgut	Hindgut	Total absorption
%Protein	58.48	13.98	3.97	76.43
%Carbohydrate	24.16	7.18	4.55	35.89
%Lipid	14.71	7.19	3.27	25.17

Table 2a: Proximate composition of the stomach content of *Clarias gariepinus* collected from Ogbese River

Parameters measured	Stomach	Foregut	Midgut	Hindgut	Feaces
%ASH	3.00	30.50	40.69	41.08	45.56
%Moisture content	2.41	9.50	11.36	11.65	12.56
% Crude Protein	60.87	36.14	22.02	19.50	15.58
% Fat	3.30	2.84	2.60	2.49	1.85
% Fibre	Nd	1.02	5.73	8.78	10.56
% Carbohydrate	30.42	20.00	17.60	16.50	13.89
Energy kcal/g	2.83	1.89	2.51	4.49	3.36

Nd = Not detected

Table 2b: Rate of absorption of protein, carbohydrate and lipid in the gut of *Clarias garieapinus* during the period of study

Nutrients	Foregut	Midgut	Hindgut	Total absorption
%Protein	40.63	23.20	4.14	67.97
%Carbohydrate	34.25	7.89	3.62	45.76
%Lipid	13.93	7.27	3.33	24.53

Table 3: Anova table of nutrient composition (%) of the fish species from Ogbese River

Sample	Ash	MC (%)	CP (%)	Fat (%)	Fiber (%)	CHO (%)	Energykcal/g
Parachanna obscura	36.40^a	8.80^c	27.27^b	4.65^d	6.27^d	14.52^c	3.08^d
Clarias gariepinus	32.16^a	9.49^c	30.82^a	2.57^c	5.21^c	19.68^b	3.02^c

NOTE: Column with the same letter are not significantly different (p>0.05).
Note: MC = Moisture Content, CP = Crude Protein, CHO = Carbohydrate.

Discussion

The major nutrients in the diet of the two species, *Parachanna obscura* and *Clarias gariepinus* from Ogbese River, Ekiti state is protein irrespective of size of the fish. This is so due to the fact that the diet of the species in the river is dominated by animal materials mainly on fish and insects. Similar observation has been reported by (Idowu, 2011) in *Hepsetus odoe*. Also Ugwumba (1996) made similar observation in *Heterotis niloticus* in Awba Lake.

More protein seems to have entered the body tissues of both species than carbohydrate and lipid. Protein from animal origin was the major component of the ingested food in both species. It is established that the activity of digestive enzymes in fish correlates with the nature of its food (Idowu, 2011). In omnivorous fish like *Heterotis niloticus* whose intestinal amylase is capable of releasing about 10mg of reducing sugar at optimum pH of 8.45 unlike herbivorous fish like *Sarotherodon melanotheron* which have a strong amylase activity and that intestinal amylase is capable of releasing about 20 mg of reducing sugar at optimum pH of 8.45 (Ugwumba, 1996). Nikolsky (1963) reported that amylase activity in a carnivorous fish can be 150 times weaker and lesser than that of an herbivorous fish.

It is seen that percentage absorption was higher for protein than for carbohydrate and lipid in both fish species. Protein was more absorbed across sections of intestines for both species. The fact that total absorption of protein in *Parachanna* was 76.4%, carbohydrate 35.9% and lipid 25.2% means that 23.6% protein, 64.1% carbohydrate and 74.8% of lipid consumed were lost. Likewise in *Clarias gariepinus*, total protein that was absorbed was ~68%, carbohydrate 45.8% and lipid 24.5% which deduce that 32.0% protein, 54.2% carbohydrate and 75.5% lipid that was consumed were probably lost. In both species, the amount of carbohydrate and lipid absorbed may reflect the lower capability for digestion of carbohydrate and lipid than protein. Protein is the most important diets for *Parachanna obscura*. Its short intestine favored digestion of flesh materials which increase the digestion and absorption of protein, which is further proofed by the value of protein which is 76.4%. *Clarias gariepinus* in Ogbese River, an omnivorous fish but fed mainly on food materials from animal origin, which is further proofed by the value of protein which is 68.0%. This denotes that *Parachanna obscura* absorb more protein than *Clarias gariepinus*. Diet rich in protein may be more useful to both species than one rich in carbohydrate and fat. This information will be useful during artificial feed formulation for culturing any of these two species.

In this study, the nutrients in the two species were significantly different from each other. Through statistical analysis protein value is 27.27^{b} for *Parachanna obscura* and 30.82^{a} for *Clarias gariepinus*, the carbohydrate value is 14.52^{c} for *Parachanna obscura* and 19.68^{b} for *Clarias gariepinus* and lipid value is 4.65^{d} for *Parahanna obscura* and 2.57^{c} for *Clarias gariepinus.* This could be due to differences in their food items and feeding habits.

