INTESTINAL ABSORPTION BY SAROTHERODON GALILAEUS (SYN TILAPIA GALILAEA) OF LAKE KAINJI, NIGERIA

by

E.A. Akintunde
Department of Zoology
University of Ife, Nigeria

ABSTRACT

Carbohydrates, protein, lipid and crude fibre were found to reduce in amount from the anterior to posterior regions along the gut of Sarotherodon galilaeus collected from Lake Kainji. Different regions of the gut exhibited different absorptive power and all the compounds were differently absorbed in amount. Different sizes of fish showed different absorptive capacity.

INTRODUCTION

Absorption involves the taking in of digested food into the body cells. Van Slyke and White (1911) were the pioneers in the study of absorptive sites in fish. They found that 25% of protein fed to dogfish were absorbed even before the food left the stomach. They also observed further protein absorption in the intestine. Greene (1913) working on King Salmon, Oncorhynchus teshanytscha, observed that some absorption occurred in the stomach.

Al-Hussaini (1949) fed Castor oil to cyprinids which has been fasted for 2 to 3 weeks and found evidence that fat was absorbed mainly by the second and third limbs of the intestine, mainly in the middle limb of the intestine.

Matthews and Parker (1950) observed lipid absorption in the stomach of Caterrhinus.

Winberg (1956) has reported that by the time the food of fish leaves the body as faeces only about 20% of its energy value is left, that is about 80% of the food has been absorbed; that the crude protein in the stomach contents of the deposit - feeding Tilapia in Lake George is reduced to 60% of its value by the time it reaches the rectum. Needham (1964) has provided a simple scheme demonstrating that much less than half of the food energy ingested ends up as new tissue or products of tissue. A considerable fraction is usually undigestible. Moriarty and Moriarty (1973) observed that S. niloticus of Lake George was able to assimilate between 70% and 80% of the carbon in the blue-green algae Microcystis and Anabaena. This means that only between 20% and 30% of the food could not be absorbed.

The present investigation has been undertaken to determine the degree of absorption which occurs in S. galilaeus, the sites of absorption along the alimentary canal, and whether absorptive power depends on fish size. The absorption of different food stuffs is important in fishery for the following reasons:

(1) The proportion of each food item to be used in preparing the pelleted food can be determined.

(2) In transporting fish for stocking or restocking, one has some idea of how long the fish can go without being fed.

(3) It gives one the idea of sources of energy in the fish.

MATERIALS AND METHODS

Fishing was done between July, 1976 and May, 1978. One hundred and ninety-seven specimens of various sizes were used for the determinations. They were brought to the laboratory where they were measured (in cm) weighed (in gm) and cut open. Upon dissection the intestine showed three distinct regions based on colour differences. These were designated as intestinal region I, II and III. The intestinal region I was that region that followed the stomach with the colour of the contents close to the stomach contents, while the region III was the rectal region with harder contents more or less in pelleted forms. The region II was the region between the 1st and 3rd.

The contents of the stomach and the last 5cm of each intestinal region were preserved separately in the freezer until analysis could be done on them. The following determinations were carried out on each of these sections separately.

Carbohydrates determination described by Nelson (1944) and modified by Somogyi (1945) was adopted. Crude protein was determined by biuret method (Gornall et. al. 1949). The method of Allen (1974) was used in the determinations of the quantity of lipids and crude fibre in the gut contents.

RESULTS

All the food items investigated were found to occur in the different amounts in the different regions of the gut and the reduction were regarded as evidence of absoption. Table 1 gives the result of carbohydrate analysis along the gut of different sizes of fish.

By the time the carbohydrate got to the first region of the intestine it has been reduced by 13.40% of its stomach value. Before leaving the second section 60.71% of it has been absorbed and the faecal material contained just about 11.7% of the carbohydrate in the diet. The very young specimens seem to have less capacity for carbohydrate absorption.

With respect to the protein, a similar trend was obtained. Table 2 shows that about 15% of the protein in the diet was absorbed in the first region of the intestine, and this increased to about 57% in the second region. The faeces that left the body contained about 22% of the original protein in the diet.

Only about 3% of the lipid contents of food in the stomach was absorbed at the 1st region of the intestine. At the second region of the intestine about 59.15% was absorbed and the faeces contained only about 16.25% of the original lipid fraction of the food in the stomach.

In the case of crude fibre there was gradual reduction in the percentage of this along the gut so that by the time the food reached the last region of the gut only 32.3% of it was absorbed (Table 4).

