EVALUATION OF FOOD AND FEEDING HABITS OF *HOPLOBATRACHUS OCCIPITALIS* (GÜNTHER, 1858) FROM FOUR LOCATIONS ON OBAFEMI AWOLOWO CAMPUS, ILE-IFE.

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ABSTRACT

The food and feeding habits of *Hoplobatrachus occipitalis* (Dicroglossidae), in Obafemi Awolowo Campus, Ile-Ife were evaluated. This was with a view to determining the feeding behaviour and the foraging preference for prey by the species. The ingested food items were retrieved by stomach flushing and viewed under a dissecting microscope and identified to the lowest possible taxonomic level. The rate of feeding activity was estimated as the percentage of stomach containing food with respect to the total number of stomachs examined. One hundred and fifty eight (158) adult specimens of *H. occipitalis* with Snout-Vent length (SVL) varying from 7.60 ± 0.23 cm to 12.4 ± 0.18 cm were utilized for this study. The rate of feeding activity in the frog was estimated at 92.41% while the Vacuity index was 7.59 %. A total of Eight hundred and fifty four prey items which belonged to 15 categories were recovered from the stomachs of specimens collected from the four sampled locations. Of these, ants (24.60 %), earthworms (18.97 %), and termites (15.57 %) made up the dominant prey item categories. The study concluded that *Hoplobatrachus occipitalis* in Obafemi Awolowo University Campus was an opportunistic feeder which consumed a variety of food items depending on their availability.

Keywords: Feeding, *Hoplobatrachus occipitalis*, Stomach Flushing, vacuity Index.

INTRODUCTION

Amphibians play diverse roles in natural ecosystems and their decline may cause other species to become threatened or may undermine aspects of ecosystem function (Matthews *et al.,* 2002; Whiles *et al.,* 2006). Frogs are an important prey source for diverse predators and their tadpoles, which are usually filter feeders, contribute to the stability of water quality in ponds and streams (Mohneke *et al.*, 2010). The larval stage of the African tiger frog (*Hoplobatrachus occipitalis)* is carnivorous and feeds on small aquatic animals like tadpoles and mosquito larvae, making them an important part of the food chain. A drop in population of *H. occipitalis* as a predator, due to overexploitation of the species could lead to increase in prey populations (Mohneke *et al.*, 2010).

H. occipitalis is a common and widespread West African frog occurring in both savanna and disturbed forest habitats. It also inhabits diverse water habitats including small, large, fast flowing, stagnant, temporary and or permanent water bodies (Rödel, 2000). It has also been found in forested regions (Hughes, 1988; Gruschwitz *et al.*, 1991). It is native to Nigeria according to IUCN (2014) and in view of the wide distribution, it is tolerant to a wide variety of habitats. The presumed large population of *H. occipitalis* led to its categorization as "Least Concern" by the International Union for Conservation of Nature (IUCN) probably because it is unlikely to be declining fast enough to qualify for listing in a more threatened category. Its population however, is on the decline (IUCN, 2014).

A survey of edible anuran species in the southwestern part of Nigeria showed that *H. occipitalis, Xenopus muelleri* and *Ptychadena pumilio* were the species most sought after (Mohneke *et al.*, 2010). Due to its large size, *H. occipitalis* was identified as the most commercialized species followed by *X. muelleri* (Onadeko *et al.,* 2011). As at the time of this study, only Ogoanah and Uchedike (2011) has been established to have studied the feeding habits of the African tiger frog in Nigeria.

Most amphibian studies in Nigeria have focused mainly on the parasitology (Aisien *et al.*, 2009), ecotoxicology (Ezemonye and Tongo, 2010) and diversity (Schiotz, 1963, 1966; Reid *et al.*, 1990; Oldham, 2000; Akanni *et al.*, 2003) of this taxon. *H. occipitalis* is a frog native to southern Nigeria and other African countries (Ezemonye and Enuneku, 2011; IUCN, 2014).

