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Diet of the frog *Phrynobatrachus latifrons* Ahl 1924 in two types of anthropogenic wetlands in West Africa

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Abstract
We studied the diet of *Phrynobatrachus latifrons* in Daloa city shallows and Aghien freshwater lagoon wetland of Ivory Coast to understand diet regarding habitat types and food choice. Four prey categories were identified: Insecta, Myriapoda, Invertebrate debris and Plant material. Insects prey category, preferentially coleopterans and hymenopterans (Formicidae), were mainly consumed by this frog (abundance ≥86%, occurrence ≥ 65 %). Four insects order were absent to the diet of *P. latifrons* from Aghien lagoon. Conversely dipterans and trichoptera were absent to the diet of specimens from Daloa sites. Myriapoda and Plant materials were occasionally preyed in all sites (abundance ≤ 11%, occurrence ≤ 27%). Whatever the sex considered, the diet of this species was preferentially based on coleopterans and hymenopterans in all study sites. Though in Daloa shallows, female secondary preyed on lepidopteran. These prey compositions never differed significantly. Hence, this study revealed that *P. latifrons* is insectivorous.

Keywords: Anura, *Phrynobatrachus latifrons*, Diet, prey choice, West Africa wetland

Introduction
Research has shown that many frog species have food choice [1]. Indeed, many species of dendrobates and some bufonids exclusively preyed on ants [2-4]. This diet specialization, encountered in some amphibians may be significantly related to low diversity of prey in a given ecosystem [5, 6]. Food choice depends on several factors: namely, resource availability, preference, and size [7, 8]. Moreover, the composition of amphibians diet can also bring light upon their trophic role in the structure and dynamics of locale communities [9, 10]. The study of prey composition of amphibians can help in understanding the dietary needs and adaptive strategies to ensure their survival in ecosystem.
For this study we use Ahl's river frog (or Accra river frog) *Phrynobatrachus latifrons* Ahl 1924 synonym of *Phrynobatrachus accraensis* [11] which is abundant in disturbed habitats. It is an extremely common species listed as least concern in view of its wide distribution; it presumed large population, and because it is unlikely to be declining to qualify for listing in a more threatened category [12]. *Phrynobatrachus latifrons* (Phrynobatrachidae) is characterized by a presence of tarsal tubercle and dermal folds more or less protruding drawing an open chevron (V or X shaped) back orbits. This species have a continuous black stripe on the side and a yellow vocal sac in the male; large discs at the ends of the toes; SVL: male = 15-21 mm, female = 13 to 25 mm.
In Ivory Coast, studies on frog diets are few [13] worked on the diet of *Phrynobatrachus ghanensis* and *P. phyllophilus* in protected area of Banco National Park. Whereas [14] worked on dietary strategies of the giant swamp frog *Hoplobatrachus occipitalis* (Dicroglossidae) in degraded areas of this park. Therefore, diet of *P. latifrons* in anthropogenic habitats are rarer.
In this paper, we compare the diet of *P. latifrons* in two wetlands located in central-west and southeastern Ivory Coast to understand the prey preferences of this frog.

Material and Methods
Study sites
Aghien lagoon (5°22'-5°26'N and 3°49'-3°55'W) is a freshwater lagoon located at Bingerville city in the north of Abidjan, the economical capital of Ivory Coast (Figure 1). Aghien lagoon

covers 19 km^2 and can reach 11 m deep. In this lagoon, the water is all year almost exclusively of continental origin [15]. Covered by dense evergreen forest, this study area is now heavily degraded due to human activities such as urbanization and expansion of oil palm and rubber plantation. The sampling site located in a village Elaeis (due to expansion of oil palm plantation) is strongly represented by a large grassland and large ponds.

Daloa city is located in the central-west of Ivory Coast (6°53' N and 6°27' W). Covered by dense evergreen forest, this region is now disturbed due to expensive cacao and coffee plantations.