DISCUSSION

By the time the food ingested by the fish left the gut as faeces, 88.3%, 77.5%, 83.7% and 36.60% of its carbohydrates, proteins, lipid and crude fibre respectively has been absorbed into the body tissues. It has been found that on the average, 41.64% of the food consumed by the fish was protein 28.58% carbohydrate, 9.23% lipid and 3.23% crude fibre (Akintunde 1981). It then follows that even in terms of weight, more protein entered the tissues of the fish than any other food component in the diet. Crude fibre occurred in very low proportion, and even then, only a little of it could be utilized by the fish. Luckily this item is a non-energy food.

It is difficult to say whether the stomach played any role in the food absorption in the fish, since the food in the stomach was not compared with the food in the environment (not yet ingested by the fish) in terms of these chemical materials. Nevertheless the first region of the intestine played some role in the food absorption. Before the food left this section of the gut,

Table 1 - Fish size variation in relation to the absorption of carbohydrates at different sections of the gut

Number of specimens examined	Size range (cm)		Stomach	Intestinal region I	Intestinal region II	Intestinal region III	% of Carbohydrate in the faecal material
19	1-5	Mean %	16.83	14.56	6.95	3.53	20.97
		S.E.	1.05	0.65	0.85	0.63	
24	6-10	Mean %	28.44	26.40	11.23	3.83	13.47
		S.E.	1.70	2.08	0.33	0.47	
21	11-15	Mean %	32.51	28.27	10.83	3.10	9.54
		S.E.	1.2	1.01	0.91	0.64	
24	16-20	Mean %	29.64	26.82	9.68	2.52	8.5
		S.E	1.34	1.37	0.55	0.47	
22	21-25	Mean %	31.85	28.63	-	-	-
		S.E.	1.53	1.33	-	-	-
25	26-30	Mean %	28.29	22.68	11.13	3.75	13.26
		S.E.	1.02	0.83	0.63	1.76	
18	31-35	Mean%	30.80	23.53	10.50	3.42	11.10
		S.E.	1.72	1.03	0.96	0.85	
20	36-40	Mean %	29.73	25.46	12.45	3.36	11.3
		S.E.	1.13	1.04	1.03	0.68	
19	41-45	Mean %	25.43	21.22	13.16	3.46	13.61
		S.E.	1.68	1.36	1.35	0.76	
5	46-50	Mean %	32.25	29.93	15.13	3.05	9.46
		S.E.	1.06	1.22	1.19	0.25	
Mean			28.58	24.75	11.23	3.34	11.69

Mean % = The percentage carbohydrate found in the gut contents

S.E. = Standard Error

Table 2 - Fish size variation in relation to the absorption of protein at different sections of the gut

Number of specimens examined	size range (cm)		Stomach	Intestinal region I	Intestinal region II	Intestinal region III	% of Protein in the faecal material
19	1-5	Mean % S.E	50.98 0.78	44.92 1.30	14.6 0.85	10.6 1.10	20.79
24	6-10	Mean % S.E.	41.62 0.65	29.55 0.82	11.63 1.45	8.9 1.37	21.38
21	11-15	Mean % S.E.	39.59 0.76	35.87 0.51	13.93 0.42	6.63 0.61	16.75
24	16-20	Mean % S.E	39.36 1.46	32.24 1.13	16.45 0.97	7.52 1.48	19.11
22	21-25	Mean % S.E.	38.93 0.68	33.84 0.40	11.72 0.79	9.23 1.36	23.71
25	26-30	Mean % S.E.	38.65 1.71	32.76 0.98	12.36 1.60	6.8 1.55	17.59
18	31-35	Mean % S.E.	36.77 1.04	30.74 0.90	10.9 0.81	6.05 0.77	17.68
20	36-40	Mean % S.E.	36.33 1.46	31.80 0.54	11.04 0.64	5.16 0.56	14.2
19	41-45	Mean % S.E.	34.90 0.60	31.79 0.80	12.03 0.84	8.62 0.69	24.7
5	46-50	Mean %	33.28	29.98	11.7	7.31	21.97
Mean			39.04	33.35	12.64	7.68	19.67

Note: - Mean % = The percentage protein found in the gut contents

S.E. = Standard Error

Analysis of lipid values are shown in Table 3.