Detailed studies concerning the amount and composition of the diet of *H. occipitalis* in the tropics have until now been limited to countries like Senegal (Lescure, 1971), Ivory Coast (Tohé, 2009; Tohé *et al.,* 2013), Kenya (Bwong and Measey, 2010) Congo (Mady-Goma *et al.,* 2012). Though Hirschfeld and Rödel (2011) carried out their research mainly in the Republic of Benin; they sampled specimens from Burkina Faso, Niger Republic and Nigeria. The study of the food preference and feeding habits of frogs is also important considering the concerns regarding global declines of amphibian populations (Pechmann and Wilbur, 1994).

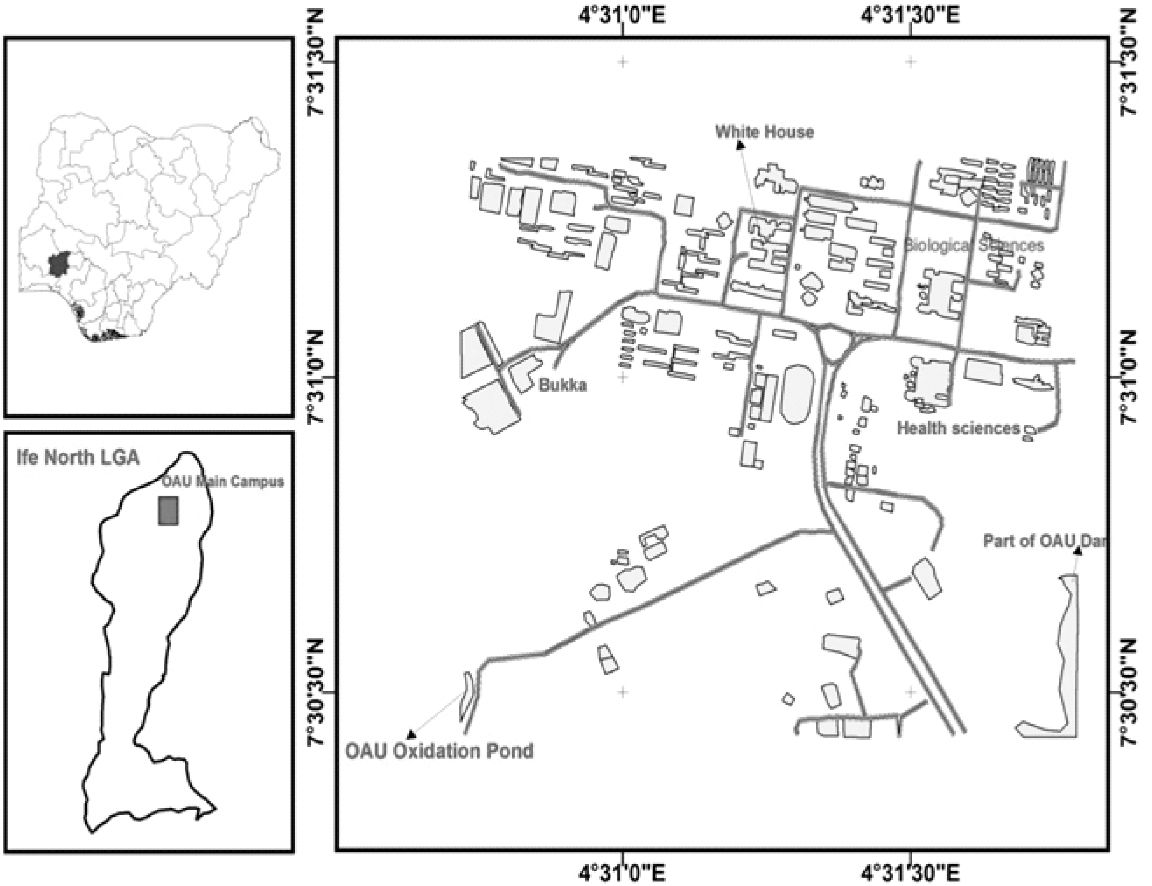
This study aimed to determine the feeding behaviour of *H. occipitalis* in the wild, its foraging preference and the prey composition of its diet.

