Feeding habits of *Synodontis* species downstream of Taabo dam (Bandama River, Côte d'Ivoire)

ABSTRACT

The building of hydroelectric dams has consequences on the ecological conditions of ecosystems, such as the regression or disappearance of certain species that have a benthic entomophagous diet or a proliferation of omnivorous and planktivorous species. The study of fish feeding can provide data not only on the presence of prey, but also on the abundance and availability of trophic potential. In view of the new hydroelectric development project on the Bandama River, this study proposes to examine the diets of *Synodontis bastiani, S. schall* and *S. punctifer* that are captured in the area. Stomachs were collected and contents examined from fish caught monthly between November 2019 and October 2020 using gill nets in the N'Dènou locality. A total of 417 fish belonging to *S. bastiani, S. schall, S. punctifer* were examined. The food spectrum of the studied species is wide and diversified. It is mainly composed of Macrophytes, Insects, Worms, Mollusks, Zooplankton, Crustaceans. These species are all omnivorous with a benthophagous tendency. No difference was observed in the diet according to the size.

1. INTRODUCTION

Freshwater ecosystems are home to important animal and plant biodiversity on which many people depend. For example, about 40% of known fish species, or more than 20% of vertebrates, live in freshwater [1]. Anthropogenic activities such as the construction of dams, pollution of various origins (agriculture, industry, household), deforestation, excessive fishing, the use of ichthyotoxins, the introduction of exotic species, exert an ever increasing pressure on this immense wealth [2-3]. In particular, the creation of dams, especially those for hydroelectric use, has immediate consequences on the ecological conditions of ecosystems, namely a regression or disappearance of certain species that have a benthic entomophagous diet or a proliferation of omnivorous and planktivorous species [4-5]. According to [6], the study of fish feeding can provide data, not only on the presence of prey, but also on the abundance and availability of trophic potential.

A project to build a hydroelectric dam on the main riverbed of the Bandama River is underway downstream from the Taabo dam. In this area, the locality of N'Dénou is located, where fishing products are landed. Among the fish caught, there is a large number of species of the genus *Synodontis*. Updated data on the feeding ecology of these economically important fish species in this locality would be necessary to assess the impact of the new Singrobo-Ahouaty dam on the adaptations and feeding habits of these fish. In addition, there is a lack of data on the diet of species of the genus *Synodontis* in this area. The main objective of this study is to examine the diets of *Synodontis bastiani, S. schall* and *S. punctifer*.

2. MATERIALS AND METHODS

2.1 Study area

The study area is located on the portion of the Bandama River downstream of the Taabo dam and upstream of the construction area of the future Singrobo-Ahouaty dam (Fig. 1). The dam construction site is located about 32 km downstream of the Taabo dam, about 3.5 km from the village of Singrobo and 2 km from that of Ahouaty, in the Agneby-Tiassa region. Specifically, the latitudes and longitudes of the dam construction site are respectively 06°06’11.3’’N and 4°57’0.7’’W [7]. This site was chosen because of the commercial fishing activities that take place at the N'Dènou landing and the impact that the dam under construction could have on this area.

