

THE PUDDLE FROG *PHRYNOBATRACHUS LATIFRONS* AHL 1924 DIET IN THE FISH FARM OF THE BANCO NATIONAL PARK (IVORY COAST)

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ABSTRACT

The diet of *Phrynobatrachus latifrons*, an invasive frog species of the Banco National Park, was carried out in the park fish farm area from March 2004 to February 2005. The prey composition was determined from stomach contents of 60 voucher specimens (30 males and 30 females) with respect to sexes and seasons in order to have a better understanding of the species' ecology. Our results revealed that *P. latifrons* consumed various prey items ranging from insects, crustaceans, annelids, arachnids, molluscs, millipedes to plant parts. However, at sex level males mainly preferred ants and in addition spiders while ants especially were the major prey of females. With respect to seasons, this anuran preferred mostly preying on winged ants predominantly in the rainy season, and wingless ants and spiders as dominant prey in the dry season. Further surveys should document if the plant parts found in the frog's stomach contents are devoured deliberately or not.

Keywords: Amphibians, feeding habits, urban ecology, Ivory Coast, Upper Guinea.

INTRODUCTION

From the eastern Ivorian forests extending from Abidjan to Ghana border, up to 10 anuran species from the genus *Phrynobatrachus* have been recorded so far (Assemanian *et al.* 2006; Kouamé *et al.* 2014; Kpan, *et al.* 2014). This genus together with species of the genus *Arthroleptis* are among the most abundant leaf litter frogs in West Africa (Rödel, 2000). However, only a few studies have so far investigated the feeding habits of the West African *Phrynobatrachus* (Barbault, 1974; Rödel, 1995; Kouamé *et al.* 2008). From the Banco National Park, only one of the five *Phrynobatrachus* species, namely *Phrynobatrachus latifrons* Ahl1924, is able to prevail in the degraded forest areas characterized by diverse anthropogenic impacts i.e. logging, agricultural sites, constructs of buildings and pollution (Assemanian *et al.* 2006). This invasive species is the most widespread diurnal frog occurring in the fish farm of the park. There, it is abundant and reaches its highest calling peak in the morning around 06:00 GMT (Tohé *et al.* 2008). However, while the food composition of *P. ghanensis* and *P. phyllophilus*, and *Hoplobatrachus occipitalis* have been studied in details from the Banco National Park (e.g. Kouamé *et al.* 2008; Tohé *et al.* 2014), it is surprising that comparative studies are still lacking for *P. latifrons* in the park.

We thus herein, document the diet of *P. latifrons* in order to have a better understanding of the ecology of this invasive species in the Banco National Park, and in the fish farm area in particular.

METHODOLOGY

Study Site

With a superficies of 3374 ha, the Banco National Park is a small rainforest park located in the middle of Abidjan, a West African big city and the economic capital of Ivory Coast. Its geographical coordinates are comprised between 5°21'–5°25' N and 4°01'–4°05' W. The mean annual temperature in the park is between 26–27°C. The mean annual precipitation ranges from 600–2500 mm. The equatorial-type climate (Eldin, 1971) includes a long rainy season with the highest peaks in precipitation between March and July, and a long dry season from December to March. A short rainy season extends from October to November while the short dry season lasts from August to September. The survey was carried out in the fish farm within the Banco National Park (Figure 1) between March 2004 and February 2005, hence covering the rainy and dry seasons. Field work was done by tree people. The fish farm (05°23' N and 04°03' W) consisted of 16 stagnant pools that were used to breed *Tilapia* fishes, a forest edge with shrubs, bamboo plots, grasses, reeds and water filled ditch at nearby a large central clearing. The site also comprised flowing creeks and the Banco river which crosses the central clearing and runs down along the rain forest.