Furthermore, the department is watered by the Sassandra River and its tributary, the Lobo flood all localities. The survey was realized in three rice field located in the north, west and south part of Daloa city. The sites located in the north and the south are characterized by a large lake. The western rice field was on the same site with a fish farm.

In these areas, the climate is equatorial characterized by four seasons. A longer major dry season extends from December to March, and is followed by the period with highest precipitation during April to July. A minor rainy season lasts from October to November and a minor dry season from August to September [16, 17].

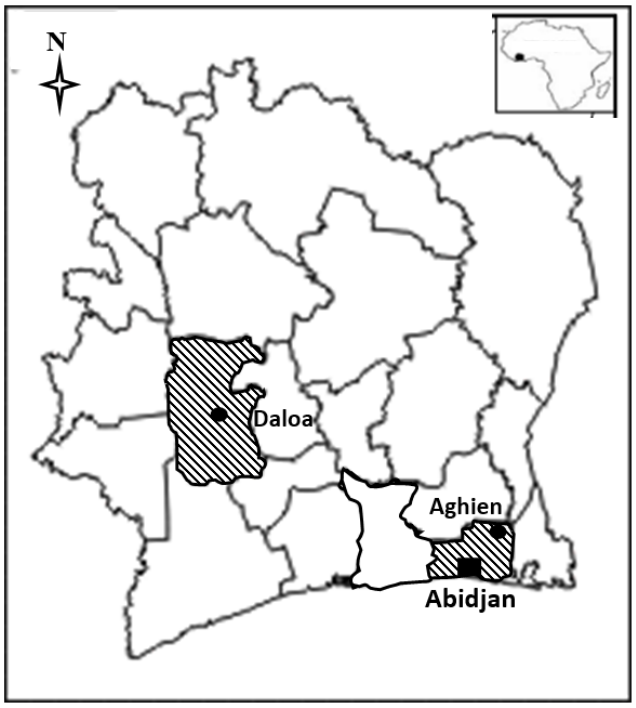

Fig 1: Location of Daloa city and Aghien freshwater lagoon area in Ivory Coast (satellite image of Google Maps 2015).

Data collection

We collected adult females and males of *P. latifrons* on swampy habitat along Aghien lagoon and on three shallows (used as rice field) of Daloa city. The survey sampling was realized in rainy season (June to July 2014) because this is the period of high abundance of frogs and prey items [13, 14] in the various environments. We sampled the target species using visual and acoustic surveys in different habitats applying standard techniques by [18, 19]. Due to its diurnal activities, this species was captured early in the morning and sexed. Representative specimens were collected, anesthetized, scarified in chlorobutanol solution and preserved in 70% ethanol. Collected specimens thereafter were dissected in the laboratory. Each stomach was dissected through a ventral longitudinal incision and its content was analyzed with the aid of a stereoscopic binocular and microscope. For every specimen we determined and counted the prey items. We distinguished between insect orders, myriapods, other animal remains and plant parts with the aid of keys [20, 21].

Specimens of species were deposited in the collection of the Department of Biology and Animal Physiology at Jean Lorougnon Guédé University (Ivory Coast).

Data analysis

In order to characterize the diet of *P. latifrons* in the two localities, we evaluated the relative abundance of a particular prey category RA% = (n*i*/Σn*i*) x 100; with n*i* = a particular prey category, Σn*i* = total prey category.

The number of stomachs containing a particular prey category was evaluated as the percentage or the frequency of occurrence FO% = (FO*i* / N) x 100; with FO*i* = occurrence of a particular prey category, N = stomachs with diet.

This index provides a better representation of food preferences of animals [22-24].

We used the Kruskal-Wallis and Mann-Whitney non-parametric tests to search for potential prey differences in relation to the frogs' sizes. All these tests were performed with PAST 2.17.

