Spatio-temporal dynamics of anuran populations in the wetlands of Korhogo, Côte d'Ivoire

ABSTRACT

Aims: The Korhogo commune contains several natural habitats that are home to a large community of frogs. But today, these habitats are facing strong anthropic pressures. This study aims to show the effect of anthropogenic activities on wetlands and the organisms that live there.
Methodology: Sampling took place from June 2023 to May 2024, and samples came from experimental fishing using deep-net dip nets with 2 mm mesh or rod and line, and from commercial fishing using various gears.
Results:A total of 791 individuals were caught, for a total biomass of 48.872 Kg. These individuals were divided into 5 species, 4 genera and 4 families. Spatially, diversity was highest in the lakes (80) and lowest in the rice fields (20%). Temporally, diversity was highest in the rainy season (100%) and lowest in the dry season (40%). The species *Hoplobatrachus occipitalis* dominated the population with 94.66% of captures. It accounted for 25.46%, 24.27%, 22.81%, 13.93% and 13.53% respectively in lakes, rice fields, rivers, wells and shallows. The strong presence of this species in the wetlands of this commune shows that these areas are highly threatened.
Conclusion: This study contributes to the knowledge of the frog population and helps to combat the degradation of wetlands in the city of Korhogo.

Keywords: frog, temporal, spatial, anthropized, diversity

1. INTRODUCTION

Amphibians are descended from fish and appeared over 400 million years ago. Equipped with lungs and limbs, they were the first vertebrates to conquer land, paving the way for reptiles, birds and mammals. It is a highly diverse group, with around 6,000 species [1]. This group of organisms is considered to be good ecological indicators of the state and stability of ecosystems [2]. In economic terms, some edible amphibian species generate income and are an important source of animal protein for humans [3].Amphibians can be found in the majority of environments, such as grasslands and woodlands, but also in more or less anthropized areas such as industrial zones or the very heart of certain cities. However, this class of amphibians is highly vulnerable to direct or indirect degradation of their habitats, with the disappearance of water bodies (particularly ponds) and the direct destruction of species now making certain populations dangerously fragile. In addition, other factors such as habitat fragmentation and trivialization, the introduction of new pathologies, the introduction of exotic species, pollution, climate change, etc., are either responsible for the decline of many species, or constitute serious threats to the future evolution of populations [4]. In Côte d'Ivoire, and particularly in the town of Korhogo, the advance of urbanization is considerably reducing habitat opportunities for biological species. This situation poses a real threat to the sustainability of amphibian populations living in this region, especially with the

disappearance of the ponds that constitute their main breeding grounds. Thus, the implementation of strategies for the protection and conservation of these animals in the Korhogo area would be more than necessary today. The present study is therefore proposed to describe the structure of the frog population in the wetlands of the Korhogo commune, with a view to their conservation.

2. MATERIAL AND METHODS

2.1 Study area

Nicknamed the “City of Poro” and located 635 km from Abidjan, Korhogo is the largest urban agglomeration in northern Côte d'Ivoire and the country's fourth largest urban agglomeration in terms of population: 440,926 inhabitants [5]. Like these northern cities, it lies between 5° 16' and 16° 16' west longitude and 8° 32' and 10° 20' north latitude. It enjoys a Sudanese-type climate with two seasons: a dry season from November to March and a rainy season from April to October [6]. In this city, seven sites were the subject of this study (Fig. 1). Based on similar characteristics, these seven (07) sites were grouped into five (05) major wetlands (lake, lowland, river, rice field and well).

