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Dietary Strategies of the Giant Swamp Frog *Hoplobatrachus occipitalis* in Degraded areas of Banco National Park (Ivory Coast).

B. Tohé[1*], N. G. Kouamé[2], N. E. Assemian[2], G. Gourène[1] and M.O. Rödel[3]

[1] Nangui Abrogoua University, Laboratoire d'Environnement et de Biologie Aquatique, UFR-SGE, 02 B.P. 801 Abidjan 02 (Côte d'Ivoire);
[2] Jean Lorougnon Guédé University, Department of Biology and Animal Physiology, Daloa, BP 150, Côte d'Ivoire;
[3] Museum für Naturkunde, Leibniz Institute for Evolution and Biodiversity, Invalidenstr. 43, 10115 Berlin, Germany.

ABSTRACT

We report on the dietary strategies of the Giant Swamp Frog *Hoplobatrachus occipitalis* from the Banco National Park, south-eastern Ivory Coast. . We determined the prey composition with respect to sites, seasons, frogs' size and sex. This species is a generalist that feeds on a variety of prey. Insects (65.6%) dominated the general diet of this frog species. We determined insect prey items down to the level of the order. At this level the diet of *Hoplobatrachus occipitalis* was mostly represented by hymenopterans (30%), orthopterans (19%) and coleopterans (14%). The prey composition differed with respect to habitats (sites), seasons and sex however not significant statistically. Our study revealed only a significant difference between the diet of juvenile and adult frogs.

KEY WORDS: African Tigrine Frog, diet, *Hoplobatrachus occipitalis*, *degraded* forest, rainforest.

Corresponding Author :

B. Tohé
Nangui Abrogoua University,
Laboratoire d'Environnement et de Biologie Aquatique,
UFR-SGE, 02 B.P. 801 Abidjan 02 (Côte d'Ivoire);
E - Mail: toheblayda@yahoo.fr

INTRODUCTION

Amphibians are important components of various terrestrial and aquatic ecosystems, acting as prey, predators and herbivores [1, 2, 3, 4]. Their biphasic life-cycles, physiology and ecology make them well suited to serve as indicators of environmental health of both aquatic and terrestrial ecosystems [5, 6, 7, 8]. Moreover, they are an important source of animal protein for humans [9, 10, 11, 12, 13, 14]. According to[11], 50 amphibian species harvested from natural stocks are consumed worldwide. This also concern many African countries where frogs are used as main source of animal protein in the feeding habits of local populations [15, 16].

In Ivory Coast, frogs are important component of animal protein in the feeding habits of local populations from the western part of the country. This is also observable in the south where frog consumption is very appreciated in big restaurants of Abidjan (Tohé, pers. obs.). However, among presumed edible frogs, the most consumed species is the giant swamp frog *Hoplobatrachus occipitalis*, a very robust aquatic frog. Several studies have concerned its reproduction [17, 18, 19, 20]. As for its diet, the data available only in central Ivory Coast are sparse and fragmentary [21, 22, 23]. They indicate that this species consumes insects, earthworms, slugs and other frogs.[24] as well as [25] reported similar results in Congo-Brazzaville and Senegal respectively. Thus, the feeding strategies of this species are understudied. Herein, the present survey on the dietary strategies of *Hoplobatrachus occipitalis* in Banco National Park is the first for the south of the country. This park is a protected forest located in the heart of Abidjan, the economic capital of Ivory Coast, with a population of about six millions. This is an evergreen forest that normally should not accommodate this anuran which is a savannah species [23]. However, because of its geographical location in the midst of Abidjan [26], the high anthropogenic pressures on this rainforest have come to alter some habitats. Despite some important research activities on the herpetofauna of the south-eastern Ivorian forests [26, 27], the ecology and biology of these animals are still poorly known. This study concerne in particular the giant swamp frog *Hoplobatrachus occipitalis* which is illegally preyed for its flesh in degraded parts of Banco National Park and surroundings by local population (Tohé, pers. obs.). Herein, we aim to document the dietary strategies of persisting populations and collect more information on its ecology.