Results

Diet composition

A total of 55 individuals (30 from Daloa city shallows and 25 from Aghien lagoon) were analyzed. We founded in *P. latifrons* stomachs from Daloa sites 500 prey items and 36 prey items from Aghien lagoon areas. Four prey categories (Insecta, Myriapoda, Invertebrate debris and Plant material) were identified (Figure 2). These results revealed that *P. latifrons* mainly preyed on insects; invertebrate debris were mainly composed by the remains of insects (head, legs, wings) already digested in the stomach at the time of frog capture. Both these prey category represents more than 86% of prey relative abundance estimated and more than 65 % of prey occurrence (Figure 3). Myriapoda were occasionally preyed in all sites (abundance ≤ 3%, occurrence ≤ 25%). Plant material occurred in diet of all specimens with sometimes high percentage of occurrence (26.7 to 75%) and low abundance (≤ 11%).

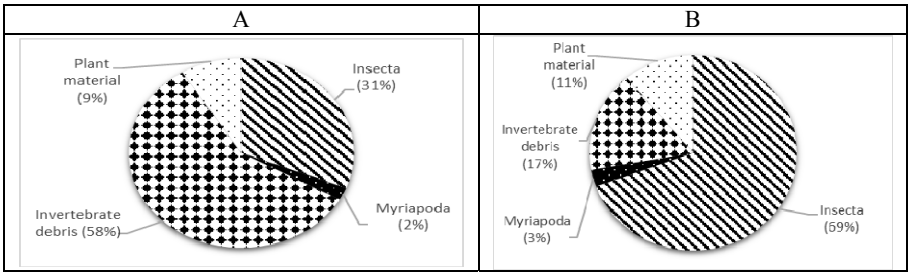

Fig 2: Contribution (percentage) of each prey item found in *Phrynobatrachus latifrons* stomachs in terms of relative abundance in the Daloa city shallows (A) and the Aghien lagoon (B).

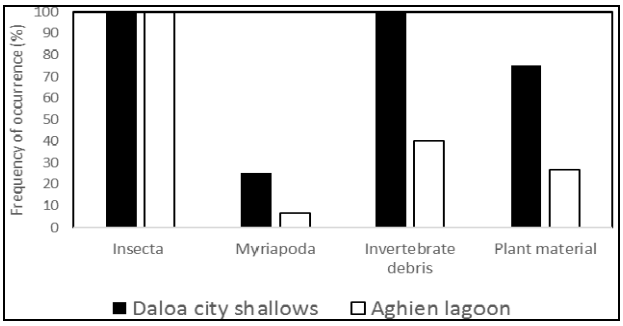

Fig 3: Contribution (percentage) of each prey item found in *Phrynobatrachus latifrons* stomachs in terms of frequency of occurrence in the Daloa city shallows and the Aghien lagoon.

Diet regarding insects prey

These insects prey items belong to eight orders: Coleoptera, Lepidoptera, Orthoptera, Dictyoptera, Hymenoptera, Diptera, Trichoptera and Isoptera (Table 1). From these insects coleopteran and hymenopteran (Formicidae) were the main prey items. In terms of total abundance, coleopteran and hymenopteran were the most abundant taxa collected in stomach of specimens from Daloa city shallows (abundance of both prey items = 77.4%) and from Aghien lagoon areas (abundance of both prey items = 84%). Moreover, these prey items were constantly present in the stomachs dissected from Daloa city shallows (occurrence ≥ 90%). In contrast, the occurrence of coleopteran and hymenopteran in the stomachs of specimens from the Aghien lagoon was relatively low (26.7% and 46.7% respectively).

Four insects order (Lepidoptera, Orthoptera, Dictyoptera and Isoptera) were absent from the diet of *P. latifrons* from Aghien lagoon, and two taxa (Diptera and Trichoptera) were absent from the diet of specimens captured at Daloa sites.

However, neither the prey composition differed significantly between the localities (Mann-Whitney test; $p \geq 0.3056$).

Table 1: Contribution (percentage) of insect prey items found in *Phrynobatrachus latifrons* stomachs in terms of relative abundance (RA) and frequency of occurrence (FO) in the Daloa city shallows and the Aghien lagoon; N = anuran sample size, n = abundance of a prey category.