MATERIALS AND METHODS

Visual encounter surveys according to Crump and Scot (1994) were conducted periodically for two hours usually at night but occasionally during daytime as a pilot study to determine the presence and estimate the population density of *H. occipitalis* in various locations within Obafemi Awolowo University Campus, Ile-Ife. Specimens were collected from four locations; Biological Sciences Area (07°31'3"N, 004°31'3"E), Health Sciences Area (07°31'1"N, 004°31'31"E), Oxidation Pond Area (07°30'26"N, 004°30'41"E) and White House Area (07°31'7"N, 004°31'12"E) (Figure 1) hereafter referred to as sites A, B, C and D respectively. These sampling locations were selected based on the availability of specimens, proximity to the laboratory, accessibility to the sampling locations and safety of specimen collectors.

Specimens were collected weekly with the aid of a torch light and dip-net, between the hours of 23:00 and 02:00 GMT; this is the period when the highest activity of the species was observed. Collection was carried out weekly from April to November, 2014. No sampling site was visited more than once in thirty days to avoid stomach flushing the same specimen more than once a month as the specimens were not tagged before being returned to their provenance location. An active method of prey capture was employed as against passive methods which include the use of traps in order to ensure that the time lag between ingestion of the food items and evacuation from the stomach was minimal. Traps were not used because the exact time of capture would be impossible to determine and the process of digestion may have reached an advanced stage by the time the frogs' stomach contents are retrieved.

The captured specimens were brought to the laboratory in separate captivity cages, sorted and identified using standard identification keys by Rödel and Spieler (2000) while arthropods were identified based on identification keys by Choate (2003) and Whiting (2011)



◆ Sampling locations

Figure 1: Map Showing Sampling Locations on Obafemi Awolowo University, Ile-Ife.

and literatures such as Wheeler *et al.* (2001). Care was taken to tag each specimen collected with its location so as to be able to return them to their precise habitat in order to prevent possible dispersion of pathogens. Chloroform was used to anesthetize the specimens for about five to ten minutes until writhing responses ceased. Stomach contents were obtained by stomach flushing, a procedure which involves the use of a catheter attached to a 60 ml syringe with the end inserted into the frog's oesophagus to deliver water into the frog's stomach in order to flush the stomach content. The frogs were held head down in a vertical stance so that the force of the injection and gravity sufficed to eject the stomach content through the mouth.

The rate of feeding activity was estimated as the percentage of stomach containing food with respect to the total number of stomachs examined, after Sala and Ballesteros (1997). The vacuity coefficient (%V) was also calculated; this is the ratio of number of empty stomachs divided by the total number of digestive tracts.

$$\%V = \frac{\text{Number of empty digestive tracts} \quad X\ 100}{\text{Total number of digestive tracts}}$$

The percentage prey abundance (% PA) was calculated as

$$\%PA = \frac{\text{Number of recovered prey item per taxa} \quad X\ 100}{\text{Total number of prey item recovered}}$$

The percentage frequency of occurrence (% FO) was calculated as

$$\% FO = \frac{\text{Number of digestive tracts containing prey category X 100}}{\text{Total number of digestive tracts containing food}}$$

RESULTS

A total of 158 adult *H. occipitalis* specimens were utilized for this study with 53, 40, 33 and 32 specimens captured from sites A, B, C and D respectively (Table 1). The snout-vent length of the frog specimens ranged from 7.6 cm to 12.4 cm (Table 1) with the mean size of frogs obtained overall being 9.6 ± 0.11 cm. with mean values 9.88 , 10.04, 9.77 and 9.55 cm recorded from sites A, B, C and D respectively (Table 1). Male frogs accounted for about 59% of the captured specimens while 41% were females.

146 specimens had food items in their stomachs while 12 frogs had empty stomachs. The estimated rate of feeding activity of the frogs was 92.41% while the Vacuity index was 7.59%. Recovered food items from the frogs were classified into 15 prey categories.