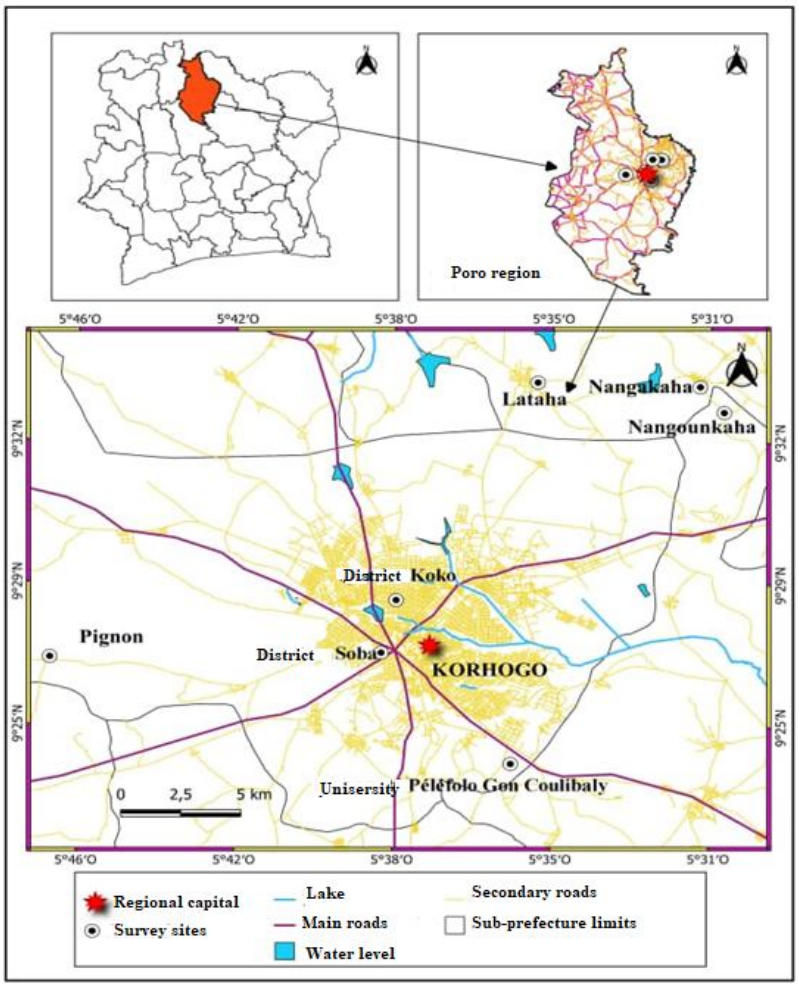

Fig. 1. Location of sampling sites in Korhogo and surrounding area

2.2 Sampling

Amphibians were collected monthly from June 2023 to May 2024. Organisms were collected from both experimental and commercial fisheries. In the case of experimental fishing, organisms were caught using a deep-net dip net with 2 mm mesh or a rod. For commercial fishing, however, a wide range of gear was used. Captured specimens were identified according to [7], then weighed to the nearest gram using a 0.1 g precision scale with a 12 kg capacity.

2.3 Data processing

2.3.1 Species richness

Species richness is a measure of the biodiversity of all or part of an ecosystem. It corresponds to the total number of species found in a given environment. Its observed value is only an approximation of the number of species actually present, and depends directly on the quality of sampling.

2.3.2 Percentage of occurrence

Percentage of occurrence (PO) provides information on the continuous presence of a species in an environment. In this study, it was obtained by calculating the percentage of sites where a species i was sampled in relation to the total number of sites sampled. It is calculated according to the following formula:

$PO = (Si / St) \times 100$

Si: number of sites where species i is observed;St: total number of sites surveyed.

2.3.3 Numerical and weight percentages

Numerical (N) and weight (P) percentages are calculated as the ratio of the number or mass of individuals of a species or family to the total number or mass of individuals multiplied by one hundred. They are calculated according to the following formulas [8]:

$N = (n / Nt) \times 100$

$P = (p / Pt) \times 100$

With n: number of individuals of a given species Nt: total number of individuals;p: mass of individuals of a given species or family in g;Pt: total mass of individuals in g.
Numerical and weight percentages were used to compare specific dominance in catches.

2.3.4 Shannon diversity index (H') and equitability index (E)

The Shannon index is used in the present study for its independence of sample size and the fact that it takes into account only the abundance of each species [9]. It has been used both to observe the evolution of the stand over time and to measure the degree of organization of the stand [10]. This index is expressed as follows:

$H' = \sum (Ni/N) \times \log_2 (Ni/N)$

With Ni: number of individuals of a given species, i ranging from 1 to S (total number of species).N: total number of individuals. H' (bits/individual).
H' is zero if the sample is composed of a single species and maximum (of the order of 5) if all species in the community are equally represented in the sample [11].
Equitability (E) was used to describe the distribution of abundances of the different species sampled in the lake as expressed by [12]. It was estimated using the following formula:

$E = H'/\log_2(S)$

With H': Shannon's diversity index (H') and S: number of species.
E varies from 0 to 1 and is at its highest when species present abundances in identical proportions. On the other hand, E has minimal values if a single species dominates the stand.

