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Ontogeny and stomach content analysis of *Bagrus bayad* (Forsk., 1977) in Zobe reservoir, Katsina, Nigeria

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Abstract

Bagrus bayad is a freshwater fish with high commercial value in northern Nigeria. This study was conducted to assess the stomach contents and changes in diet composition of *Bagrus bayad* from Zobe reservoir with increasing fish size. 126 specimens of *B. bayad* were obtained from the artisanal fishermen's catches at the reservoir from May to December 2021. About 85.50% of the sample had food in their stomachs, while 14.5% were empty. The stomach contents analysis reveals the presence of fish species: *Tilapia zilli*, *Alestes baremose*, *Petrocephalus bane*, *Clarias gariepinus*, fish eggs, molluscs, aquatic insects, and detritus as food components. The food with the highest percentage frequency (% of occurrence in the young *Bagrus* (≤ 30 cm TL) was insects (26%), while crustaceans (28%) and teleost fishes (46%) recorded the highest % of in juvenile *Bagrus* (30.0-60.0 cm TL) and adult *Bagrus* (≥ 60.0 cm TL), respectively. Invertebrate groups dominated the gut content of young and juvenile *Bagrus*, with a cumulative percentage numerical abundance of 50.7% and 57.8%, respectively. Debris was found only in the stomachs of young *Bagrus*, accounting for a percentage numerical abundance of 31%. The percentage index of relative importance was highest (42.57%) for debris in young *Bagrus*, while in both juvenile and adult *Bagrus bayad* in Zobe reservoir, teleost had the highest IRI of about 77%. This study showed that the species is piscivorous. The young are detritivores, while the juveniles also prey on insects.

Keywords: *Bagrus*, feeding habits, ontogeny, Zobe dam

Introduction

Nigerian freshwater systems have been identified for huge natural fish production with *Bagrus bayad* contributing to catches in most Nigerian freshwater fisheries^[1, 2]. Even though *Bagrus bayad* contributed to catches in the area, its food habits in Zobe Dam have been poorly reported. *Bagrus bayad* is well identified as the only freshwater species with visible vertical lateral lines together with the horizontal ones; in addition, it has long maxillary barbells^[3]. These differentiate it from the other members of the genus *Bagrus*^[3]. Studies on *B. bayad* have shown fast growth and high fecundity^[2]. Food and feeding habits of *Bagrus* in various locations showed it's carnivorous^[4, 5, 6]. The ontogeny and change in diet of *Bagrus* species from juvenile to adult have not been well reported. Despite the fact that the culture and captive rearing of *Bagrus* have not been developed, information on the stomach contents of fish is very useful for ecological studies as well as the formulation of artificial diets in fish culture. Food and feeding studies reveal the dietary requirements of fish in the wild^[7] as well as species interactions^[8]. Fisheries of the Zobe reservoir have been studied by a few authors^[9, 10]. Fish exploit food substances in aquatic environments according to their adaptations like gape size, stomach lengths, dentition, and gut system^[11]. Hence, developmental stages in the life history of fish showed differences in the food grid in stomach content analysis. Therefore, the focus of the present study is to examine the food habits of *Bagrus bayad* fish in Zobe reservoir with a view to establishing the changes in their diet from the young through the adult stage.

Materials and Methods

Study area: Zobe Reservoir is located between latitudes 12°23' 17.9" to 7° 28' 28.9"N and longitudes 7°27' 57.12" to 7°34' 47.68"E in Dutsin-ma Local Government area of Katsina State. It has a height of about 19m and a total crest length of 2,750m (Figure 1).

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The reservoir was constructed to supply water to Katsina metropolis and for irrigation activities. Despite this, there are

a lot of fishing activities in the reservoir.

