



Food and Feeding Habits of Three Selected Fish Species of Lower River Benue, Benue State, Nigeria

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ABSTRACT

This study aimed to investigate the food and feeding habits of three fish species: *Hydrocynus forskahlii*, *Citharinus citharus*, and *Mormyrus rume*, caught from the Lower River Benue. Currently, there is not enough information available on the feeding habits of these fish species in the Lower River Benue. The study examined 189 *Hydrocynus forskahlii* from Abinsi, 214 from Wadata station, 372 *Citharinus citharus* from Abinsi, 366 from Wadata, and 384 and 363 *Mormyrus rume* from Abinsi and Wadata, respectively, using gill and cast nets. Specimens were collected every two weeks from fishermen in the Lower River Benue between April 2019 and March 2020. The study measured gut weight and length, performed gut content analysis using the frequency of occurrence, numerical abundance, and total point methods, identified food items, and obtained the stomach vacuity index. Results showed that *H. forskahlii* mainly feeds on worms, insect parts, and juvenile fish. *C. citharus* feeds mainly on detritus and plant materials, while *M. rume* feeds predominantly on detritus, plant materials, worms, and whole fish. *H. forskahlii* and *C. citharus* have higher percentages of food in their stomachs from Wadata, while *M. rume* had it from Abinsi. In conclusion, *H. forskahlii* is confirmed to be a carnivorous species, while *C. citharus* and *M. rume* are omnivorous species.

Keywords: Feeding habits, Detritus, Worms, Stomach, Insect, Gut

INTRODUCTION

Knowledge of the feeding habits of freshwater fish species is a subject of continuous study as it is essential to understand the capacity of fish populations, provide information about the niche of the particular fish in its ecosystem, and understand these mechanisms is critical to the development of conservation and management plans (Saikia, 2015; Udoh and Ekpo, 2017). Different fish feed on different food items (Odedeyi and Fagbenro, 2010). Fish exploit food substances in an aquatic ecosystem according to their adaptation characteristic or features (mouth, gill rakers, dentition, and gut system) (Musa *et al.*, 2016). Therefore, it is important to understand the spectrum of food preferred by wild fish (Olufeagba *et al.*, 2016). Primarily, a classification of fishes into three broad trophic groups herbivorous, carnivorous, and omnivorous does not indicate any precise food preferences with specific biochemical nature (Saikia, 2015). Different fish species adapt to different feeding habits from fry to the maturity stage with various food items constituting the principal diet as they age (Udoh and Ekpo, 2017). *Hydrocynus forskahlii* is abundant, widely distributed, and important in the food chain (Tigerfish are the top predators in these systems) (McHugh *et al.*, 2011). *H. forskahlii* is a piscivorous and ferocious pelagic predator (Jackson, 1961; Dalu *et al.*, 2012; Simasiku *et al.*, 2017). According to Dadebo and Mengistou (2008), *H.*

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forskahlii feeds on zooplankton, insects, macrophytes, and fish fry; they feed mainly on zooplankton when young and consume Pisces when they attain the adult stage. Omoike (2021), reported *H. forskahlii* to feed on fish, fish parts, crustaceans/parts, and zooplankton in their natural habitats.

Poelen *et al.* (2014) reported that *C. citharus* feeds on debris, detritus, phytoplankton, and haptophyte. According to Simasiku *et al.* (2017) and Stergiou and Karpouzi (2005), *C. citharus* is an omnivore feeding on mud, detritus while feeding primarily on zoobenthos like clams, aquatic insect remains, other mollusks, and fish parts. According to Udoeh and Ekpo (2017), *C. citharus* feeds on Chlorophyceae, aquatic insect remains, mud, and sand, presenting it as an omnivorous fish species. *C. citharus* feeds on plant materials, debris, and detritus (Laleye, 2020). Adeyemi *et al.* (2020) reported *C. citharus* feeds on sand, mud, plant part, insect part, and algae.

Fawole (2002), reported detritus and plant remains to constitute the most important food items of *M. rume* in Lekki lagoon, and also feeding on mud, fish eggs, fish bones, remains of shrimp larvae, and diatoms. Ipinjolu *et al.* (2004) reported *M. rume* in River Rima and Goronyo reservoir (Nigeria) to feed on items of both plant and animal origin. Odedeyi and Fagbenro (2010) reported *M. rume* to feed preferentially on insects, and also feeding on crustaceans, plant parts, detritus, rotifers, diatoms, algae, nematodes, annelids, protozoan, with all the food items to be encountered in all the stomachs irrespective of size and season. The authors also reported *M. rume* to be a bottom dweller and a detritivore, suggesting that its trunk-like snout coupled with the small terminal mouth encourages the consumption of detritus. Yoboue *et al.* (2019), reported *M. rume* to be an insectivorous burrowing fish that searches for its prey. Omoike (2021) reported *M. rume* to feed on fish parts, crustaceans/parts, zooplankton, insects, phytoplankton, sand/mud, detritus, and plant parts.

The rate at which fish feed can be determined by comparing the frequency of stomach fullness to that of empty stomachs, and these stomachs can be categorized as almost empty, half full, almost full, and full for those with food, and empty for those without food (Ogbeibu and Ezeunara, 2005). Individual fish are said to be poorly fed when the frequency of less than half ($\frac{1}{2}$) full stomach is higher than or equal to half ($\frac{1}{2}$) full stomach (Ogbeibu and Ezeunara, 2005). Regarding this, all the fish species of this study except *C. citharus* from Wadata fed poorly from all the stations since the frequency of less than half ($\frac{1}{2}$) full stomach was higher than full (1) stomach.