Table 3 - Fish size variation in relation to the absorption of Lipid at different section of the gut

Number of specimens examined	Size range (cm)		Stomach	Intestinal region I	Intestinal region II	Intestinal region III	% of Lipid in the faecal material
19	1-5	Mean %	9.6	8.47	2.95	1.11	11.56
		S.E.	0.74	1.66	0.75	0.33	
24	6-10	Mean %	9.21	7.85	3.04	1.59	17.29
		S.E.	1.12	0.84	1.05	0.11	
21	11-15	Mean %	5.6	5.64	3.03	1.39	24.82
		S.E.	1.04	1.04	1.39	0.97	
24	16-20	Mean %	11.62	9.89	5.06	1.54	13.25
		S.E.	0.78	0.78	0.67	0.65	
22	21-25	Mean %	11.07	10.56	4.91	1.48	13.37
		S.E.	0.95	1.00	0.56	0.76	
25	26-30	Mean %	11.72	11.31	4.66	1.86	15.87
		S.E.	1.40	1.13	0.63	0.86	
18	31-35	Mean %	11.48	14.32	2.70	1.67	14.55
		S.E.	1.26	1.09	0.96	0.77	
20	36-40	Mean %	8.84	8.9	4.92	1.8	20.36
		S.E.	0.98	0.61	1.03	0.79	
19	41-45	Mean %	9.98	9.57	4.25	1.27	12.7
		S.E.	1.17	0.57	0.92	0.61	
5	46-50	Mean %	3.21	3.05	2.13	1.02	31.78
		S.E.	0.69	0.72	0.42	0.84	
Mean			9.23	8,96	3.77	1.50	

Note: - Mean = The percentage Lipid found in the gut contents

S.E. = Standard Error

Table 4 - Fish size variation in relation to the absorption of Crude Fibre at different sections of the gut

Number of specimens examined	Size range (cm)		Stomach	Intestinal region I	Intestinal region II	Intestinal region III	% of Crude fibre in faecal material
19	1-5	Mean % S.E.	4.3 1.08	3.3 1.02	3.19 0.8	3.09 0.79	71.90
24	6-10	Mean % S.E.	4.93 0.65	3.0 0.76	1.97 0.16	1.97 0.96	39.96
21	11-15	Mean % S.E.	4.31 0.52	3.7 0.67	3.25 0.81	2.9 0.06	67.29
24	16-20	Mean % S.E.	2.76 0.89	1.58 0.32	1.29 0.12	1.49 0.62	53.99
22	21-25	Mean % S.E.	2.65 0.93	1.78 0.74	1.41 0.05	2.16 0.04	81.51
25	26-30	Mean % S.E.	3.19 0.94	4.04 1.21	3.85 1.01	2.08 0.95	65.2
18	31-35	Mean % S.E.	2.84 1.03	2.98 0.67	2.23 1.18	2.14 0.82	75.35
20	36-40	Mean % S.E.	4.34 1.13	4.14 1.02	4.07 0.78	2.01 1.05	46.31
19	41-45	Mean % S.E.	2.36 1.11	2.11 0.88	1.69 0.33	2.08 0.15	88.14
5	46-50	Mean % S.E	2.01 1.17	1.96 0.08	- -	0.90 0.91	44.78
Mean			3.00	2.86	2.55	2.08	63.4

Note: - Mean % = The percentage of crude fibre found in the gut contents

S.E. = Standard Error

13.40% of the carbohydrate, 14.6% of the protein, 3% of the lipid and 15.1% of the crude fibre had been absorbed. This also shows that this section did not absorb different food materials equally, probably as a result of different degree of digestion of these materials in the region in question or in the fore gut.

The second region proved to be one most actively concerned with absorption. From the data obtained this section absorbed about 4 times the carbohydrates, 4 times the protein, 12 times the lipid and $1\frac{1}{2}$ times the crude fibre absorbed by the first intestinal region. The third region also absorbed food materials much less than the the second region, except in the case of crude fibre where the difference was slight.

Sivadas (1965) found that only the intestine of Tilapia mossambica absorbed fat. He divided the intestine arbitrarily into three distinct regions, anterior, middle and posterior limbs. He also observed that the three regions exhibited a differential absorptive capacity. The anterior limb exhibited a strong positive reaction when compared to the middle and posterior regions of the intestine. His observation is very different from the present result where middle region exhibited much stronger positive reaction than the other regions.

These differences of course reflect a kind of division of labour along intestinal regions. The first section of the intestine was found to contain many more digestive enzymes than the second and third regions (Akintunde 1981) which is an indication that the first intestinal region was probably more concerned with digestion of food, while the second region was for absorption. The third intestinal region otherwise known as rectum is known in many vertebrates to be concerned with water absorption. Although no direct measurement was made during this study, usual observation showed that the contents of this region were drier than the contents of other regions of the gut. It seems then that the rectum was primarily concerned with water absorption. As is well known, the length of the different portions of the gut relate to their function. The first intestinal region has a mean length of 63.8 cm, second region has a mean length of 106.4 cm while the third has a mean length of 21.3 cm, thereby giving a ratio of 3:5:1 for 1st, 2nd and 3rd regions respectively (Akintunde 1981). The second intestinal region could be said to be adapted for absorption because it was much more massive in area than other regions thereby giving a condition conducive to absorption, that is large surface area.