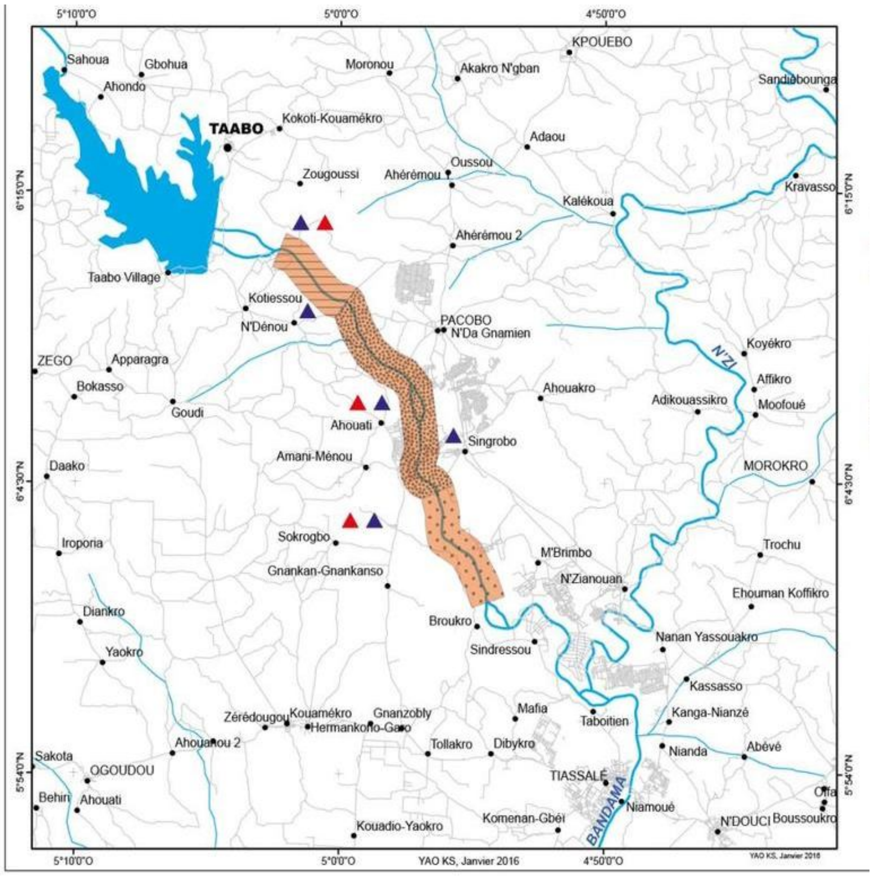

Fig. 1: Map showing the collection sites (BNETD, 2017)

2.2 Data Collection

Fish were caught monthly between November 2019 and October 2020 using gill nets. These nets were set in the evening between 5:00 and 6:00 p.m. and visited the next day at 8:00 a.m. and again at 12:00 p.m. by fishermen. The fish caught were identified using [8]. They were measured (standard length) to the nearest millimeter and weighed to the nearest 0.1 g; then dissected to avoid enzymatic digestion and with care to highlight the digestive tract. The length of the intestine (LI) was measured from the pyloric valve to the anus. Stomachs were collected and preserved in formaldehyde (5%) for analysis of their contents in the laboratory. In the laboratory, after rinsing and spinning, each stomach was emptied of its contents into a Petri dish containing water. After dilution, the different food items were sorted and counted under a binocular loupe and then weighed. Finally, the items were identified using the keys established by [9-10] for the invertebrates. Thus, all insect parts (wings, legs, thorax...) were considered as insect remains because it is not possible to give the order or the family. Roots, stems, fibers were classified as plant debris. Non-whole food items were counted by taking into account the heads or abdominal extremities or the spine present in the food bolus. For those that could not be counted, the number 1 was assigned to their presence in the stomach regardless of quantity and weight according to [6].

2.3 Data processing

Food items for each specimen were determined and quantified using the following food indices:

(1) The corrected frequency (Fc) [6,11]

$$F_C = \frac{F_i}{\sum F_t} \times 100$$

Where : F_i = Frequency of a prey i and F_t = Total Frequency

(2) The numerical percentage (%N) [12-13]:

$$N = \frac{n_i}{N_t} \times 100$$

Where n_i = total number of individuals of item i; and Nt = total number of all food items.

(3) The weight percentage (%P) [14]:

$$P = \frac{p_i}{P_t} \times 100$$

where p_i = total weight of item i; and Pt = total weight of all food items inventoried. It allows to appreciate the relative importance of each item

(4) The index of Relative Importance of the Food (IRA) [15] was chosen to express the diet of the species studied.

$$IRA = \frac{\%Fc+\%P+\%N}{\sum_1^s(\%Fc+\%P+\%N)} \times 100$$

The different prey items were ranked according to the classification scale established by [15]**.** For these authors, food items are primary prey if IRA > 50%; secondary prey if 10% < IRA < 50% and incidental or accessory prey if IRA < 10%.

The intestinal coefficient (IC), defined as the ratio of intestinal length (IL) to the standard length (SL) of the fish, was calculated for each fish; and the mean intestinal coefficient (MIC) estimated for each species. According to [16]; If CIM is less than 1, the species are carnivorous; If CIM is between 1 and 3, the species are omnivorous and If CIM is greater than 3, the species are herbivorous.

2.4 Statistical tests:

Spearman's rank correlation test was performed to compare diets by individual size. Analyses were performed using the STATISTICA version 7.1 program. Correlations were considered significant at p-Value less than 0.05 ($P < 0.05$).