MATERIALS AND METHODS

Study Area

The study was conducted in the Lower River Benue, specifically in Wadata and Abinsi, as shown in Figure 1. Wadata is situated at latitude $7^{\circ} 43' 0''$ North and longitude $8^{\circ} 32' 0''$ East, while Abinsi is located at latitude $7^{\circ} 45' 0''$ North and longitude $8^{\circ} 45' 0''$ East. The river Benue originates from the Adamawa Mountains of Cameroon, which is about 500 km away from the Nigerian border and flows westward across East Central Nigeria (Nedeco, 1959). It is the largest tributary of the Niger River, which joins at Lokoja. The highest water levels in the river occur between August and September, while the lowest are from March to April (Akombo *et al.*, 2011).

Fish Sample Collection and Identification

Fish samples caught using gill and cast nets were collected fortnightly from fishermen from Wadata and Abinsi, between April 2019 and March 2020. A total of 189 *H. forskahlii* comprising 97 females and 92 males, were sampled from Abinsi station, while 214 comprising 115 females and 99 males were sampled from Wadata station. A total of 372 *C. citharus* comprising 167 females and 205 males were sampled from Abinsi station, while 366 comprising 173 females and 193 males were sampled from Wadata station. A total of 384 *M. rume* comprising 217 females and 167 males were collected from Abinsi station, and 363 comprising 204 females and 159 males were obtained from Wadata station. The fish were placed in an ice box containing an ice block to avoid decomposition and were immediately transported to the General multi-purpose laboratory, of the Department of Fisheries and Aquaculture, Joseph Sarwuan Tarka University, Makurdi. The fish species were identified using Paugy *et al.* (2003) identification guide.



Figure 1: Map of Guma Local Government Area showing the sampling stations in Lower River Benue (Source: Ministry of Lands and Survey, Makurdi, 2013).

Identification of food items in the Stomachs

The process of assigning serial numbers to fish specimens involved meticulously inscribing them on a designated piece of paper. Subsequently, the numbered paper was carefully inserted into the opercula of each specimen, ensuring a systematic and organized cataloguing system. Gut content analysis and food items were identified (Malami and Magawata, 2009). The specimens were dissected from the anal opening to the pectoral fin region on the ventral side. The stomachs were weighed in grammes (g) using an electronic balance (Model: HC-D Golden-Mettler, USA in an air-tight environment. The gut length was measured using a measuring board and measuring tape millimeters (mm). The stomach of each sample was opened, the content emptied into a petri dish, and food items were identified macroscopically, after which three slide preparations for each stomach contents were made and examined under a light camera microscope. The stomach contents of the fish species were investigated using the frequency of occurrence methods. Frequency of occurrence (FO) of food items were calculated using the formula:

$$FO = \frac{\text{Number of stomachs with a food item}}{\text{Total number of non-empty stomachs}} \times \frac{100}{1} \text{ (Bagenal, 1978).}$$

The number of guts in which each food item occurred was listed and expressed as a percentage of the total number of guts examined. The fish population that fed on a particular food item was estimated (Inyang and Nwani, 2004).

Numerical method

Different types of items in the stomach content of the fish species were calculated under the numerical method (NM) using the formula:

$$NM = \frac{\text{Food item}}{\text{Total number of different food items}} \times \frac{100}{1}$$

The values obtained were called percentage composition of food items (% CFI) by number (Bagenal, 1978). The total number of each food item in each gut was summed up for all guts and expressed as a percentage of all food items (Inyang and Nwani, 2004).

Points method

One hundred points were awarded to all the contents of a stomach, and each food item was allotted a few points based on the macroscopic and microscopic judgments. All the points gained by a particular food item were expressed as a percentage of the total points scored by food items in the stomach samples; thus, the point method (PM) was calculated using the formula:

$$PM = \frac{\text{Total points scored by a food item}}{\text{Total number of points of all food items}} \times \frac{100}{1}$$

One hundred points were shared amongst the food items in each gut according to their sizes and expressed in percentage (Inyang and Nwani, 2004). The degree of fullness was assessed and recorded as (0) empty, $\frac{1}{4}$ almost empty, $\frac{1}{2}$ half full, $\frac{3}{4}$ almost full, and (1) full. The Stomach Vacuity Index (SVI) was calculated using the formula:

$$SVI = \frac{\text{Number of empty stomachs}}{\text{Total number of stomachs}} \times \frac{100}{1} \quad (\text{Bagenal, 1978}).$$

Statistical Analysis

Student *t*-test was used to determine the differences in seasonal and sex-wise gut length and gut-weight of the three selected fish species from Lower River Benue. They were analyzed using the procedure of Gayanilo Jr. *et al.* (2005) of the FiSAT II (version 1.2.2) computer software package for fish stock assessment.

RESULTS

Food Composition of the Fish Sampled

The food items found in the stomach of *H. forskahlii* are presented in Figures 2-4. Worms had a higher percentage as the food item found in the stomach of *H. forskahlii*, from both Abinsi and Wadata stations. 6.33% of *H. forskahlii* by the frequency of occurrence method (Fig. 2) feed on fish juveniles from Abinsi compared with 14.66% from Wadata. 49.37% fed upon insect parts from Abinsi compared with 54.45% from Wadata. 62.03% fed upon insect larvae from Abinsi compared with 43.46% from Wadata. 84.81% fed upon worms from Abinsi compared with 83.77% from Wadata. 31.65% fed upon daphnia from Abinsi

compared with 39.79% from Wadata. 0.00% fed upon fish bones from Abinsi compared with 4.19% from Wadata. 8.86% fed upon water snails from Abinsi compared with 0.00% from Wadata.