All the specimens above 5 cm in length, were different in their absorptive power from those below this size. This difference might be due to the difference between the diet of the fry and that of the bigger fishes. The fry fed on zooplankton while the juveniles and adults fed on phytoplankton (Moriarty 1973 and Akintunde 1977).

SUMMARY

Sarotherodon gaililaeus of Lake Kainji was found to be able to absorb protein, carbohydrates, lipids and crude fibre contained in its food to different extents. The absorptive capacity of different sections of the gut varied.

The intestine showed three distinct regions. Region II or the middle section was the major site of absorption in the fish. Region II or the rectum was responsible for water absorption.

ACKNOWLEDGEMENT

The financial assistance given by University of Ife for this study is highly appreciated. I am also very grateful to Professor A.M.A. Imevbore and Dr. E. Ngaha for reading through this manuscript.

REFERENCES

Akintunde, E.A. (1977) Food and feeding habits of cichlid fishes of Lake Kainji. Afr. J. Trop. Hydrobiol. Fish. Vol. 6 No. 1

Akintunde, E.A. (1981) Nutrition in Sarotherodon galilaeus of Lake Kainji, Nigeria. Ph.D Thesis University of Ife, Nigeria.

Al-Hussaini, A.H. (1949) On the functional morphology of the alimentary tract of some fish in relation to differences in their feeding habits. Cytology and physiology. Quart. J. Microscop Sci. 90 323-354

Allens, S. (1974) Chemical Analysis of Ecological materials. Blackwell Sc. Publication. Oxford, London.

Fish, G.R. (1955) The food of Tilapia in East Africa. Uganda J. 19. 85-89

Gornall, A.G., Bardawill, C.J. & David, M.M. (1949) Determination of serum proteins by means of biuret reaction. J. Biol. Chem. 177 751-766

Greene, C.W. (1913) The fat absorbing function of alimentary tract of King Salmon Bull. U.S. Bur Fisheries 33 149-175

Matthew, L.H. & Parker, H.W. (1950) Note on the anatomy and biology of the basking shark (Cetorhinus maximus) (Gunner). Proc. zool. Soc. (Lond) 120 535-576

Moriarty, D.J.W. (1973) The physiology of digestion of blue-green algae in the cichlid fish Tilapia nilotica. J. Zool. Lond 171 pp.25-30

Moriarty, C.W. & Moriarty, D.J.W. (1973) Quantitative estimation of the daily ingestion of phytoplankton by Tilapia nilotica and Haplochromis nigripinnis in Lake George. Uganda J. Zool Lond. 171, 15-23

Needham, A.E. (1964) The growth processes in animals. Pitman. Lond.

Nelson, N. (1944) A photometric adaptation of the Somogyi method for the determination of glucose. J. Bio. Chem. 153, 375-380

Sivadas, P. (1965) Absorption of fat in the alimentary canal of Tilapia mossambica (Peters) (Teleostei). J. Cell. comp. physiology 65 (2) 249-254

Somogyi, M. (1945) A new reagent for the determination of sugars. J. Biol. chem. 160, 61-68

Van Slyke, D.D. & White, G.F. (1911) Digestion of protein in the stomach and intestine of the dogfish. J. Biol. Chem. 9, 209-217

Winberg, G.G. (1956) Rate of metabolism and food requirements of fishes. Fish Res. Bd. Can. Transl. Serv 194

DISCUSSION

J.K. Balogun: Is the colour variation along the intestine/alimentary canal a permanent feature in the fish?

E.A. Akintunde: The colour differentiation was vissible in fresh materials.

S.O. Talabi: What method was used in the analysis? Was it done on dry or wet weight?

E.A. Akintunde: Analysis was on wet weight.

S.O. Talabi: What about the problem of external deposition of fat along the intestine which may give different shades of colours.

E.A. Akintunde: Tilapia is not a fatty fish and no fat deposit was seen.

S.O. Talabi: Was there any relation between size range and the absorption?

E.A. Akintunde: There was significant difference between size range and food absorption.

S.O. Fagade: How many of the specimens collected had fresh intestinal content and on what basis was the analysis done.

E.A. Akintunde: Specimens used in the study were those with fresh materials or those that had just fed between 12.00 a.m. - 5.00 a.m. (the feeding period of the sp.)