2.4 Statistical treatment

Seasonal variation in the Shannon and equitability indexes was compared using the Man-Whitney test.

3. RESULTS AND DISCUSSION

3.1 Results

3.1.1 Spatial and seasonal variation in species richness

This study resulted in the identification of 5 species of anurans (Fig. 2), divided into 4 genera and 4 families (Table I). Spatial variation in species richness shows that the highest diversity is observed in lakes and the lowest in rice fields. In terms of occurrence, the most frequent species is *Hoplobantrachus occipitalis* (100%). The least frequent species is *Hemisusmarmoratus* (20%). Seasonal variation in species richness shows that the highest diversity is observed during the rainy season (Fig. 3).

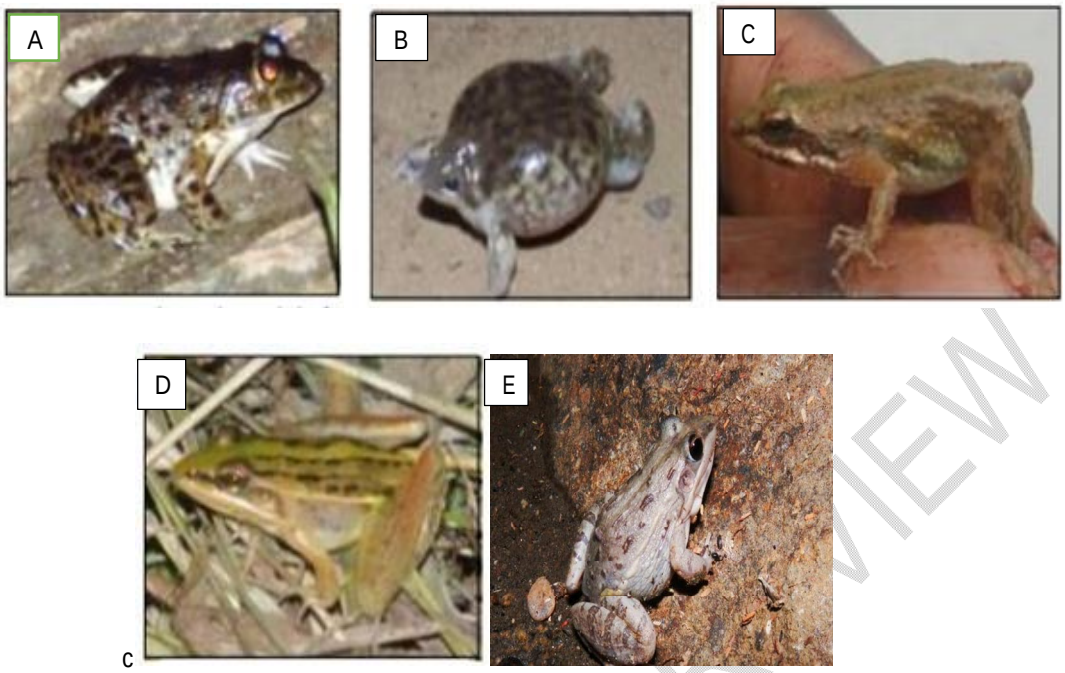

Fig. 2. Frog species recorded in Korhogo wetlands from June 2023 to May 2024 (A: *Hoplobatrachusoccipitalis* ; B: *Hemisusmarmoratus* ; C: *Phrynobatracusaccraensis* ; D: *Ptychadenapumilio* ; E: *Ptychadenaschillukorum*)