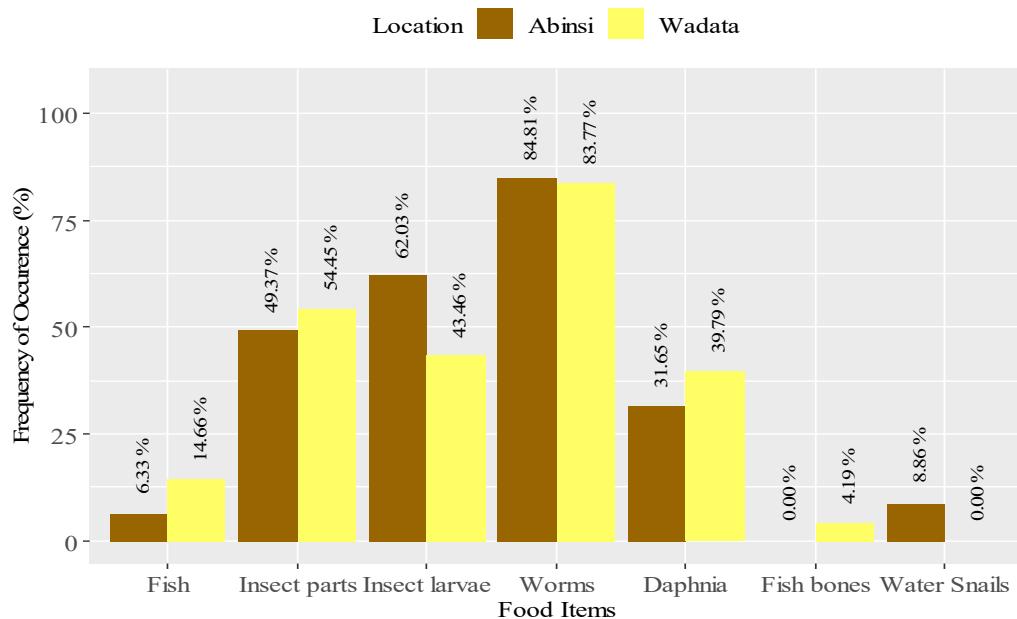


Figure 2: Food items in the stomach of *H. forskahlii* by frequency of occurrence method from Lower River Benue.

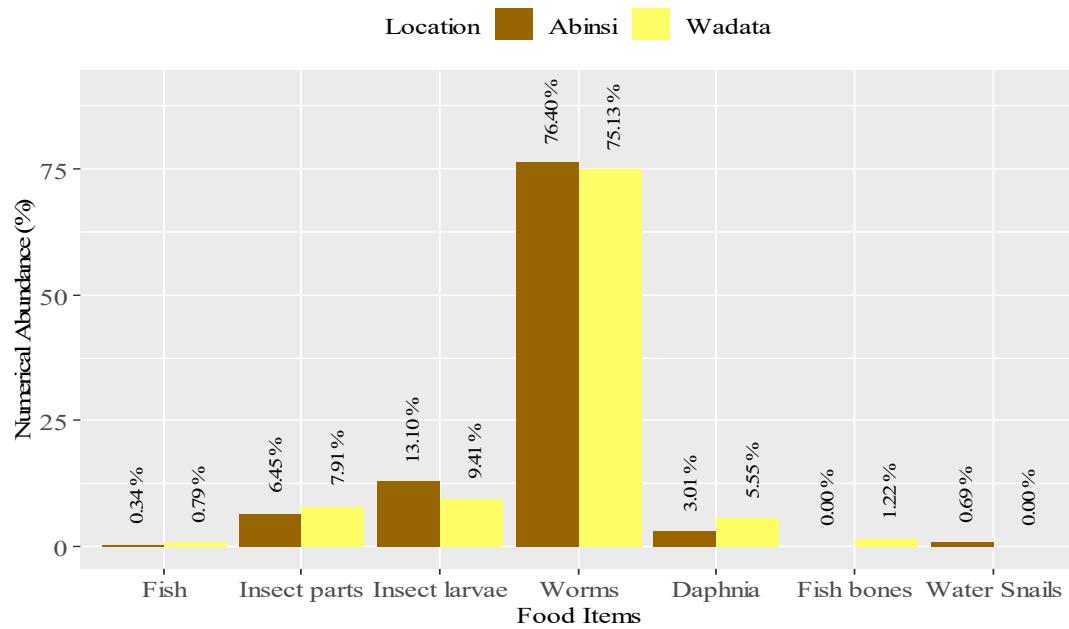


Figure 3: Numerical abundance of food items in the stomach of *H. forskahlii* from Lower River Benue. *Hydrocynus forskahlii* from Abinsi were found to contain fish juveniles in their stomach by the numerical abundance method (Fig. 3) compared to 0.79% from Wadata. 6.45% fed on insect parts from Abinsi

compared with 7.91% from Wadata. 13.10% fed upon insect larvae from Abinsi compared with 9.41% from Wadata. 76.40% fed upon worms from Abinsi compared with 75.13% from Wadata. 3.01% fed upon daphnia from Abinsi compared with 5.55% from Wadata. 0.00% fed upon fish bones from Abinsi compared with 1.22% from Wadata. 0.69% fed upon water snails from Abinsi compared with 0.00% from Wadata. About 0.16% of *H. forskahlii* by the points method (Fig. 4) was found to contain juvenile fish in their stomach in Abinsi compared with 0.36% from Wadata. 4.89% fed upon insect parts from Abinsi compared with 6.10% from Wadata. 11.92% fed upon insect larvae from Abinsi compared with 8.70% from Wadata. Eighty-one (81.10 and 81.04 %) of *H. forskahlii* from Abinsi and Wada respectively, were found to have worms in their stomach, while 83% were observed to have eaten daphnia from Abinsi compared with 3.42% from Wadata. No fish that fed on fish bones from Abinsi compared to 1.37% from Wadata. Very few fish (0.10%) ate water snails compared in Wadata station.