In all examined stomachs, a total of 854 prey items were recovered with 313, 186, 156 and 199 prey items recovered from specimens collected from sites A, B, C and D respectively. A total of 54 prey items were unidentifiable. Some of these food items were at a fairly advanced stage of digestion and no physical feature could be used to identify them. Only items that were firm enough were recorded as unidentified prey items. More unidentifiable prey items in relation to number of specimens captured was obtained from sites C and D than from sites A and B.

Members of the Order Hymenoptera (ants, bees and wasps) were the most abundant ingested prey item with an abundance of 24.60% followed by the Phylum Annelida represented by the Order Oligochaeta (Earthworms) with an abundance of about 18.97% and the Order Isoptera with an abundance of 15.57% (Table 2). The Family Formicidae also had the highest frequency of occurrence for prey items at 95.89 % (Table 3).

The mean values shown in Tables two and three represent the collective values across all sites and not the mean of the mean values obtained from each location.

Table 1. Descriptive Data for the Snout-Urostyle Length of Sampled *H. occipitalis*

	n	Minimum	Maximum	Mean ± SD	Median
Site A	53	8.0	12.4	9.88 ± 1.29	9.6
Site B	40	7.9	12.2	10.04 ± 1.26	9.8
Site C	33	7.8	12.4	9.77 ± 1.26	9.7
Site D	32	7.6	12.2	9.55 ± 1.32	9.15

Table 2: Percentage Prey Abundance in Adult *H. occipitalis*

Taxa/Location	Site A (%)	Site B (%)	Site C (%)	Site D (%)	Mean (%)
Annelida	-	-	-	-	-
Oligochaeta	21.73	20.97	15.38	15.57	18.97
Arthropoda	-	-	-	-	-
Blattodea	2.56	1.61	0	1.01	1.52
Coleoptera	3.83	3.76	1.92	1.01	2.81
Diptera	12.46	9.14	8.33	9.04	10.19
Hemiptera	1.28	1.61	3.21	3.02	2.11
Hymenoptera	-	-	-	-	-
Apidae	1.0	0.54	0	1.01	0.70
Formicidae	24.92	23.66	25.0	24.62	24.60
Isoptera	13.42	15.59	17.31	17.59	15.57
Lepidoptera	3.51	6.99	5.77	5.53	5.15
Odonata	0	0.54	0	1.51	0.47
Mollusca	-	-	-	-	-
Gastropoda	0.32	1.08	0	0.50	0.47
Vertebrata	-	-	-	-	-
Anura	0	1.08	0	0	0.23
Plant matter	8.31	6.99	9.62	9.05	8.43
Pebble	0.96	2.67	5.13	0.26	2.58
Unidentifiable prey item	5.75	3.76	8.33	8.04	6.32

Table 3: Percentage Frequency of Occurrence of Prey items recovered from *H. occipitalis* Guts..

Taxa/Location	Site A (%)	Site B (%)	Site C (%)	Site D (%)	Mean (%)
Annelida	-	-	-	-	-
Oligochaeta	91.12	96.64	68.97	78.13	89.73
Arthropoda	-	-	-	-	-
Blattodea	7.84	5.88	0	6.25	5.48
Coleoptera	17.65	11.76	6.90	6.25	11.64
Diptera	49.01	55.88	31.13	40.63	45.21
Hemiptera	7.84	5.88	10.34	12.50	8.90
Hymenoptera	-	-	-	-	-
Apidae	3.92	2.94	0	6.25	3.42
Formicidae	94.12	100	93.10	96.88	95.89
Isoptera	60.78	61.76	72.41	81.25	67.81
Lepidoptera	9.80	32.35	20.69	25.00	20.55
Odonata	0	2.94	0	9.38	2.74
Mollusca	-	-	-	-	-
Gastropoda	1.96	5.88	0	3.13	2.74
Vertebrata	-	-	-	-	-
Anura	0	5.88	0	0	1.37
Plant matter	43.14	26.47	44.83	37.50	38.36
Pebble	5.88	14.71	27.59	15.63	14.38
Unidentified prey item	35.29	17.65	37.93	46.88	34.25