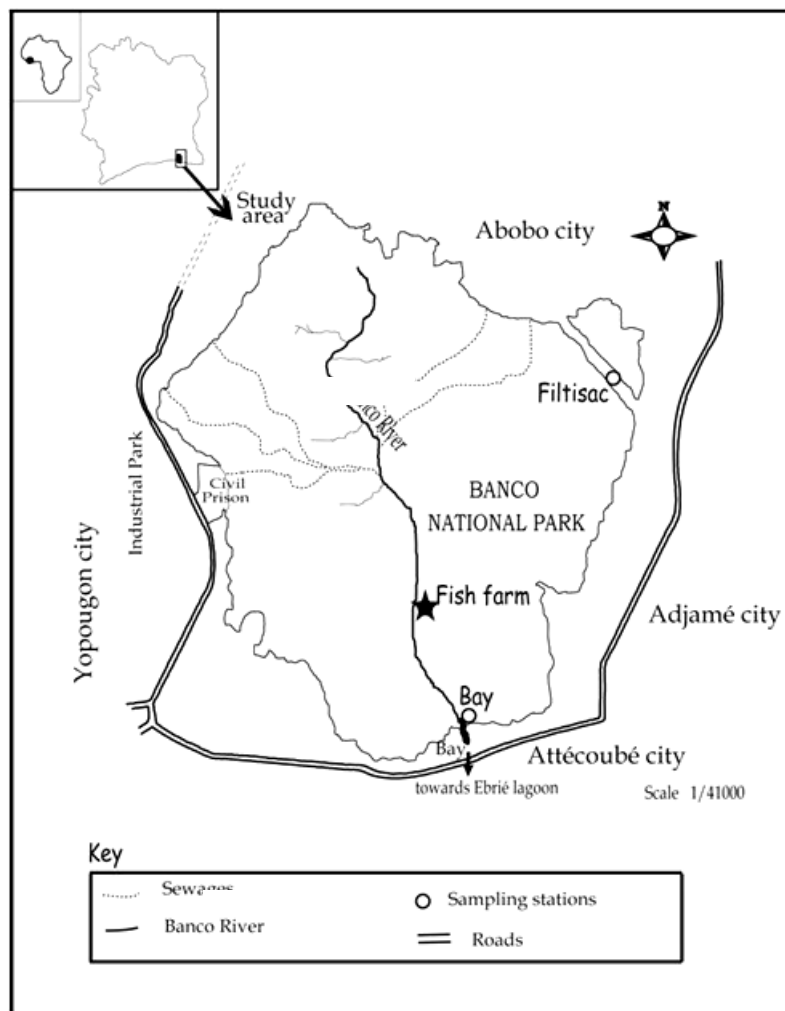


Figure 1. Map of the Banco National Park (inlet: Africa with the position of Ivory Coast). The fish farm is marked by a black star is marked within the Banco National Park.

Target Species

Phrynobatrachus latifrons Ahl 1924, is a small anuran species widely widespread in the West African savannahs and farmbrush habitats (Rödel, 2000). In south-eastern Ivory Coast, this species inhabits the degraded forest areas of the Banco National Park (Asseman *et al.* 2006). Some searches of the frog in other eastern forests, e.g. the Yakassé-Mé village forests (Kouamé *et al.* 2014) and the Tanoé-Ehy Swamp Forests (Kpan *et al.* 2014), have shown that *P. latifrons* lived in puddles and ponds surrounded by grasses within the disturbed forest parts. At sex level, the main distinctive character between adult males and females is the throat coloration. Females and males have their throat colored whitish and yellow respectively (Rödel, 2000; compare also Figure 2).



Figure 2. *Phrynobatrachus latifrons* from the fish farm of the Banco National Park, Ivory Coast. Shown are in lateral and ventral views of a female (A and B) and a male (C and D).

Prey Composition

We collected 30 adults of both sexes in the fish farm. We collected 15 males during the rainy season and 15 during the dry season. From females we collected as well 15 individuals during the rainy and 15 other individuals during the dry season. Snout-urostyle-lengths of the living frogs were taken with a dial calliper (accuracy ± 0.5 mm). Unfortunately, from a morphological point of view the frogs were too small and too fragile to employ stomach-flushing, as described by Joly (1987) and Solé *et al.* (2005). These frogs were euthanized in a chlorobutanol solution and thereafter dissected. Stomachs were preserved in 70% ethanol and stomach content analyzed in the laboratory with the aid of a dissecting microscope. For each specimen we determined, counted, dried and weighed the prey items (Sartorius scale; accuracy ± 0.0001 g). We distinguished between insect orders, arachnids (Arachnida), crustaceans (Isopoda),

millipedes (Diplopoda), and other invertebrate remains and plant parts (Dierl & Ring, 1992; Tachet *et al.* 2003). The frogs were deposited in the collection of the Laboratoire d'Environnement et de Biologie Aquatique at the Nangui Abrogoua University (ex-University Abobo-Adjamé, Abidjan).

Statistical Analysis

For a quantitative analysis of the frogs' diets we calculated: the frequency of presence F (Rosecchi & Nouaze, 1987; Gray *et al.* 1997; Young *et al.* 1997); the exact percentage of prey weight P (Hyslop, 1980) and the index of occurrence of the percentage of weight Ip [$Ip = (F.P*100)/(\Sigma F.P)$; Ip may vary from 0 to 100, Natarajan & Jhingran, 1961]. The different prey categories were classified according to the scheme of Simenstad (1970). As principal prey we defined those prey items that summed to more than 50% of the Ip index. As secondary prey we defined those items that accomplished the Ip index to more than 75%.