MATERIALS AND METHODS

Study site

The Banco National Park (Figure 1) with an area of 3474 hectares [28], is a protected forest located in the heart of Abidjan, the economic capital of Ivory Coast. It contains the Banco river which takes its source in the northern edge of the forest and flows down south into the Ebrié lagoon.

This park is under the influence of a hot and humid tropical climate. The mean annual temperature in the Banco National Park is 26.4°C. The mean annual precipitation sums to about 2000 mm. A longer great dry season lasts from December to March and is followed by the period with highest precipitation in April to July. A minor dry season lasts from August to September whereas the minor rainy season stretches from October to November [29]. In this rainforest, *Hoplobatrachus occipitalis* were surveyed in three degraded sites where encountered populations were abundant. The first site, Bay (05 ° 21' N and 04 ° 02' W), located at the main entry in the south of the park (Figure 1), is an open zone covered by grass, heavily degraded and water polluted due to the "Fanico" launderers, people that use the Banco river for religious rituals or car washing. The second site, Fish farm (05 ° 23 N and 04 ° 03' W), is a central clearing with 16 artificial ponds, partly open, partly heavily degraded and only with shallow water, temporary and perennial waters (the latter stocked with *Tilapia* fish). This site is characterized by flowing creeks which crosses the central clearing and runs along the forest, surrounded by a swampy forest, the Banco river and bamboo plots. The third site, Filtisac (05 ° 24' N and 04 ° 01' W), is located in the north of the park and characterized by a heavily degraded forest with open canopy, three larger ponds that are polluted due to the nearby mechanic quarters, a factory, corn, cassava, and yam plantations (Figure 1).

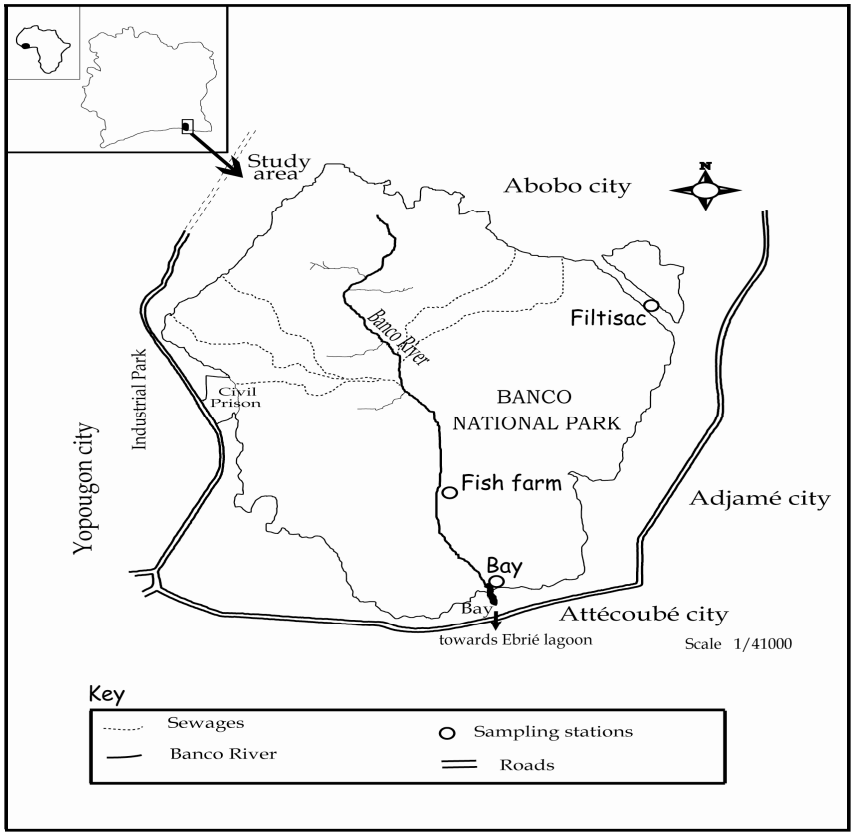

Figure 1: Overview of the Banco National Park and study sites (Map CNTIG modified).