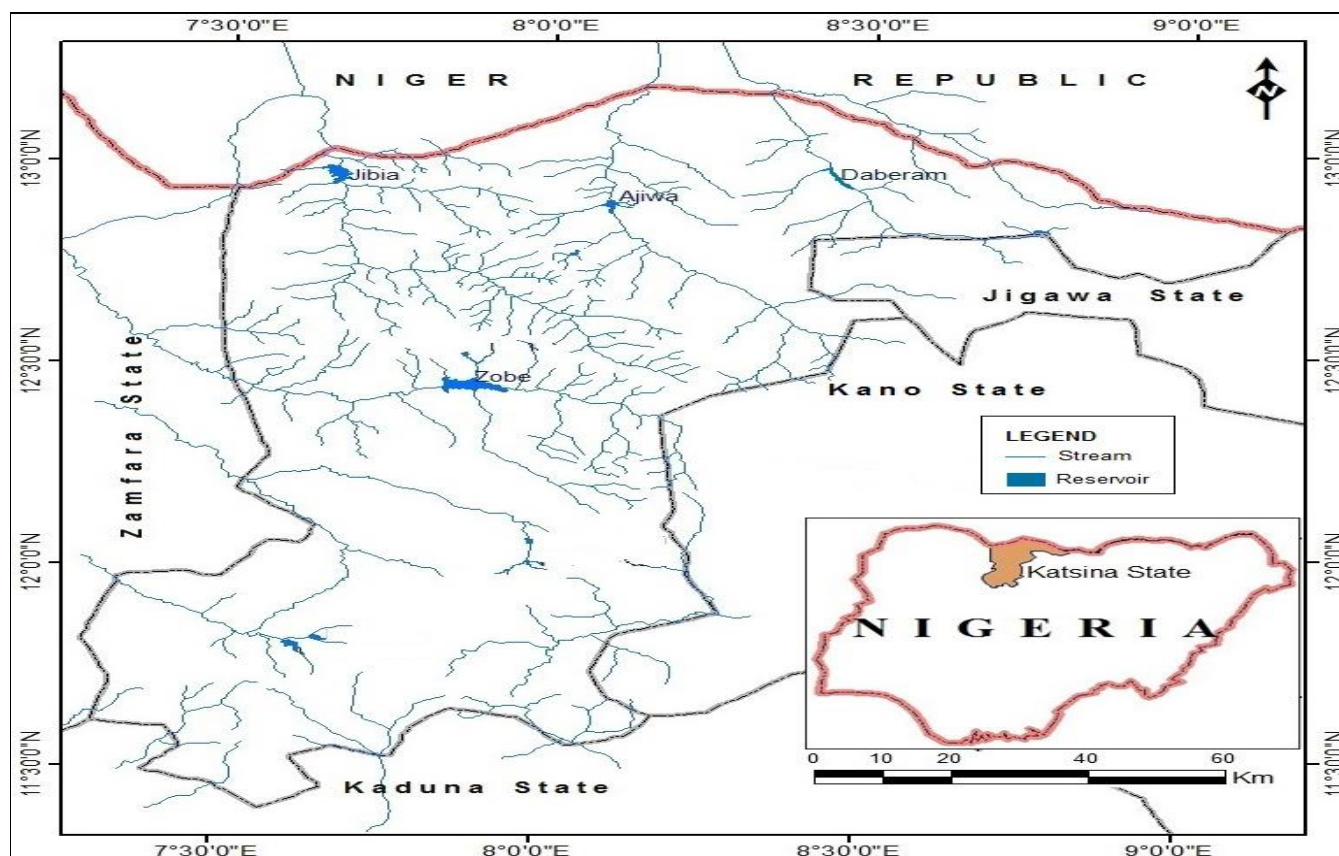


Fig 1: Map of the Katsina State showing inland waters and Zobe Dam.

Sample collection: The collection of fresh samples of *B. bayad* was done from the fish-landing site of Zobe reservoir. The fishermen use gillnets, traps, hooks, and lines. Fish were sampled weekly for three months (May-July, 2021). Fish samples were transported to the laboratory in an ice box to prevent postmortem changes. Fish samples were identified using identification guides by [12] and [3]. The 126 specimens of *Bagrus bayad* obtained were measured for total length (TL cm), a distance from the tip of the snout to the end of the caudal fin using a meter rule, standard length (SL cm), measured from the tip of the snout to the caudal peduncle, and total weight (W g), measured using an electric digital weighing balance.