RESULTS

Snout-urostyle-lengths in female frogs ranged between 18.5–23.5 mm (mean \pm sd: 20.9 ± 1.2 mm). Males varied from 16–20 mm in size (mean \pm sd: 17.8 ± 1.2 mm). Hence both sexes showed significant size differences (Mann-Whitney-U; $Z = -6.21$; $p = 0.001$; $N = 60$). Prey items were encountered in the stomach contents of all 60 frogs (Table 1). In the fish farm, *Phrynobatrachus latifrons* consumed a total of eight different major prey categories namely: Insecta, Annelida, Arachnida, Mollusca, Diplopoda, Isopoda, Other invertebrates and Plant parts. From a general overview, stomach contents were mostly filled by insects. An overview of insects showed that six orders i.e. dipterans, heteropterans, isopterans, orthopterans, phthirapterans and thysanopterans were less consumed whereas hymenopterans (predominantly), lepidopterans and coleopterans were the most abundant prey.

Table 1. Number of particular prey items (n) in stomachs of *Phrynobatrachus latifrons* males and females (each N = 30)

Prey categories	Males		Females	
	N	Stomachs	n	Stomachs
Insecta				
Coleoptera	16	10	9	9
Diptera	6	4	3	3
Heteroptera	3	3	1	1
Hymenoptera	60	19	81	26
Isoptera	5	5	0	0
Lepidoptera	10	7	12	6
Orthoptera	2	2	4	4
Phthiraptera	0	0	3	3
Thysanoptera	2	2	0	0
Annelida	3	3	1	1
Arachnida	18	12	3	2
Mollusca	2	2	1	1
Diplopoda	2	2	1	1
Isopoda	2	2	0	0
Other invertebrates	9	9	9	9
Plantparts	6	6	6	6

The percentage of prey categories (Ip) consumed in both sexes is summarized in Table 2.

Males and females mainly fed on insects, 68.5 and 75 respectively. Hymenopterans (predominantly ants) were important prey items for both sexes, but especially for females (50.3%). Arachnids (19.5%) represented only by spiders became of increasing importance for males (Table 2). While males of *P. latifrons* also captured coleopterans (beetles) and other invertebrates as secondary preys, females secondarily fed on spiders and grasshoppers.

Table 2. Diet of *P. latifrons* with respect to sexes. Values indicate the percentage of prey categories (Ip) consumed in males and females.

Prey categories	Males	Females
Coleoptera	15.3	7.4
Diptera	4.5	1.0
Heteroptera	0.5	0.2
Hymenoptera	40.4	50.3
Isoptera	0.4	0
Lepidoptera	5.0	6.5
Orthoptera	1.5	9.5
Phthiraptera	0	0.1
Thysanoptera	0.9	0
Insecta (Σ)	68.5	75
Annelida	2.7	0.1
Arachnida	19.5	12.7
Mollusca	1.7	0.5
Diplopoda	0.9	0.1
Isopoda	0.2	0
Other invertebrates	5.7	9.8
Plantparts	0.8	1.8

The diet of *Phrynobatrachus latifrons* with respect to seasons was always dominated by insects (Table 3). During the rainy season, hymenopterans (51.6%) were the dominant prey of the frog species. These hymenopterans were predominantly winged ants. Within the same season, the stomach contents of the frogs encompassed other invertebrates, beetles and spiders which were secondary preys. However, during the dry season wingless ants and spiders were the most dominant prey items for frogs and these amphibians then also captured more beetles (Table 3). Through the dry season, some frog stomachs were filled with plant parts (2.6%). Twelve stomachs contained plant items, 10 were almost completely filled.

Table 3. Diet of *P. latifrons* with respect to seasons. Values indicate the percentage of prey categories (Ip) consumed in rainy and dry seasons.

Prey categories	Rainy season	Dry season
Coleoptera	8.8	13.9
Diptera	0	5.5
Heteroptera	0.3	0.4
Hymenoptera	51.6	39.1
Isoptera	0.4	0
Lepidoptera	8.9	2.6
Orthoptera	7.9	3.1
Phthiraptera	0	0.1
Thysanoptera	0	0.9

Insecta (Σ)	77.9	65.6
Annelida	2.0	0.8
Arachnida	8.6	23.6
Mollusca	2.2	0
Diplopoda	0	1.0
Isopoda	0	0.2
Other		
invertebrates	9.3	6.2
Plantparts	0	2.6