Sampling and analysis

Frogs were searched during the day of the night, from December 2004 to July 2005. Our searching techniques included visual scanning of terrain and refuge examination through which frogs were captured by hand and sexed. As the giant swamp frog is regularly collected in Banco National Park and sold for human consumption [26], we completed our collection buying some frogs sold at the Fish farm site.

For the diet analysis, we used 75 individuals of the giant swamp frog which were euthanized in chlorobutanol solution, preserved in ethanol 70% and deposited since 2004 in the Laboratory of Environment and Aquatic Biology, at the Nangui Abrogoua University. We extracted each stomach through a ventral longitudinal incision. Stomach contents were identified by the use of stereoscopic binocular. We determined and counted the prey items, and thereafter dried and weighed the prey (Sortørius scale: accuracy ± 0.0001g). To determine prey items, the keys of [30, 31], and [32] were used to distinguish between insect orders, arachnids (Arachnida), earthworms (Annelida), molluscs (Mollusca), vegetables (Plant material), other animal remains, and undetermined.

For a quantitative analysis of the frogs' diet, we calculated the Index of Relative Importance *IRI* according to [33]: [$IRI = (N + P) \times F$]

Where: F = the percentage of occurrence; N = the numerical percentage of prey; P = the exact percentage of prey weight. Because frogs' abundances and their prey items were not distributed normally (Kolmogorov-smirnov test) we referred to the Kruskal-Wallis and Mann-Whitney non-parametric tests to compare the diet with respect to sites, seasons, frogs' size and sex. . We referred to STATISTICA version 7.1 for the non-parametric tests.

RESULTS

Overall, we found prey items from 75 frogs' stomachs.(out of 81 analyzed including: emptiness index 6.7%) Eleven different major prey categories were consumed by the giant swamp frog: Insecta, Amphibians, Annelida, Arachnida, Birdies, Crustacea, Diplopoda, Fishes, Mollusca, Plant material and "Other preys" (Table 1). Insects (65.6%) with seven prey items represented the bulk of the general diet. In general, *H. occipitalis* mainly preyed on hymenopterans (ants, 30%), orthopterans (grasshoppers, 19%) and coleopterans (beetles, 14%).

Among the 75 frogs, 16 were collected to the Bay, 45 to the Fish Farm and 14 to the Filtisac site (Table 1). At the bay site *H. occipitalis* mainly consumed amphibians (18.3%), beetles (16%), plant material (14.7%) and hymenopterans (12.2%). However at the Fish Farm, the main diet is composed of arachnids (20.1%, spiders), beetles (19.8%), hymenopterans (17%, predominantly

ants), orthopterans (9.6%, grasshoppers). The main prey at Filtisac site comprised ants (43.4%) and grasshoppers (37.4%). The prey composition differed between the three sites however, not significant statistically (p = 0.1404, Kruskal-Wallis test).

Table 1: Diets of *Hoplobatrachus occipitalis* in general and according to the habitats in the Banco National Park. FF = Fish farm; Fi = Filtisac; n = number of full stomachs.

Prey category	**Index of Relative Importance (%)**			
	General diet (n = 75)	**Bay (n = 16)**	**FF (n = 45)**	**Fi (n = 14)**
Coleoptera	14.0	16	19.8	2.7
Dermaptera	0.4	0	0	1.7
Diptera	0.2	0	0	1.1
Heteroptera	0.1	1.2	0.1	0
Hymenoptera	30	12.2	17	43.4
Lepidoptera	1.9	0	2.7	0.3
Orthoptera	19	6.4	9.6	37.4
INSECTA (Σ)	65.6	37.8	49.2	86.6
AMPHIBIANS	11	18.3	8.3	8
ANNELIDA	0.1	0	0.2	0
ARACHNIDA	9	10	20.1	0
BIRDIES	2.2	0	4.4	0
CRUSTACEA	0.1	0	0	0.3
DIPLOPODA	0.5	7.3	1.1	0
FISHES	0.3	0	0	2
MOLLUSCA	3.6	11.4	3.5	1.4
PLANT MATERIAL	4.3	14.7	8.4	0.8
Invertebrate debris	2.5	1.3	4	0.6
Sand	0.7	1.2	0.8	0.3

During the dry season, arachnids (spiders predominantly) became the most dominant prey item for *Hoplobatrachus occipitalis* which also captured more snails and beetles. However dominant prey items in the rainy season were ants and grasshoppers (Table 2). Juvenile frogs predominantly preyed on ants while adult frogs switched from arachnids to orthopterans, amphibians and hymenopterans (Table 2). The prey composition differed significantly between juveniles and adults (p = 0.016, Mann-Whitney test).