	Daloa city shallows (N = 30)			Aghien lagoon (N = 25)		
Insect prey items	**n**	**RA (%)**	**FO (%)**	**n**	**RA (%)**	**FO (%)**
Coleoptera	67	43.2	90	8	32	26.7
Lepidoptera	16	10.3	45	0	0	0
Orthoptera	8	5.2	15	0	0	0
Dictyoptera	3	1.9	10	0	0	0
Hymenoptera	53	34.2	100	13	52	46.7
Diptera	0	0	0	3	12	20
Trichoptera	0	0	0	1	4	6.7
Isoptera	8	5.2	13.3	0	0	0

Diet regarding sex

Our results revealed that whatever the sex considered, the diet of *P. latifrons* was preferentially based on coleopteran (beetles) and hymenopteran (ants) in all study sites (Figure 4). However in Daloa city shallows, female specimens secondary preyed on lepidopteran (abundance = 15%; occurrence = 87%). In Aghien lagoon wetland, dipteran were quite common in the diet of male specimens (abundance = 20%; occurrence = 43%). We have not found this prey category in the females' stomach at this site. Prey composition not differed significantly between female and male from these both localities (Kruskal-Wallis test, $p \geq 0.2791$).

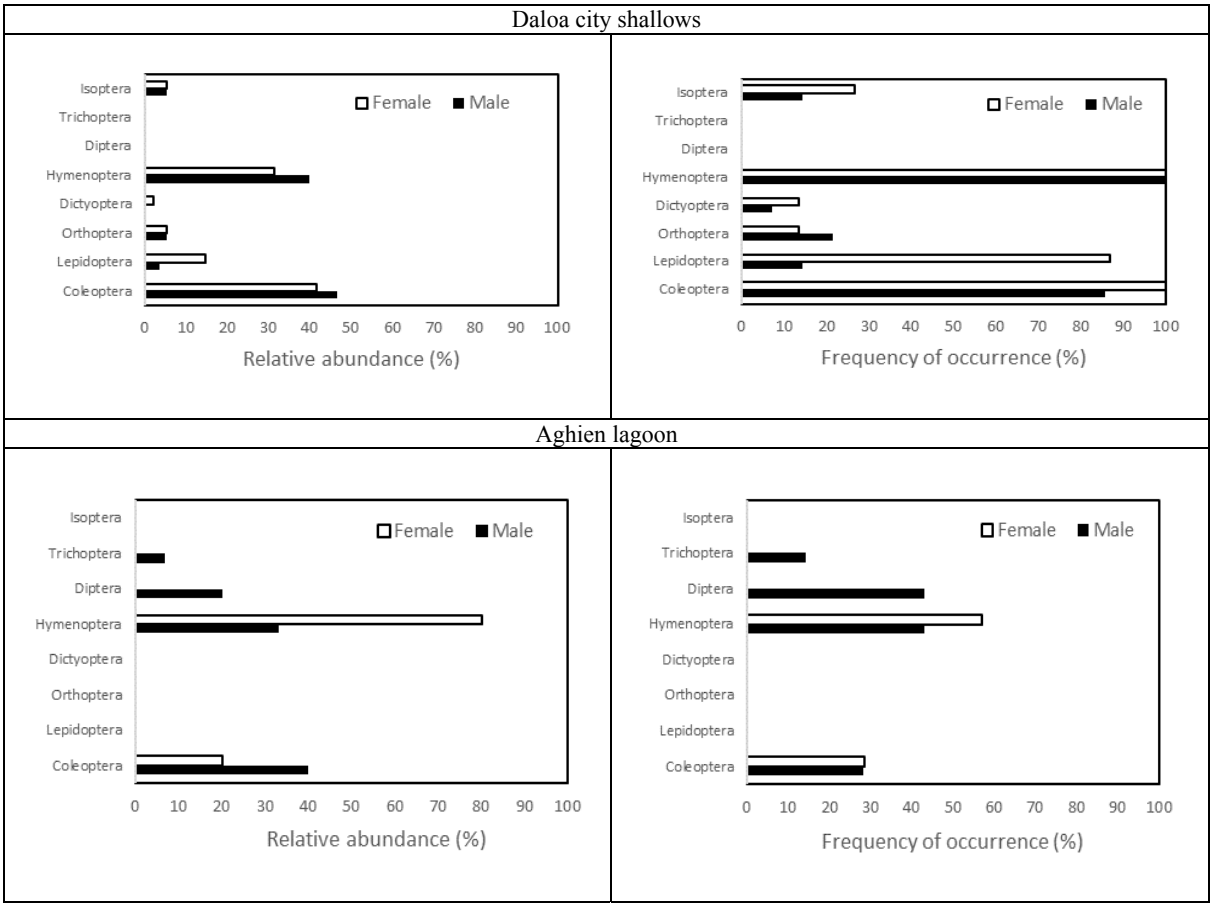

Fig 4: Contribution (percentage) of each prey category found in male and female *Phrynobatrachus latifrons* stomachs in terms of relative abundance (%) and frequency of occurrence (%) in Daloa city shallows and the Aghien freshwater lagoon.

Discussion

Despite the fact that the number of stomachs analyzed is rather low due to ethical concerns, this paper provides descriptive information about the diet of *Phrynobatrachus latifrons* in both sites sampled. The diet of the analyzed specimens revealed insectivorous behavior of *P. latifrons*. This study showed that *P. latifrons* mainly preyed on insects preferentially coleopteran (beetles) and hymenopteran (ants). Our results coincide with those by [13] which showed that the diet of two sympatric species belonging to the same genus (*P. ghanensis* and *P. phyllophilus*) was mainly dominated by the two prey items. In our study areas, these two prey items occurred in all stomachs containing food with high relative abundance (≥ 77.4%). However in Daloa city shallows, coleopteran prey category were more consumed by the specimens than hymenopteran. Conversely in Aghien lagoon area, it was hymenopteran (particularly ants) which were more consumed. The characteristics of each habitat could help to understand this differences diet. Indeed, Aghien lagoon wetland was covered by banana and oil palm plantations, while Daloa city shallows were used for rice field. In this last site there is competition between bird and frog on insects prey category.