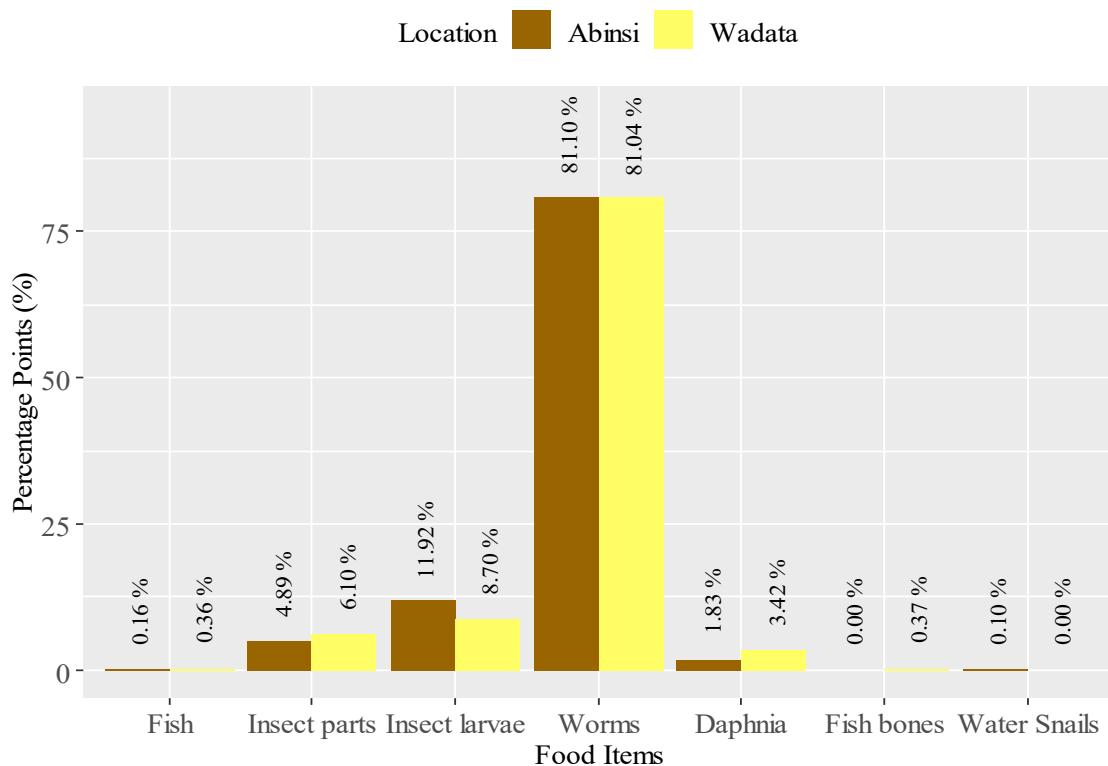


Figure 4: Points of food items in the stomach of *H. forskahlii* from Lower River Benue.

The food items found in the stomach of *C. citharus* are presented in Figures 5-7. Detritus were the higher number of food items found in the stomach of *C. citharus*, from both Abinsi and Wadata stations. Accordingly, plant materials were found to be more food items in the stomach of *C. citharus*, from both Abinsi and Wadata stations. In the Abinsi and Wadata stations, the percentage of *C. citharus* with phytoplankton in their stomach was found to be 24.75% and 28.81%, respectively. In Abinsi, 61.75% of fish feed on plant materials, while in Wadata, this percentage is 64.54%.