3. RESULTATS

3.1 Relationship between intestinal length (Li) and standard length (LS)

A total of 417 individuals of the genus *Synodontis* were examined in this study and are distributed as follows: *Synodontis bastiani* (192), *S. schall* (138) and *S. punctifer* (87). Standard lengths ranged from 105 to 215 mm for *S. bastiani*, from 79 mm to 180 mm for *S. schall*, and from 90 mm to 170 mm for *S. punctifer*. The mean intestinal coefficients are 1.5; 1.31 and 1.25 for *S. bastiani*, *S. schall* and *S. punctifer*, respectively. The relationships between gut lengths and standard lengths of these three fish species are of the linear type y=ax+b and are given by the respective equations for *Synodontis bastiani*, *S. schall* and *S. punctifer*. Li = 1.66(LS) - 19.28; Li = 2.79 (LS) - 174.43; Li = 1.34 (LS) - 11.055. The different correlation coefficients are all greater than zero **(Fig 2-4).**

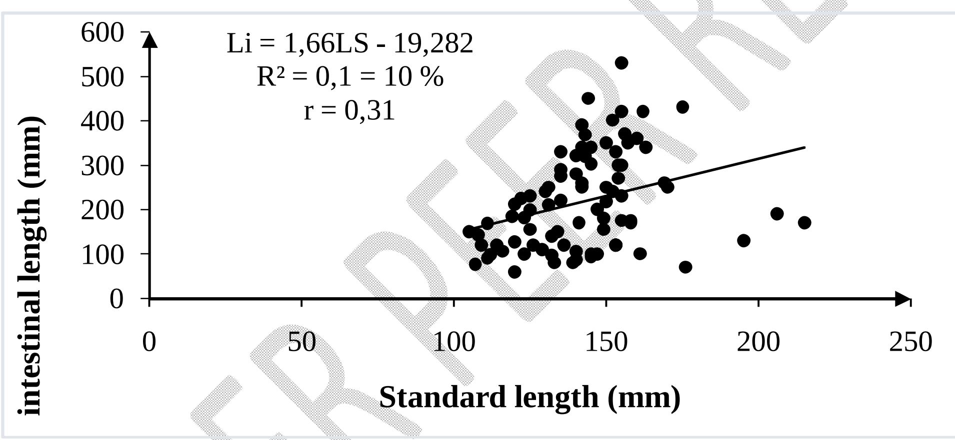

Fig. 2: Curve of the standard length according to the length of the intestine of *S. bastiani*

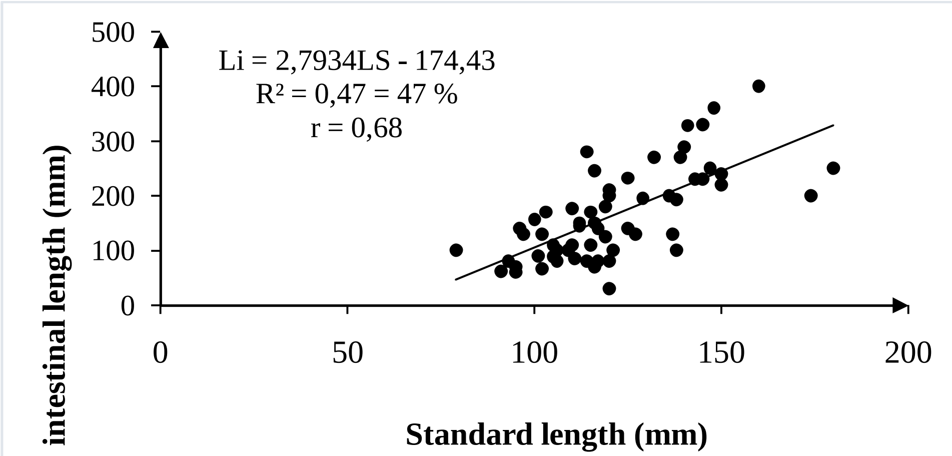

Fig. 3 Curve of the standard length according to the length of the intestine of *S. schall*