Two frog specimens were recovered from frogs collected from site B, this amounted to 0.23% of the total prey item ingested. It was difficult to ascertain the species of the ingested frogs as their digestion had already begun. Four dragonflies which represented the Order Odonata were recovered from one specimen in site B and three from Site D. This accounted for 0.47% of the percentage prey composition. Dipterans made up 10.19% of the ingested prey items across all collection sites with 87 flies recovered from the frogs' guts. Only 18 Coleopterans were seen among ingested prey. Six bugs were recovered from frogs captured from site D, 5 from frogs of Site C while 4 and 3 Hemipterans were recovered from frogs obtained from sites A and B respectively with a frequency of occurrence of 8.90% (Table 3). Twenty four beetles were recouped from frogs collected from all locations making up only 2.81% of the total ingested preys while the Order Blattodea made up for only 1.52% of the ingested prey items with 13 prey items. Plant matter accounted for 8.43% while the Orders Lepidoptera and Hymenoptera made up 5.15% and 0.70% prey items respectively.

DISCUSSION

More male than female specimens were captured during this research, this may not be enough proof that male specimens of *H. occipitalis* abound more than females. More than 50% of captures from all capture locations were males, this higher male incidence may be due to their more boisterous nature which makes them more susceptible to capture.

No noticeable difference was observed in the feeding pattern and prey preference of male and female specimens in this study.

H. occipitalis is quite an evasive species; this made it difficult to make meaningful observations of their feeding behaviour in their natural environment especially during daytime. *H. occipitalis* were usually observed along the edges of the drainage canals and remained properly camouflaged with most of their body hidden in the vegetation waiting for prey to move. Deductions could be made from this that they are a "sit-and-wait" predator.

The mouth of the frog opens directly into the oesophagus which is a continuous tube with the stomach. The frog's stomach is usually found on the right side of the body cavity i.e. the frog's left side and is continuous with the small intestine. They have relatively short intestines in relation to their body size; this indicates that they are carnivores.

The presence of a wide variety of prey items suggests an opportunistic feeding behavior. This frog captures all the moving preys which have a suitable size for consumption (Balint *et al.,* 2010). *H. occipitalis* is a generalist feeder based on the wide food diversity in its diet. The presence of about fifteen prey categories and plant parts indicates an intense feeding based on the availability of a rich trophic base.

In view of the frog population decline and the likelihood of spreading pathogens, latex gloves were used and changed when handling frogs which were obtained from different locations. Specimens were returned in separate captivity cages to their provenance location as soon as flushing was completed in the laboratory in accordance with Solé *et al.* (2005) who stated that the immediate return to the place of capture prevents behavioural disturbance, especially during the period of reproduction.

Myrmecophagy was observed in this study. Termites and ants were recovered from frogs obtained from all sampling sites. The abundance of these prey items as well as relative ease of capture may be responsible for the high occurrence of this prey groups. The results obtained in this study agree partly with Solé *et al.* (2005) who in Southern Ivory Coast, found that Hymenoptera (including ants) were the most important prey category of dissected *H. occipitalis*.

The Order Isoptera was the third most consumed prey after ants and earthworms. A similar result was obtained by Hirschfeld and Rödel (2011) who worked with the same species, and recovered 91 individuals which amassed an index of relative importance (IRI) of 139 %. Partly contrasting results were obtained by Silva *et al.* (2009) and Bwong and Measey (2010). The termites ingested were presumed to be individuals on nuptial flight as some of the specimens still retained their wings.

The high incidence of termites among ingested prey item was observed only during the rainy season and ceased abruptly as the dry season commenced.

Earthworms found in the diet of *H.* occipitalis accounted for about 19 % of the total food intake. One frog specimen was observed in the process of ingesting an earthworm. This study further enriched the list of standing accounts of anurans with earthworms in their diet, which comprises *Hyla japonica* (Hirai and Matsui, 2002), *Lithobates catesbeianus* (Carpenter *et al.*, 2002), *Leptodactylus latrans* (Solé *et al.*, 2009), *Limnonectes leporinus* (Inger, 2009) *Fejervarya limnocharis* (Kumar *et al.*, 2010), *Craugastor rhodopis* (Aguilar-López and Pineda, 2013). However, researches such as Silva *et al.* (2009), Bwong and Measey (2010) and Tohé *et al.* (2013) only recorded very low frequencies of occurrence for the class Oligochaeta as against the high percentage frequency of occurrence (89.73 %) obtained in this study.