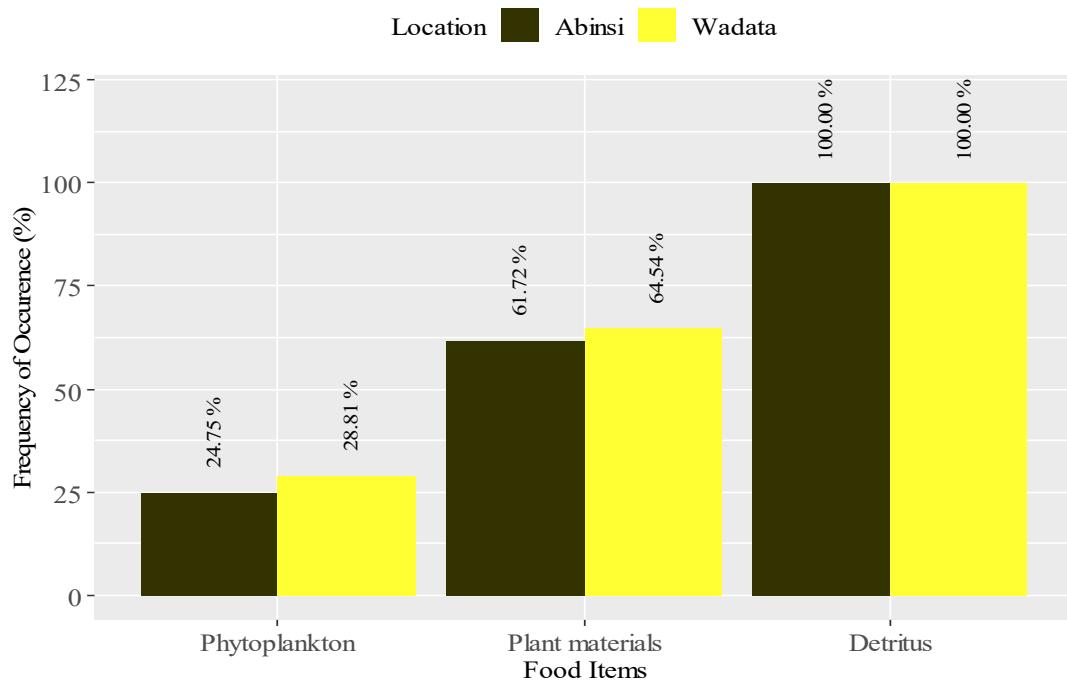


Figure 5: Food items found in the stomach of *C. citharus* by frequency of occurrence method from Lower River Benue.

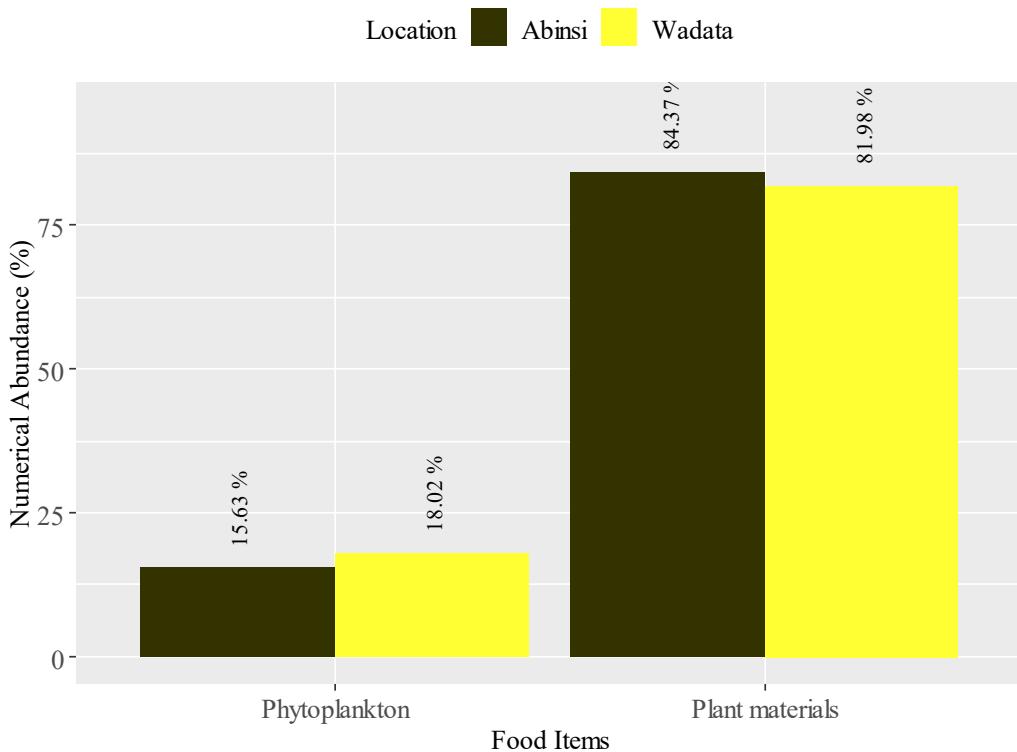


Figure 6: Numerical abundance of food items in the stomach of *C. citharus* from Lower River Benue

All fish in both stations were found to have consumed detritus. By the numerical abundance method, 15.3% of *C. citharus* from Abinsi and 18.02% from Wadata consumed phytoplankton. Additionally, 84.37% of *C. citharus* in Abinsi ate plant materials compared to 81.98% from Wadata. About 4.48% of *C. citharus* by the point method (Fig. 7) consumed phytoplankton at Abinsi station, and only 5.15% in Wadata. Seventy-two (72.52) % of *C. citharus* from Abinsi ate plant materials while 70.25% in Wadata, and 23.00% were found to contain detritus from Abinsi compared with 24.61% from Wadata. Plant materials had a higher percentage as the food item consumed by *C. citharus*, based on numerical abundance and point methods from both Abinsi and Wadata stations.

In Abinsi, 99.45% of the diet of the species was detritus, while the same was 95.07% in Wadata. In Abinsi, 64.19% of the diet was plant material, while the same was 72.75% in Wadata. No crustaceans were found in the diet of the species in Abinsi, while 8.41% of the diet in Wadata was crustaceans. Similarly, no arthropods were found in the diet of the species in Abinsi, while 3.19% of the diet in fish from Wadata was arthropods.

Figure 9 showed 0.83% of *M. rume* by the numerical abundance ate fish juveniles from Abinsi while 1.48% were observed in fish from Wadata. *Mormyrus rume* consumed 9.65% insect parts in Abinsi, and 27.58% in Wadata. Worms of up to 57.65% were observed in the stomach of *M. rume* from Abinsi. However, 2.45% worms were found in the stomach of *M. rume* from Wadata. Detritus was not found in the stomach of *M. rume* caught from Abinsi and Wadata. Plant materials at 22.99% and 61.66% were observed in the stomachs of *M. rume* from Wadata and Abinsi, respectively. However, no (0.00%) crustaceans were seen in the stomach of *M. rume* obtained from Abinsi. However, 3.74% crustaceans were recorded in *M. rume* from Wadata. No arthropods were noticed in the stomach of *M. rume* caught from Abinsi, but 1.16% were noticed in *M. rume* caught from Wadata station.