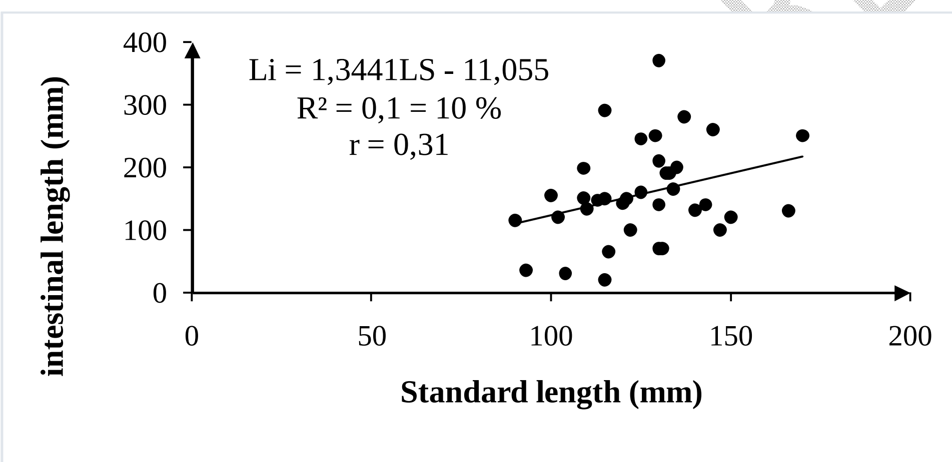

Fig. 4: Curve of the standard length according to the length of the intestine of *S. punctifer*

3.2 General diet of the studied species

The qualitative analysis of the stomach contents of species of the genus *Synodontis* allowed us to identify two food fractions of animal and plant origin.

The animal fraction includes 20 items divided into 5 categories including Insects, Molluscs, Worms, Crustaceans and Zooplankton. Insects are the most diversified taxa with 10 families. The plant fraction is made up of macrophytes such as fruits, leaves and plant debris. In addition, a sediment fraction consisting of detritus, sand grains and mud was observed, as well as some fish scales. Table I indicates that these three species have no food preferences but insects, macrophytes, worms, mollusks are the secondary prey (IRA > 10%). Next are crustaceans, zooplankton (IRA < 10%) which are incidental foods.

Table 1: Composition of the diets of the fish species of the genus Synodontis present in N'Dénou

Categories	Food items	%IRA		
		S. bastiani	*S. schall*	*S. punctifer*
Insects	Dytiscidae	0,73	1,36	3,51
	Elmidae	0,73	2,75	0
	Chironomidae	8,4	6,32	1,78
	Simuliidae	0,73	0	0
	Baetidae	2,63	4,31	3,51
	Ephéméridae	0,73	0	0
	Gerridae	0,73	1,36	0
	Corixidae	0,73	1,36	1,78
	Gomphidae	0,85	1,65	0
	Libellulidae	2,43	1,36	0
	Insects remains	5,04	10,81	15,02
Crustacean	Shrimp remains	4,04	1,36	2,95
Zooplankton	Cladocera	3,65	3,82	2,32
	Copepoda	1,52	2,14	1,46
Worms	Oligochaetes	7,43	12,28	6,42

	Nematodes	3,09	2,72	5,27
Molluscs	Gastropoda	4,03	2,43	3,81
	Bivalves	4,58	1,36	8,8
Macrophytes	Fruits	13,99	6,22	6,13
	leaves	12,69	8,26	10,23
	Vegetable debris	8,06	8,04	5,62
Other	Fish scales	3,54	3,34	4,37
	Detritus	7,13	12,58	11,37
	undetermined	2,51	4,17	5,65
Total				
Insects		23,75	31,28	25,61
Molluscs		8,6	3,79	12,61
Worms		10,57	15	11,68
Crustaceans		4,04	1,36	2,95
Zooplankton		5,17	5,96	3,78
Macrophytes		34,74	22,53	21,99
Other		13,18	20,09	21,38

3.3 Diet according to the size of the individuals of the different species studied

Different size classes grouped in 2 classes according to their numbers were determined with Sturge's rule. For *Synodontis bastiani*, at the level of size class I, Macrophytes and Insects are the secondary foods (IRA between 10% and 50%) and Crustaceans and Zooplankton are considered as accessory or incidental foods (IRA <10%) (Table 2). At the class II level, Macrophytes, Insects and Molluscs are consumed at the same time. Spearman's rank test (N = 7; R = 0.86 and P = 0.01) showed that there is similarity between the different foods of the two size classes. For *S. schall* and *S. punctifer*, similarity was also observed between the diets of the two defined size classes. Spearman's rank correlation test ($p = 0.002$ and $p = 0.04$) shows that the items ingested are not different between the two classes. The figure 5 shows the different variations in size.