Absorption and assimilation of nutrient is known to vary with fish species. It has been discovered that different species belonging to different families and genera, they absorb their food in a diverse manner (Bungher, 1995). Different fish species living in different habitats survive, live and depend on things available for them in their habitat. It has been confirmed and established by many authors that the type of food materials that is present in the environment of fish determines the type of absorption. Indolise (1992) stated that absorption of food in fish mainly depend on the food materials available. Bowen (1981) reported that *Oreochromis mossambicus* assimilated 63% organic matter, 77% protein and 63% carbohydrate in its food implying that 37% organic matter, 23% protein and 37% carbohydrate were lost. *Tilapia rendalli* assimilated 63-70% of the dry weight in the apical segment of *Ceratophyllum demersum* thus losing 30-37% (Caulton, 1978). *Oreochromis niloticus* assimilated about 50% and 80% of carbon in green and blue- green algae, thus losing 50% and 20% respectively (Moriarty, 1973). Similar to what Torchel (1997) reported. The author used *Oreochromis mossambicus* and fed them with plant material (algae), he discovered that about 60% and 70% of carbon in green and blue-green algae were absorbed and assimilated, thus losing 40% and 30% respectively. *Hepsetus odoe* absorbed about 72% of protein, 63% of carbohydrate and 51% of lipid thus losing 28% of protein, 37% of carbohydrate and 49% of lipid (Idowu, 2011).

This study shows that protein have higher percentage absorption than other nutrients present. Some authors that have reported that carbohydrate have higher percentage absorption than other nutrients. Ugwumba (1996) discovered that *Serathoredon melanotheron* absorbed about 58% of carbohydrate, 50% of protein and 54% of lipid. In *Heterotis niloticus*, about 65% protein, 40% carbohydrate and 78% lipid consumed were absorbed, thus 22-60% were lost (Ugwumba, 1996).

This present study confirmed previous report that the absorptive capacity varies along the intestine. The fore and midgut were the main sites of absorption of food in *Parachanna obscura* and *Clarias gariepinus*. Over half of the protein, carbohydrate and lipid in the ingested food found in the stomach were absorbed in the foregut. There was little absorption of lipid in the hindgut. A similar observation was made by Ugwumba (1996) in *Sarotherodon melanotheron*. Likewise Al-Hussainin and Kholy (1953) reported similarly in cyprinids and Akintunde (1982) in *Sarotherodon galilaeus*. Fat absorption mainly occurred in the midgut of these fishes.

Absorption of food has also been reported to occur mainly in the foregut (Bowen 1981, Idowu 2011) as well as in the mid gut (Al-Hussainin and Kholy, 1953) or in the pyloric caeca depending on the species. Generally, there is little or no absorption of food in the hindgut.

In *Parachanna obscura,* less than 5% absorption of protein, carbohydrate and lipid occurred in the hindgut. Likewise in *Clarias gariepinus*, only about 5% of protein and carbohydrate were absorbed and only about 3% of lipid was absorbed in hindgut (Table 1b and 2b). This may be due to the fact that the surface area for absorption of food in the foregut and midgut may have been increased by the numerous and compact mucosal folds in these sections of the gut compared to the hindgut where the folds are less numerous and wide apart (Ugwumba, 1996). The mucosa folds are known to function in absorption of food.

It was not possible to say whether absorption of food occurred in the stomach of *Parachanna obscura* and *Clarias gariepinus* since the chemical composition of food in its stomach was not compared with that in the environment. However it is possible for absorption of food to occur in the stomach of fish. Absorption of food was reported in the stomach of dog fish. In dog fish 35% protein was absorbed.

Conclusion

Dietary protein, carbohydrate and lipid contents of the food as well as the absorptive capacity decrease across the sections of intestine of both fish species. it is confirmed that protein has higher absorption in these two species than other nutrients in Ogbese River. The nutrients (protein, carbohydrate and lipid) in both fish species are significantly different from each other. Information on their dietary composition and nutrient level will provide base- line information useful in artificial food formulation and culture of suitable live organisms for the species during culture of either species.

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Authors' Contribution

Eunice O. Idowu: Handled the proximate analysis of stomach content of the Fish samples and also contributed financially to the research.

Folasade A. Ola-Oladimeji: Handled the statistical analysis of the results obtained.

Dolapo F. Odeyemi: Collation of results and compilation of the manuscript.

Akintayo Joshua Oluwaseun: Collection of fish samples.

Adewumi Adejoke: Supervised the estimation of food absorption along the gut.

Josephine B. Edward: Supervised the proximate analysis of stomach content of the fish samples.

Conflict of Interest

There is no conflict of interest

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