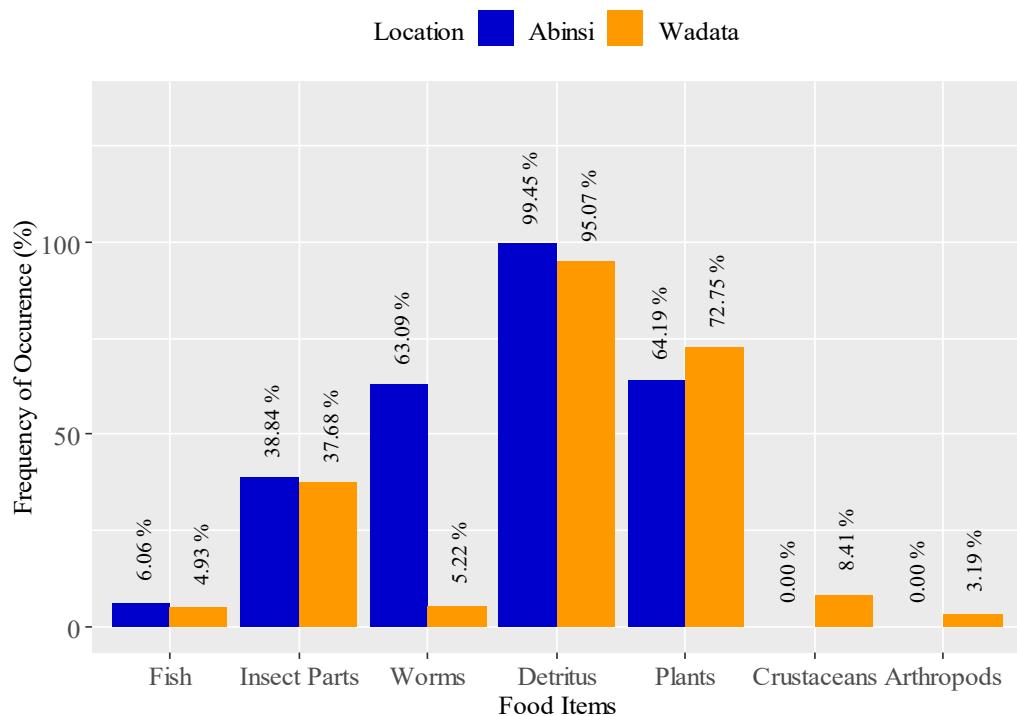


Figure 8: Food items in the stomach of *M. rume* by frequency of occurrence method (%) from Lower River Benue.

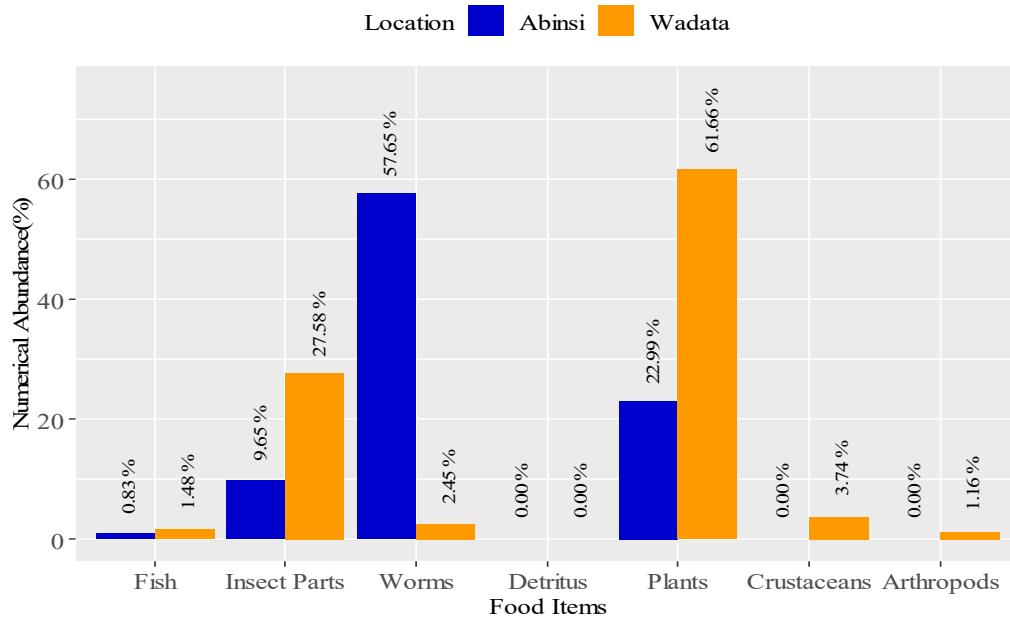


Figure 9: Numerical abundance of food items in the stomach of *M. rume* from Lower River Benue.

In the study, it was found that *M. rume* had 0.39% juvenile fish in their stomachs at the Abinsi station, while 0.71% were observed in fish from the Wadata station. The majority of *M. rume* caught from Abinsi had 97.62% insect parts in their stomachs, whereas only 21.99% of the fish at Wadata ate insects. item for *M. rume* at Abinsi, while plant materials were the most common at Wadata.