The sub phylum Vertebrata was represented by two juvenile frogs which were recovered from specimens obtained from Site B. The ingested frogs were not identifiable due to the effects of digestion on the prey items. Vertebrates in frog diets have been reported by Bwong and Measey (2010) who found 3 tadpoles in the diet of *X. borealis,* Balint *et al.* (2010) who found a Urodelan, Hirschfeld and Rödel (2011), Mady-Goma *et al.* (2012) who found fishes, frogs, lizards and rats.

A representative of the Order Blattodea was found among the food items retrieved from frogs captured from all collection sites except from those collected from Site C. All retrieved cockroaches were immature individuals. Hirschfeld and Rödel (2011) retrieved one individual of the total prey consumed while studying *H. occipitalis* from Benin. In Nigeria, Ogoanah and Uchedike (2011) found that they constituted only 1.89% of the percentage frequency of occurrence of the same species. These results show that cockroaches when found in the diet, have a low occurrence rate and agrees with the result obtained in this study.

Dipterans accounted for 10% of the prey abundance and were recovered from frogs obtained from all locations (Table 2). The presence of flies in frogs' guts has been documented. Hirai and Matsui (2000) recorded a frequency of occurrence of about 36% having studied the Japanese Tree Frog, *Hyla japonica*. Conradie *et al.* (2010) recovered flies from the stomach of 13 Bullfrogs. Balint *et al.* (2010) recorded a frequency of occurrence of 6.45% in the diet of *Pelophylax ridibundus*. Fatroandrianjafinonjasolomiovazo *et al.* (2011) Caldart *et al.* (2012) and Tohé *et al.* (2013) also recorded the presence of dipterans in frogs' diet.

The Order Lepidoptera was found among ingested items. Both representatives of this Order which consists of butterflies and moths were observed in this study. The percentage prey abundance and frequency of occurrence accounted for by this order conforms to results obtained by other researchers such as Silva *et al.* (2009), Balint *et al.* (2010), Conradie *et al.* (2010), Hirschfeld and Rödel (2011), Mady-Goma *et al.* (2012) and Tohé *et al.* (2013).

Four dragonflies were observed among the food items consumed. The recorded low occurrence of this group of food item corroborates results obtained by Balint *et al.* (2010), Bwong and Measey (2010), Hirschfeld and Rödel (2011) and Mady-Goma *et al.* (2012).

Four snails in all were recovered from the guts of the frogs observed. The largest of the ingested snails measured 12 mm in length. One of the specimens which ingested a snail noticeably had no other prey item in its guts. Gastropods have been observed among frog ingested items by researchers such as Hirschfeld and Rödel (2011), Mady-Goma *et al.* (2012) and Tohé *et al.* (2013). This low occurrence may be due to the difficulty in swallowing gastropods, the unavailability of suitable size prey items and digestibility as one specimen which ingested a snail had no other food item present in its alimentary canal.

Plant matter, though quite insignificant in some cases, was discovered in a reasonable number of all examined stomachs. The presence of plant parts amongst the food items could be an indication of the foraging habitats of preference to this species. Anderson *et al.* (1999) suggested that plant content could help in the removal of intestinal parasites, provide roughage to assist in grinding up arthropod exoskeletons, provide nutrients and serve as an additional source of water. Solé *et al.* (2009) and some other authors however think that the presence of vegetal parts in the stomach contents could be accidental being taken in as the amphibians aim at the prey while Kovacs *et al.* (2007) documented that the accidental ingestion of plants increases with the feeding intensity of the frog.

Most of the prey ingested by *H. occipitalis* in this study consisted mainly but not completely of terrestrial species. *H. occipitalis* is capable of capturing prey on terrestrial habitat, above water as well as beneath the water surface.

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