Table 2: Variation in the diet of species of the genus *Synodontis* landed at N'Dénou

Food items	%IRA					
	S. bastiani		*S. schall*		*S. punctifer*	
	Class I	Class II	Class I	Class II	Class I	Class II
Insects	18,48	26,69	28,1	27,54	25,78	21,68
Molluscs	5,64	10,69	4,04	3,12	14,52	7,74
Worms	9,91	9,35	9,71	19,6	10,72	9,8
Crustaceans	2,82	5,43	2,55	0	3,47	3,87
Zooplankton	4,27	5,45	8,28	0	6,22	0
Macrophytes	40,68	35,14	33,54	29,19	28,79	34,67
Other	18,2	7,25	13,78	20,55	10,5	22,24

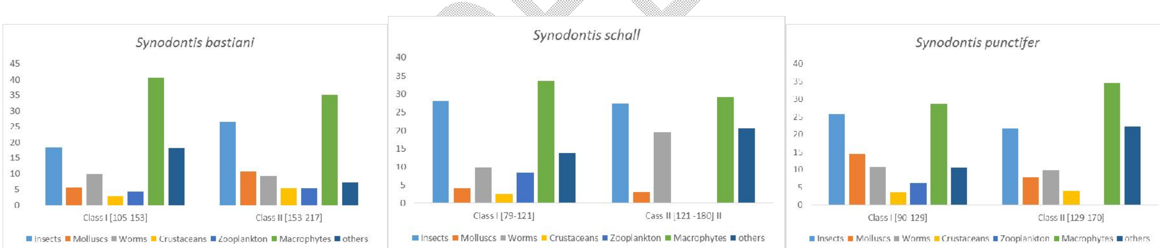

Fig. 5 Variation in diet with size

4. DISCUSSION

The mean intestinal coefficients (MIC) calculated in the different species are: 1.50 for *Synodontis bastiani*; 1.31 for *S. schall* and 1.25 for *S. punctifer*. These results indicate, according to previous work [16-17], that the species of fish of the genus *Synodontis* studied are omnivorous. Indeed according to these authors, omnivorous fishes have an average intestinal coefficient generally between 1 and 3.

The general diet composition of species of the genus *Synodontis* shows that species of this genus have a wide and diverse food spectrum. The food items include Macrophytes, Insects, Worms, Molluscs, Zooplankton, Crustaceans and the presence of fish scales and a sediment fraction. From this composition, it should be noted that the observations made on the intestinal coefficients show that these fish are omnivorous. The results obtained are similar to those of [18] in *S.bastiani* in the Bia river-lake hydrosystem, who observed the omnivorous behavior of this species in the Bia River in 2001. These same observations were made in many species of the genus *Synodontis*, *S. schall* [19], *S. comoensis* [20], *S. nigrita* [21], *S. punctifer* [22]**,** *S. membranaceus* [23] et This diversity of food items could be explained by the availability of prey in the environment and by the non-selectivity of resources by these species. Fish scales would have been found accidentally in the food bowl of *Synodontis bastiani*. One could say that the piscivorous behavior of this species is to be rejected since scales are the only fish parts found in the stomach contents as had also rejected at *Synodontis schall* in Niger River [24]. Furthermore, the sedimentary fraction (sand grains, pebbles and mud), observed in the stomachs testifies to the consumption of benthic foods by species of the genus *Synodontis*. These results are identical to those of [25-26] who reported similar feeding behaviors in *S. ocellifer* and *S. koensis*, respectively. Investigation of the diets of *S. bastiani*, *S. schall* and *S. punctifer* as a function of individuals' size showed no significant variation in diet from one size class to another. But, the proportions of some items change with size. Indeed, the difference in proportions could be explained by ontogenetic, morphological and physiological changes or by energetic requirements for growth, reproduction and swimming [27]**.**

5. CONCLUSION

The food composition of the species of the genus *Synodontis* landed at N'Dénou (Insects, Macrophytes, Crustaceans, Zooplankton, Worms, Mollusks) shows that these species are omnivorous with a benthophagous tendency. No difference was observed in the diet according to the size classes.

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