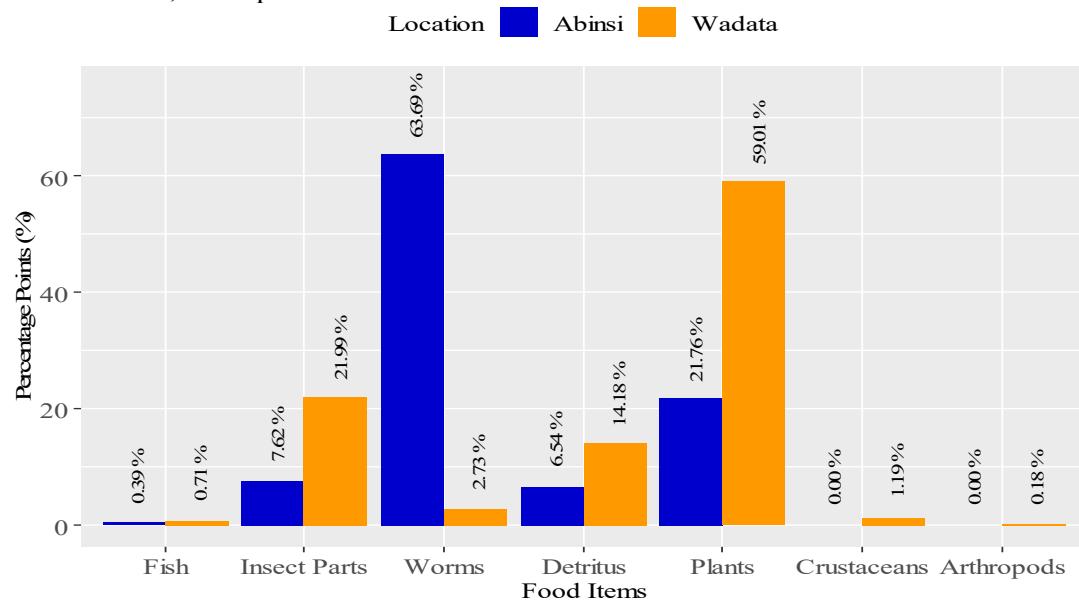


Figure 10: Points of food items in the stomach of *M. rume* from Lower River Benue.

In addition, worms were the primary food item of *M. rume* at Abinsi station, with 63.69% of fish consuming them, compared to 2.73% of fish at Wadata. On the other hand, plant materials were the main food item in *M. rume* from Wadata, with 59.01% of fish consuming the plate material, compared to 21.76% at Abinsi.

Detritus was consumed by only 6.64% of fish at Abinsi, while 14.18% of fish at Wadata ate the detritus. Finally, no fish at Abinsi were found with crustaceans or arthropods stomachs as their food, whereas 1.19% and 0.18% of fish at Wadata consumed them, respectively. Overall, worms were the most common food



Figure 11: Distribution of the vacuity for *H.forskhalii*, *C.citharus*, and *M.rume* from Lower River Benue.

Stomach vacuity index of the fish from Lower River Benue

The distribution of the vacuity percentage for *H.forskhalii*, *C.citharus*, and *M.rume* obtained from Lower River Benue is presented in Figure 11. A higher distribution of the vacuity percentage was recorded by *Citharinus citharus* from Abinsi, while *Mormyrus rume* recorded the lowest distribution of the vacuity percentage from same location.

From Wadata, *H.forskhalii* recorded the higher distribution of the vacuity percentage, while *C.citharus* recorded the lowest distribution of the vacuity percentage. *Mormyrus rume* had the distribution of the vacuity percentage of 5.47% from Abinsi and 4.96% from Wadata. *H.forskhalii* recorded the distribution of the vacuity percentage of 16.32% from Abinsi and 10.80% from Wadata. While, *C.citharus* recorded the distribution of the vacuity percentage of 18.55% from Abinsi and 1.37% from Wadata.

Gut-weight and gut-length of the fish from Lower River Benue

Table 1 shows the seasonal and sex-wise gut-weight and length of three fish species from Lower River Benue. The fish species recorded higher gut-weights and lengths during the rainy season, except for *H.forskhalii* which had a higher gut-weight during the dry season from Wadata. *M.rume*, also recorded higher values of gut-weights and lengths during the dry season from Wadata. *H.forskhalii* males from both Abinsi and Wadata had higher gut lengths, while the females had higher gut weights. *C.citharus* females from both Abinsi and Wadata had higher gut weights and lengths than their male counterparts. *M.rume* males from Abinsi had higher gut weight and length than their female counterparts, while from Wadata, the females had higher gut weight and length than the males. From the observation of this study, *C.citharus* had a longer gut length than *M.rume*, while *H.forskhalii* had the least gut length. This is confirmed by the result from the food items fed upon by these species. The result showed that *C.citharus* and *M.rume* are

omnivorous fish species, *M. rume* also fed on small sizes of fish, while *H. forskahlii* is a carnivorous fish species. There was no significant difference between the females and the males of the fish species under study, as to which had longer and heavier guts, or fed more.