Besides, lepidopteran mainly occurred in the diet of female specimens from Daloa city shallows. This result indicate that lepidopteran were choired in this area. Moreover, its relative low abundance in stomach analyzed is due to its big size. Dipteran seem to be choired by males from Aghien lagoon wetland. This specificity in diet behavior in both areas prevents food competition. [14] showed that the diet of males and females of *Hoplobatrachus occipitalis* differ significantly. These authors argument that this difference could be justified by the dimorphism and mobility of both sexes. According to [5], diet specialization, observed in some amphibians may be significantly related to low diversity of prey in a given ecosystem. Although, frogs differ in their physiological abilities to digest prey, which might also generate trade-offs [25]. Thus, amphibians adapt their dietary strategies to ensure their survival in ecosystem.

Although it is believed that frogs do not normally feed on plants, we frequently collected plant material in all stomachs. It is known that some frogs may have considerable plant material in their stomach. [26], [13] and [14] found plant material respectively in a New Guinean microhylid frog and in two Ivory Coast *Phrynobatrachus* species (*P. ghanensis* and *P. phyllophilus*) and *Hoplobatrachus occipitalis*. Perhaps, these plants were accidentally consumed when frogs captured animals prey.

Hence, this study showed that food choice depends on preference and size of prey as demonstrated [7] and [8].

Conclusion

Our study revealed that *P. latifrons* is insectivorous. This species mainly preyed on insects preferentially coleopteran (beetles) and hymenopteran (ants). However, to avoid competition for food males and females sometimes preyed on different insects items. Thus, further in-detail-analyses of food availability in a given habitat and the species' behavior may help clarifying this food choice.

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