Table 1. Distribution of frogs in Korhogo wetlands from June 2023 to May 2024

Families	Species	Lake	lowland	rice field	river	well	P.O (%)
Dicroglossidae	*Hoplobatrachus occipitalis*	+	+	+	+	+	100
Hemisotidae	*Hemisusmarmoratus*	+	-	-	-	-	20
Phrynabatrachidae	*Phrynobatracusaccraensis*	+	-	-	-	-	20
Ptychadenidae	*Ptychadenapumilio*	+	-	-	+	+	60
	Ptychadenaschillukorum	-	+	-	+	-	40
4 families	**5 species**	**4**	**2**	**1**	**3**	**2**	

+ : presence - : absent P.O : percentage occurrence

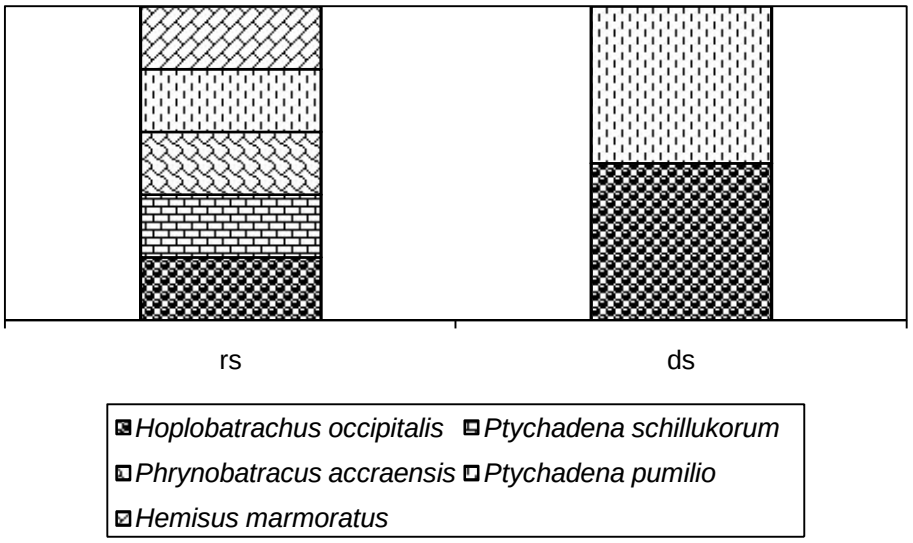

Fig. 3. Seasonal diversity of frogs collected in Korhogo wetlands from June 2023 to May 2024 (rs: rainy season, ds: dry season)

3.1.2 Spatial and seasonal variation in numerical and weight percentage

A total of 791 individuals, for a total biomass of 48.872 Kg, were caught during this study. In terms of abundance, the species *Hoplobantrachus occipitalis* was the most preponderant, accounting for 94.66% of catches. Spatially, the highest abundance of this species was observed in rice fields (25.24%), followed by rivers (24.12%), lakes (22.02%), wells (14.45%) and shallows (14.17%) (Fig. 4). This species is followed by *Ptychadenapumilio* (3.92%), then *Hemisusmarmoratus* (0.66%), *Ptychadenaschillukorum* (0.52%) and *Phrynobatrachus*. Accraensis (0.14%). Similarly, in terms of weight, Hoplobantrachus occipitalis remains the most represented species, accounting for 89.30% of total biomass. It is followed by *Ptychadenapumilio* (8.14%), *Hemisusmarmoratus* (1.20%) *Ptychadenaschillukorum*(1.05%) and *Phrynoabatrachusaccraensis* (0.28%).Overall, the highest abundance of these organisms was observed in lakes, with 25.46% of individuals caught, and the lowest in shallows (13.53%). Seasonal variation is highest in the rainy season (57.11%) and lowest in the dry season (42.89%).