Table 1: Mean (\pm SEM) Seasonal and Sex-wise Gut-length and Gut-weight of three selected fish species from Lower River Benue

Fish species	Stations					
	Abinsi		P-value	Wadata		P-value
	Rainy	Dry		Rainy	Dry	
<i>H. forskahlii</i>						
Gut-length	36.34 \pm 0.64 ^b	28.77 \pm 0.80 ^a	<0.0001	37.42 \pm 3.01	33.82 \pm 0.79	0.219
Gut-weight	8.41 \pm 0.82 ^b	6.04 \pm 0.79 ^a	0.039	3.49 \pm 0.22 ^a	6.28 \pm 0.54 ^b	<0.0001
<i>C. citharus</i>						
Gut-length	140.78 \pm 2.31 ^b	133.68 \pm 1.64 ^a	0.011	142.99 \pm 1.86	140.55 \pm 1.51	0.325
Gut-weight	17.90 \pm 0.81 ^b	15.04 \pm 0.99 ^a	0.045	21.72 \pm 0.57 ^b	16.52 \pm 0.47 ^a	<0.0001
<i>Mormyrus rume</i>						
Gut-length	27.31 \pm 0.74	27.15 \pm 0.59	0.861	22.97 \pm 0.71 ^a	27.65 \pm 0.68 ^b	<0.0001
Gut-weight	5.25 \pm 0.49	4.51 \pm 0.36	0.23	4.14 \pm 0.42	4.49 \pm 0.39	0.537
Sex-wise Gut-length and gut-weight						
<i>H. forskahlii</i>						
Females	31.86 \pm 0.88	33.08 \pm 0.75	0.297	34.47 \pm 0.86	36.67 \pm 2.99	0.454
Gut-length	7.91 \pm 0.90	6.45 \pm 0.70	0.205	5.13 \pm 0.44	4.82 \pm 0.47	0.63
<i>Citharinus citharus</i>						
Females	137.97 \pm 2.14	135.01 \pm 1.73	0.278	143.63 \pm 1.70	139.39 \pm 1.63	0.072
Gut-length	17.50 \pm 1.32	14.98 \pm 0.64	0.071	19.07 \pm 0.57	17.66 \pm 0.52	0.068
<i>Mormyrus rume</i>						
Females	27.00 \pm 0.62	27.53 \pm 0.74	0.584	25.50 \pm 0.70	25.46 \pm 0.74	0.969
Gut-length	4.80 \pm 0.41	5.01 \pm 0.47	0.737	4.50 \pm 0.40	4.11 \pm 0.40	0.496

*Means in the same row followed by different superscripts differ significantly ($p<0.05$)

DISCUSSION

Food Composition

The number of worms found in the stomach of *H. forskahlii* observed in this study showed the fish consumes more worms, which aligned with the previous observations by Omoike (2021), which presented *H. forskahlii* as a carnivorous species. This is also in agreement with Dadebo and Mengistou (2008), who reported *H. forskahlii* consumed fish fry and fish parts in their natural habitats. *Citharinus citharus* fed mainly on detritus and plant materials in the wild indicating the fish to be omnivorous. This finding is also in agreement with the report of Poelen *et al.* (2014), Laleye, (2020), and Adeyemi *et al.* (2020) who observed plant materials, debris, detritus, and phytoplankton in the stomach of *C. citharus*. Insects and fish parts were not found in the stomachs of *C. citharus* during this study, which is at variance with the findings of Simasiku *et al.* (2017), Udoh and Ekpo (2017), and Stergiou and Karpouzi (2005) who reported clams, aquatic insect remains, other molluscs, and fish parts in the stomach of *C. citharus*. *Mormyrus rume* from this finding fed predominantly on detritus, plant materials, and worms which were in line with the previous findings. *M. rume* is also fed on whole juvenile fishes. This aligns with Omoike (2021), who reported *M. rume* to feed on fish parts, Yoboue *et al.* (2019), and Odedeyi and Fagbenro (2010) to be insectivorous. There were also plant parts and detritus in all the stomachs containing food, which agrees with Odedeyi and Fagbenro (2010) who reported *M. rume* to be detritivore.

Stomach vacuity percentage

The lack of fullness of the stomachs of the fishes observed during this study signified poor feeding from the wild as suggested by Ogbeibu and Ezeunara (2005). The fullness of the stomachs of these species did not correspond with their lengths or body weights as suggested by Fawole (2002), who observed the fullness of the stomach of *M. rume* in Lekki Lagoon to concern the fish's length and weight. The various gut lengths observed in this study signify the types of diet they eat. This is with the assertion of Akombo *et al.* (2010), who reported the intestinal lengths of fish just like many other vertebrates to be an indicator of the diet the fish eats. Similarly, Karachle and Stergiou (2010) reported that intestines in herbivorous fish species are longer than in omnivorous, and that of omnivorous species is longer than in carnivorous fish.

Gut weight and length of the fish sampled

There is a paucity of information on the gut length and weight relationship of these studied species. It was observed that the fish species had longer guts which were less heavy during the dry season due to less availability of food, while in the rainy season, the guts became longer and heavier due to the abundance of food. This implies that, when there is much food intake by the fish, the gut expands, also increasing in its length. On the other hand, when there is low food intake, the gut shrinks and becomes stouter. This implies that the heavier the gut of fish, the longer it becomes. There was no notable observation of the fish species under study, as to which sex (male or female) fed better from the wild.

Conclusion

The study found that *Hydrocynus forskahlii* primarily feeds on worms and insect parts, making it a carnivorous species. *Citharinus citharus*, on the other hand, feeds mainly on plant materials and detritus. *M. rume*, an omnivorous species, feeds on a diet comprising of plant materials, detritus, worms, and whole juvenile fishes. Based on these findings, it is recommended that animal protein should be the primary source of nutrition when domesticating *H. forskahlii* and *M. rume*.

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