Stomach content analysis: The fish were dissected in the laboratory; their states of stomach fullness were classified as full, one-quarter full, half full, three-quarter full, or empty via visual observation using the characteristics described by [3]. The full stomachs were extremely packed with food items, the stomach appeared cylindrical. $\frac{3}{4}$ full stomach were nearly filled with food items, $\frac{1}{2}$ full stomach were filled with food items to approximately half of its length, $\frac{1}{4}$ full stomach have a little food item in it, while empty stomach had no trace of food or only watery digested remnants. The contents of the stomach were emptied and rinsed into a Petri dish. The contents of the stomach were preserved in 4% formalin for further examination and identification to the lowest possible taxon depending on the digestion stage of each item. The contribution of each type of food to the diet was expressed as percentage frequency of occurrence (% F), percentage numerical abundance (% N), and percentage volume (% V)

[14]. The percentage frequency (%F) was given by $(N_{i_i}/N_p) \times 100$. Where: N_{i_i} = the number of stomachs in which a food item (i) was found, N_p = the total number of all stomachs with food.

The percentage number (%N) was given by $(N_{i_i}/N_p) \times 100$. Where: N_{i_i} = the number of specific food items (i) found in a non-empty stomach.

The percentage volume (%V) was given by $V_i/V_p \times 100$. Where: N_{i_i} = the volume of a specific food item, V_p = the total volume of all food items.

Index of relative importance (IRI) for all each food species was calculated using the formula $IRI = (\% \text{ Number} + \% \text{ Weight}) \times (\% \text{ Frequency of occurrence})$ [15]. The value of IRI for each food item was converted into a percentage.

Results

Size distribution of *Bagrus bayad* in Zobe reservoir: The total lengths of 126 samples of *Bagrus* fish obtained in this study ranged from 12.0 to 55.0 cm, and the total weights ranged between 16.9 and 1260.0 g, with a mean total length and weight of 20.43 ± 6.45 cm and 109.23 ± 175.05 g, respectively (Table 1). Of the 126 *Bagrus* samples obtained from Zobe reservoir, 110 (87.30%) contained food items in their stomachs. The proportion of stomach fullness across the various size classes of *Bagrus* in this study showed that a full stomach was not recorded among young *Bagrus* (Table 1). Additionally, empty stomachs were also the highest among this group (36.5%). Adult *Bagrus* with empty stomachs had the least proportion in the sample obtained from Zobe Dam during this study.

Table 1: Morphometry and percentage of fullness of guts of *Bagrus bayad* in Zobe Dam, Katsina

Total Length (cm)			Wet Weight (g)	Stomach Fullness				
Range cm	N	Mean ± SD	Mean ± SD	Full	3/4 full	1/2 full	¼ full	Empty
≤ 30	88	19.60±2.65	73.03±40.24	0	5.5	35.6	22.4	36.5
30.0-60.0	31	34.80±4.60	301.45±295.02	9.5	30.3	13.2	11.5	35.5
≥60.0	7	52.5±2.42	1212.50±50.16	4.5	15.3	33.3	31.7	15.2

Stomach contents

The important food items of *B. bayad* in Zobe reservoir were fish eggs, annelids, insects, bivalves, crustaceans, teleosts, and debris (Table 2). The gut content of *Bagrus* in Zobe reservoir showed a considerable variation in the diet based on fish size. Insects had the highest percentage frequency (26%) among the young *Bagrus* (Table 2). The percent frequency of occurrence was highest for crustaceans (28%) in the juvenile *Bagrus*, while in the adult *Bagrus*, the frequency of occurrence was highest for teleost fishes (46%) among the food items. Invertebrate groups dominate the gut content of young and juvenile *Bagrus*, with a cumulative percentage

numerical abundance of 50.7% and 57.8%, respectively. In addition, debris was found mainly in the stomachs of young *Bagrus*, accounting for a percentage numerical abundance of 31%. Whereas, teleost fish had the highest numerical abundance in the adult *Bagrus* stomach content, with a value of 53%. Crustacean had the highest IRI among all food items in young (15.9%) and juvenile (10.89%) *Bagrus* in Zobe reservoir during this study. While teleost fish had a higher IRI in adult food items with a value of 77.46, Amphipods were well selected among the crustaceans by young and juvenile *Bagrus*, while adult *Bagrus* selected tilapia in Zobe Dam.