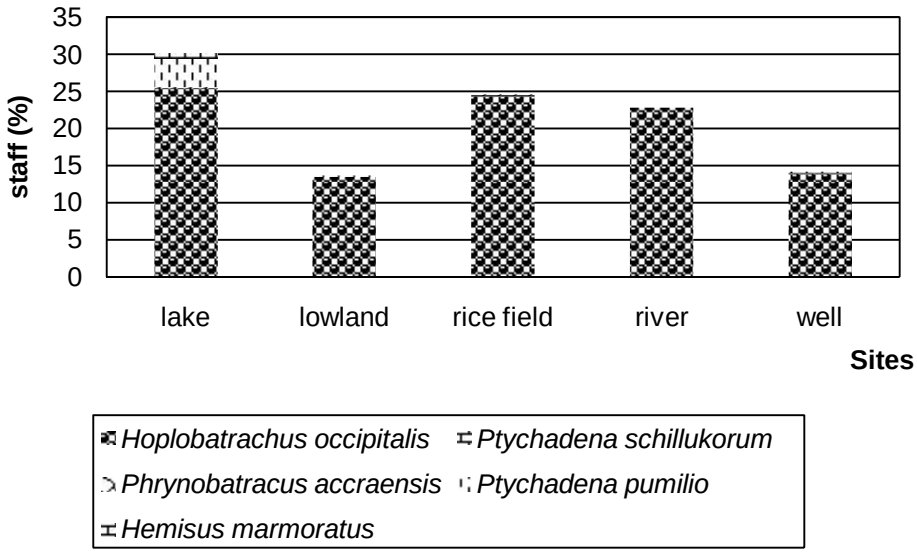

Fig. 4. Spatial variation in the number of individual frog species in Korhogo wetlands from June 2023 to May 2024

3.1.3 Spatial and seasonal variation in Shannon and equitability indices

Overall, the Shannon diversity index varied spatially from 0.00 bits/ind to 0.57 bits/ind, with the highest value in lakes and the lowest in rivers, for an average of 0.16 ± 0.23 bits/ind. The equitability index ranged from 0.00 bits/ind to 0.41 bits/ind in lakes and rivers respectively, with an average of 0.14 ± 0.16 bits/ind (Table 2). Seasonally, the highest average diversity index was obtained in the rainy season (0.32 ± 0.45 bits/ind) and the lowest in the dry season (0.02 ± 0.03 bits/ind).The Man-Whitney test revealed no significant difference in the seasonal variation of the Shannon diversity index (*P = 0.69*).
The equitability index showed the following mean values: 0.20 ± 0.28 bits / ind and 0.03 ± 0.04 bits / ind in the wet and dry seasons respectively.

Table 2. Spatial variation in Shannon and equitability indices for frogs in Korhogo wetlands from June 2023 to May 2024

Sites	Shannon index (bits/ind)	equitability index (bits/ind)
Lake	0.57	0.41
Lowland	0.06	0.08
Rice field	0.09	0.09
River	0	0
Well	0.09	0.14

bits/ind :bits per unit

3.2 Discussion

At the end of this study, the species richness observed was relatively very low. This low species richness may be related to the rapid urbanization of the region, which reduces the preferred areas for these organisms, as well as to the temporary completion of the ponds. Spatial analysis of species richness shows variations from one site to another. This variation

is linked to the characteristics of the environment. The absence or presence of certain species at these sites is also linked to the nature of the species. Species such as *Hoplobatrachus occipitalis*, *Ptychadenapumilio*, *Hemisusmarmoratus*, *Ptychadenaschillukorum* and *Phrynoabatrachusaccraensis* are characteristic of disturbed or degraded habitats [13]. Their low presence or absence in the rice field indicates that this environment is less disturbed. This finding confirms [14] observation that anurans are generally excellent indicators, and the quality of the population demonstrates the degree of habitat disturbance and the biotic and physical integrity of the environment. Furthermore, diversity decreases from the rainy to the dry season. The high diversity in the rainy season can be explained by the fact that this period is favourable for the reproduction and growth of numerous organisms, and therefore an abundance of food. Indeed, abundant water conditions the distribution of anurans, which are animals whose skin must be constantly moistened [15].

Furthermore, the strong presence of *Hoplobatrachus occipitalis*, both spatially and seasonally, in the catches shows which species is best adapted to the conditions of the environment exploited. This result corroborates the work of [16], who assert that it is the most widely distributed species in Côte d'Ivoire, and that of [17], who indicates that it is the species best adapted to degraded savannah ecosystems. However, the low presence of *Phrynobatrachusaccraensis* could be explained by the fact that these environments are not ideal breeding grounds. Indeed, the larvae of this species do not develop in water reservoirs, but in holes [18].