Table 2: Diets of *Hoplobatrachus occipitalis* with respect to seasons and size in the Banco National Park. n = number of full stomachs analyzed.

Prey category	Index of Relative Importance (%)			
	Dry season (n = 23)	**Rainy season (n = 52)**	**Juveniles (n = 22)**	**Adults (n = 53)**
Coleoptera	12.8	12	18.9	9.3
Dermaptera	0	0.5	1.3	0
Diptera	0	0.3	0.8	0
Heteroptera	0.9	0	0.2	0
Hymenoptera	5	39.4	52.2	14.5
Lepidoptera	6.5	0.8	5.1	1
Orthoptera	0.9	27.1	10.5	16.8
INSECTA (Σ)	26.1	80.1	89	41.6
AMPHIBIANS	0	6.4	0.5	15
ANNELIDA	2	0	1.3	0
ARACHNIDA	21.9	3.4	1.9	17.9
BIRDIES	9.8	0	0	4.9
CRUSTACEA	0	0.1	0.2	0
DIPLOPODA	9.7	0.3	0.8	1.8
FISHES	0	0.7	1.3	0
MOLLUSCA	19.5	1	1.4	4.4
PLANT MATERIAL	9	2.8	0.9	10.1
Invertebrate debris	1	4.6	2.5	3.4
Sand	1	0.6	0.2	0.9

With respect to sex, female frogs predominantly preyed on ants whereas males mainly consumed orthopterans, amphibians and arachnids (Table 3). The diet between males and females differed, however not significantly ($p = 0.574$, Mann-Whitney test).

DISCUSSION

The general profile of the diet of *Hoplobatrachus occipitalis* indicates that this giant swamp frog is in majority insectivorous, though amphibian prey, arachnids, molluscs, annelids, crustaceans, diplopods, birdies and plant material were observed in its prey composition. Hymenopterans, orthopterans and coleopterans were preferentially prey items. These results corroborate the eclectic diet already predicted by [34]. In Lamto reserve (central Ivory Coast) and Senegal, comparative studies revealed that insects represented the bulk of diet of the giant swamp frog [21, 25].

Table 3: Diet of *Hoplobatrachus occipitalis* with respect to sex in the Banco National Park.

n = number of full stomachs analyzed.

Prey category	**Index of Relative Importance (%)**	
	Females (n =18)	**Males (n = 35)**
Coleoptera	3	8.6
Hymenoptera	58.4	10.3
Lepidoptera	0	1.3
Orthoptera	0	21
INSECTA (Σ)	61.4	4.2
AMPHIBIANS	0	18.4
ARACHNIDA	26.5	15.2
BIRDIES	0	6
DIPLOPODA	0	2.3
MOLLUSCA	0	5.5
PLANT MATERIAL	7	8.5
Invertebrate debris	2.7	2.3
Sand	2.5	0.6