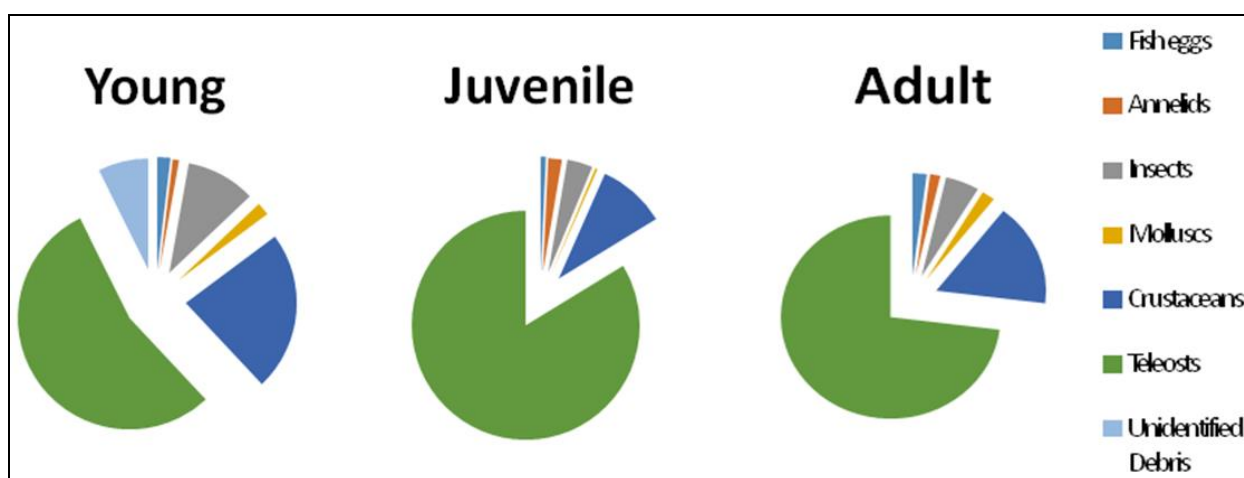


Fig 2. Percentage weight of various food item in stomach content of *Bagrus bayad* in Zobe dam.