The low value of the Shannon diversity index observed in this study justifies the very low diversity of the environment. The same is true of the equitability index, which indicates poor settlement organization. This situation is closely linked to anthropogenic activities such as agriculture and rampant, uncontrolled urbanization.

4. CONCLUSION

At the end of this study, the results show that the diversity of frogs in this area is very low. This situation is linked to the threats to their habitat from ever-increasing anthropogenic activities. Both spatially and seasonally, the frog population in this area is dominated by the species *Hoplobatrachus occipitalis*, which is the most widely distributed species in Côte d'Ivoire and is characteristic of anthropized environments. This means that virtually all Korhogo's wetlands are under threat.

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REFERENCES

1. Acemav C, Duguet R, Melki F. Amphibians of France, Belgium and Luxembourg. Parthénope Collection, Edition Biotope, Mèze. 2003; 480 p.

2. Pereira HM, Navarro LM, Martins IS. Global biodiversity change: the bad, the good, and the unknown. Annu. Rev. Approx. Resour. 2012; 37:25-50.

3. Nzigidahera B. Note on Hoplobatrachus occipitalis (Günther), edible species in Burundi. Scientific Bulletins of the EcoleNormaleSupérieure. 2005; 1:1-7.

4. Boissinot A. Influence of the structure of the breeding biotope and the layout of the landscape, on the amphibian population of a bocage region in western France. Thesis for obtaining the diploma from the ÉcolePratique des HautesÉtudes. 2009; 165 p.

5. RGPH. Overall results of the population and habitat census. 2021; 37p

6. Boko-Koiadia ANN, Guéladio C, Brama K, Dedy S. Climate Variability and Environmental Changes in Korhogo, Ivory Coast: Myths or Reality? 2016; 10:158.

7. Rödel MO. Herpetofauna of West Africa, Vol. I: Amphibians of the West African savanna. Chimaira Edition, Frankfurt/M. 2000; 335 pp.

8. Hureau JC. Comparative biology of some Antarctic fishes (Notothenidae). Bulletin of the Oceanographic Institute of Monaco. 1970; 68(1391):244 pp.

9. Daget J. Contribution to the knowledge of the fauna of the United Republic of Cameroon. Fish from Ayina, Dja and lower Sanaga. Cybium. 1979; 6:55-64.

10. Amanieu M, Lasserre G. Organization and evolution of lagoon populations. OceanologicaActa. 1982; SP:201-213.

11. Ludwig JA, Renolds JF. Statistical ecology: A primer on methods and computing. John Wiley & Sons, New York, USA. 1988; 337 pp.

12. Hill MO. Diversity and evenness: A unifying notation and its consequences. Ecology. 1973; 54:427-432.

13. Adeba PJ, Kouassi P, Rödel MO. Anuran amphibians in a rapidly changing environment -revisit ingLamto, Côte d'Ivoire, 40 years after the first herpetofaunal investigations. African Journal of Herpetology. 2010; 59:1-18.

14. Ernst R, Rödel MO. Anthropogenically induced changes of predictability in tropical anuran assemblages. Ecology. 2005; 86:3111-3118.

15. Gardner TA, Fitzherbert EB, Drewes RC, Howell KM, Caro T. Spatial and Temporal Tatterns of Abundance and Diversity of an East African Leaf Litter Amphibian Fauna. Biotropica. 2007; 39(1):105-113.

16. Kouamé NG, Ofori-Boateng C, Adum GB, Gourène G, Rödel MO. The anuran fauna of a West African urban area. Amphibian & Reptile Conservation. 2015; 9(2):1-14.
17. Kéita G. Socio-economic interests and reproductive and growth performance of the frog Hoplobatrachus occipitalis (Günther, 1858). Doctoral thesis, Jean LorougnonGuédé University, Daloa, Ivory Coast. 2023; 132 p.
18. Rödel MO, Ernst R. A new Phrynobatrachus from the Upper Guinean rain forest, West Africa, including a description of a new reproductive mode for the genus. Journal of herpetology. 2002; 36(4):561-571.