In various similar sites of Congo Brazzaville,[35] found larger amount of arthropods in stomach contents of this species with a larger preference for beetles. However, our results show some differences with the investigations of [36] in different parts of Africa. Indeed, this author mentioned the presence of crabs and lizards in the stomach contents of adult specimens of *Hoplobatrachus occipitalis*. In northern Benin, [37] reported a dominance of fish, beetles, moths and ants in the diet of the giant swamp frog. These differences could be explained by the eclectic diet of this frog. Indeed, during the rainy season, cichlid and cyprinid fishes which migrated in paddy fields were considerably consumed by *H. occipitalis* [37]. In contrast, our work which was carried out in degraded habitats where some sites comprised only temporary pools did not reveal similar results. The sedimentary fraction (sand) has no nutritional intake. Its ingestion occurred during prey captures. Indeed, it is while *Hoplobatrachus occipitalis* is snapping up their prey items that this species accidentally ingests plant debris, soil and sand [12], however, although it is believed that frogs do not normally feed on plants, it is known that some frogs may have considerable amount of plant material in their stomachs. This item was the most important food category found in stomachs of individuals of *Leptodactylus mystaceus* (Leptodactylidae) around the farmhouse of the Florentino farm in Brasil [38]. Hence, we would not *a priori* exclude the possibility that some plants are devoured deliberately and were not only swallowed randomly. This possibility is further supported by the fact that the high

percentage of plant material in the diet of *Hoplobatrachus occipitalis* was due to some stomachs completely filled with plants. With respect to studied sites, the prey composition differed however not statistically significant. These differences of prey items are due to various habitats with somewhat different prey. Indeed, the Bay and the Fish Farm sites were characterized by perennial waters due to the Banco river whereas the Filtisac site comprised temporary ponds. Moreover, between the three sites, the Fish Farm was the less polluted area due to its situation in the midst of Banco National Park. According to [39, 40], the diet of amphibians is linked to availability of prey in their habitats. Moreover, [41] noted that the taxonomic richness depends on the stability of the environment.

During the rainy season, the giant swamp frog preferentially preyed on coleopterans, hymenopterans and orthopterans. In the dry season, its diet varied more switching from beetles to arachnids and molluscs. Differences in prey composition between the rainy and dry season could be attributable to insects' availablity which are more abundant in the rainy season [42]. This may explain their abundance in the stomach contents (80.1%) of our studied frogs during the rainy season. Concerning seasonal diets, although not statistically significant, variations were recorded by [43] in the prey composition of *Phrynobatrachus phyllophilus* and *P. ghanensis*, two insectivorous frogs species in the swamp parts of the Banco National Park. Others studies in tropical areas [44, 45] revealed that frogs food resources were in general moreabundant during the rainy season than the dry season. These results concord with [46, 47] who showed that in North-east of Taiwan, the seasonal diet of *Rana longicrus* and *Rana swinhoana*, two anurans species was linked to a change in prey availability regulated by the environmental temperature. According to [48], the diet variations could also be due to ethological traits. In addition, [49] reported that seasonal fluctuations resources produce a change in the intensity of interspecific competition. In our study, juveniles of *Hoplobatrachus occipitalis* mostly consumed hymenopterans and coleopterans while adult frogs had a more diversified diet. Adult frogs consumed large sized prey (e.g. amphibians) whereas juvenile frogs are limited to the predation of small prey such as ants and beetles. These differences in feeding strategies suggest a low degree of competition between individuals of different size. The diet variation between juveniles and adults frogs has been reported in Lamto reserve by [21] for *H. occipitalis* and in Pyrénées Atlantic by [50] for the common frog *Rana temporaria* . Similar observations were made for the feeding habits of fishes by [51, 52, 53]. According to these authors, the size of frogs' mouth could explain the consumption of small prey by juveniles. Hence, prey consumption is proportionate to the head width of *Hoplobatrachus occipitalis* [12].

Our study revealed dissimilarities between the diet of males and females of *Hoplobatrachus occipitalis*. Females of this frog species mainly consumed ants and arachnids while the diet of males

was composed of various prey items. These differences could be justified in part by the dimorphism and mobility of both sexes. In particular, males which are generally smaller than females [23], are very adapted to jump. Thus, they easily prey on diverse and very mobile preys. These strategies for the conquest of prey could trigger change in the feeding habits between males and females. Moreover, [25] reported that these nimble predators select their prey according to their speed. The presence of coleopterans and hymenopterans as the only insect orders in the stomach contents of females could be attributable to dietary preferences due to their biology. In particular, the consumption of various food resources between males and females of the giant swamp frog could be the result of morphological, behavioral or energetic differences linked to reproduction [54, 55, 48].

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