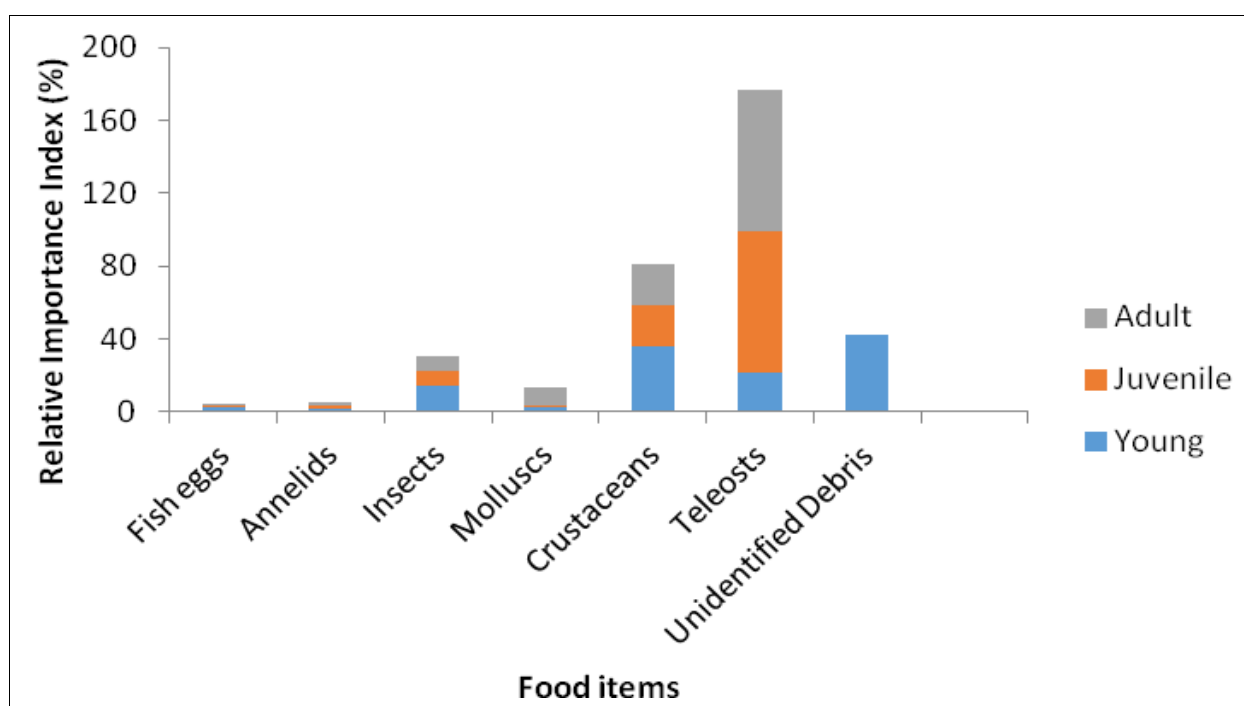


Fig 3: Percentage relative importance index of various food items in the stomach content of *Bagrus bayad* in Zobe reservoir.

Table 2: Diet composition of *Bagrus bayad* in Zobe reservoir, Katsina Nigeria

Food items	TL (cm)	< 30.0				30.0-60.0				≥ 60.0			
		N (% N)	W(%W)	F(%F)	IRI%	(% N)	W(%W)	F(%F)	IRI%	N(%N)	W(%W)	F(%F)	IRI%
Fish eggs	Fish eggs	23(8.46)	3.1(2.23)	8(4.28)	2.39	8(5.76)	2.1(0.78)	3(2.03)	0.51	5(3.73)	4.8(2.33)	3(2.83)	0.90
Annelids	Annelids	9(3.31)	1.5(1.08)	10(5.35)	1.25	5(3.60)	5.6(2.09)	12(8.11)	2.38	7(5.22)	3.5(1.70)	5(4.72)	1.54
Insects	Diptera	16 (5.88)	5.5(3.96)	17(9.09)	5.01	10(7.19)	3.2(1.20)	11(7.43)	2.47	8(5.97)	3.9(1.89)	6(5.66)	2.08
	Coleoptera	14(5.15)	9(6.47)	19(10.16)	6.96	15(10.79)	4.9(1.83)	8(5.41)	2.71	11(8.21)	4.6(2.23)	8(7.55)	3.61
	Odonata	9(3.31)	2(1.44)	13(6.95)	1.79	11(7.91)	2.3(0.86)	15(10.1)	3.31	6(4.48)	3(1.45)	10(9.43)	2.63
Bivalves	Molluscs	15(5.51)	3.1(2.23)	12(6.42)	2.68	3(2.16)	0.9(0.34)	7(4.73)	0.46	21(15.67)	4.5(2.18)	14(13.21)	9.94
Crustaceans	Amphipods	31(11.39)	9.1(6.55)	21(11.23)	11.15	25(18.00)	6.8(2.54)	17(11.1)	9.09	5(3.73)	13.64(6.61)	3(2.28)	1.83
	Arthropods	21(7.72)	4.5(3.24)	15(8.02)	4.75	2(1.44)	1.9(0.71)	25(16.9)	1.80	-	-	-	-
Teleosts	<i>Tilapia zilli</i>	7(2.57)	28(20.14)	4(2.14)	3.17	11(7.91)	85.06(31.79)	18(12.2)	36.10	13(9.70)	23.7(11.48)	19(17.92)	22.34
	<i>Alestes baremose</i>	10(3.67)	33.5(24.10)	7(3.74)	6.74	18(12.95)	78.11(29.19)	8(5.41)	15.72	15(11.19)	52.1(25.24)	8(7.55)	17.83
	<i>Petrocephalus bane</i>	8(2.94)	17.2(12.37)	2(1.07)	1.04	21(15.11)	35.67(13.33)	9(6.08)	9.86	9(6.72)	16.7(8.09)	13(12.26)	10.72
	<i>Clarias gariepinus</i>	-	-	-	-	-	-	-	-	10(7.46)	40(19.38)	3(2.83)	0.00
	Unidentified fish part	24(8.82)	10.5(7.55)	21(11.23)	10.51	10(7.19)	41.02(15.33)	15(10.1)	15.60	24(17.91)	36(17.44)	14(13.21)	26.57
Debris	Unidentified Debris	85(31.25)	12(8.63)	38(20.32)	42.57	-	-	-	-	-	-	-	-