DISCUSSION

On a more general note, the prey composition of the puddle frog *Phrynobatrachus latifrons* in the fish farm of the Banco National Park was characterized by the dominance of insects. Besides insects, this anuran also fed on other various arthropods and even some plant parts. Compared to another frog from the same fish farm with known diet such as *Hoplobatrachus occipitalis* (e.g. Tohé *et al.* 2014), insects were the staple food for the latter species as well. Likewise in the swamp forest of the Banco National Park at nearby the fish farm *P. ghanensis* and *P. phyllophilus*, two other syntopic frog species, mainly preyed on insects (Kouamé *et al.* 2008). The dominance of insects in the diet of *P. latifrons* could be attributable to the fact that this class of invertebrates was the most widespread in the fish farm area. The types of habitats from the fish farm were consisted of a forest edge with shrubs, bamboo plots, grasses, reeds, water filled ditches and 16 stagnant pools that were used to breed *Tilapia* fishes at nearby a large central clearing (Assemian *et al.* 2006). These diverse and various habitats were suitable to insects which were previously shown as being very abundant in the stomach contents of the *H. occipitalis* from the fish farm (Tohé *et al.* 2014). While *H. occipitalis* was able to eat some vertebrates such as frogs and birdies, and larger invertebrates (Tohé *et al.* 2014), *P. latifrons* only preyed on small arthropods due to its small size (16.0–23.5 mm in snout-urostyle-length), thus confirming that the diet variation in anurans depends on morphological differences between species and/or individuals (Dauça&Hourdry, 1983). The latter species seems, however, to be a generalist predator because of its prey composition ranging from insects, crustaceans, annelids, arachnids and molluscs to millipedes. But some preferences were observed for particular major prey with respect to sexes and seasons.

At sex level, the diet of male *P. latifrons* was slightly more various than this of females (e.g. compare Table 2). Although females were larger than males significantly, the more various prey items found in stomach contents of males could be explained by the behavioral strategies of the latter to feed and breed. Indeed, during the mating period, competing males occupied the best calling sites i.e, climbing on grasses and aquatic plants, and adopting a wait-and-see position around puddles and ponds where they were encountered in larger choruses with highest peaks at the break of day (Tohé *et al.* 2008). As a result of these behavioral strategies, males mainly preferred ants and in addition spiders while ants especially were the major prey of females. As amphibians, this statement on the behavioral strategies is most of the time verified in other animals such as mammals. For the latter group, the diet variations with respect to sex also resulted from differences in behavioral or energy resources linked to reproduction (Belovsky, 1978; Martins *et al.* 2006). With respect to seasons, our results revealed that *P. latifrons* consumed less various prey items during the rainy season than the dry season (e.g. compare Table 3). There seemed to be some preferences in the frog diet. Indeed, *P. latifrons* preferred preying on winged ants predominantly in the rainy season, and wingless ants and spiders as dominant prey in the dry season. Our results, however, differed with the diet of the

population of the *P. latifrons* from the Comoé National Park especially during the dry season (Rödel, 1995). Indeed, according to the latter author a scarceness of ants was recorded from the prey of the *P. latifrons* (named *P. francisci* in his paper) at the end of the dry season. Kouamé *et al.* (2008) showed that the diet of the populations of *P. ghanensis* and *P. phyllophilus* from the Banco National Park presented larger differences between seasons, although not statistically significant. Hence, as the diet spectrum of anurans may depend on habitat, season and even altitude with some preferences for particular prey (Lamotte, 1983), we presume that the food choice in the population of *P. latifrons* most likely can be explained by differences in the availability of the various arthropod taxa during seasons.

Anurans are known to prey mainly on various arthropods (Inger & Max, 1961; Lescure, 1971; Barbault, 1974; Amiet, 1987). We hence expected to find these prey taxa through the diet of *P. latifrons* in the fish farm. However, the little surprise was the evidence of some plant parts in the stomach contents of the species. It is known that some frogs may have considerable amounts of plant material in their stomachs (Simon, 1983; Kouamé *et al.* 2008; Ogoanah & Uchedike, 2011; Tohé *et al.* 2014). However, it is not known if the consumption of plant parts by *P. latifrons* is deliberately or accidentally. Further surveys should document if the plant parts are devoured deliberately or not.

CONCLUSION

P. latifrons consumed various prey items ranging from insects, crustaceans, annelids, arachnids, molluscs, millipedes to plant parts. However, this species mainly preyed on insects. At sex level males mainly preferred ants and in addition spiders while ants especially were the major prey of females. With respect to seasons, this anuran preferred mostly preying on winged ants predominantly in the rainy season, and wingless ants and spiders as dominant prey in the dry season.

ACKNOWLEDGEMENTS

We are especially grateful to the “Office Ivoirien des Parcs et Reserves” and the “Direction des Eaux et Forêts de Côte d’Ivoire” for the access permit to Banco National Park. The research collection permit was issued by the “Ministère de l’Enseignement Supérieur et de la Recherche Scientifique”, Republic of Ivory Coast. We thank Professor Mark-Oliver Rödel for his invaluable help and collaboration. This paper is part of the projects “Banco Santé Ecologique” at the Nangui Abrogoua University (ex-University of Abobo-Adjamé), Abidjan and the BIOLOG-program of the German Ministry of Education and Science (BMB+F; Project W08 BIOTA-West, FZ 01 LC 00410). These supports are gratefully acknowledged!

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