Discussion

The feeding of *Bagrus* in Zobe Dam in this study reflects higher empty stomachs among the young fish. This may not only be attributed to the sampling techniques employed and/or digestion process during capture, but also to the ability to actively select prey items as species length and trophic level have been found to affect the empty coefficient^[16]. The food items of *Bagrus bayad* in Zobe reservoir consist mainly of fish, crustaceans, bivalves, insects, annelids, fish eggs, and unidentified debris. *B. bayad*. Based on the findings of this work, *Bagrus bayads* are generalist predators that feed across several trophic levels. This is consistent with the findings of^[5, 6, 17] regarded molluscs and phytobenthics as secondary diets of *Bagrus* in Lake Albert, Nile Basin, Democratic Republic of the Congo. This may be true for juvenile and adult *Bagrus* in Zobe reservoir, as crustacean, mollusks, and debris account for about 45% of the IRI in young *Bagrus* in this area, as shown in the current study.^[4] Found that *Bagrus bayad* in Golinga reservoir, Ghana, was an omnivorous and benthic eater due to the presence of detritus in the digestive tract. Our current findings also support this, as detritus, which is predominantly plant materials, makes up 42% of the IRI in the diet of young *Bagrus* in Zobe reservoir. Even though juvenile and adult *Bagrus* in our study area were not feeding on detritus, hence, the results of the current finding would classify *Bagrus* as an omnivore in the young stage of their life history at Zobe reservoir. Fish diet and ecology vary among different fish taxa and developmental stages for a single fish species^[18]. Therefore, stomach contents analysis of fish can be used to identify differences in fish feeding strategies along the life history trajectory, as shown in this study. This ontogenetic change in diet may be due to internal conditions like body anatomical structures, behavior, and physiological demand^[19]. Most fish species are planktivorous at the onset of exogenous nutrition with limited ability to capture and ingest, while the increases in gape size and development of the alimentary tract often lead to ontogenic shifts in diet composition^[18]. This is evident for *Bagrus bayad* in Zobe dam.

Conclusion

The present study was conducted in Zobe reservoir, Katsina, to assess the food and feeding habits and changes in diet composition of *Bagrus bayad* based on fish size. 126 specimens of *B. bayad* obtained from the artisanal fishermen's catches at the reservoir between May and December 2021 revealed that 85.50% of the sample had food in their stomachs. The stomach contents reveal the presence of fish

species: *Oreochromis niloticus*, *Tilapia zilli*, *Alestes baremose*, *Petrocephalus bane*, *Clarias gariepinus*, fish eggs, mollusks, aquatic insects, and detritus as food components. Among the fish, tilapia had the highest frequency of occurrence (52.34%), while *Clarias gariepinus* had the least (5.50%). Juvenile and adult *Bagrus* (≥ 30 cm total length) in Zobe reservoir feed predominantly on fish, while young *Bagrus* (≤ 30 cm total length) prey more on mollusks and insects. The feeding habit of *Bagrus* in the reservoir showed that the species is piscivorous throughout its life stages, with the fry stage exhibiting detritus feeding.

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