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RESEARCH PAPER

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Assessment of the trophic ecology and variation in the natural diet of an anuran amphibian species (*Afrixalus dorsalis*) in the Wetlands of the Ehotilé Islands (Ivory Coast)

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ABSTRACT

Knowledge of natural diet is essential in amphibian ecology and facilitates an understanding of their role in ecosystem balance. This study assessed the diet of *Afrixalus dorsalis* and evaluated how it varies according to age class, sex, and spatial distribution in Etuessika, in southeastern Côte d'Ivoire. A total of 80 individuals were studied, and their stomach contents were analyzed**.** Six stomachs were empty, corresponding to a stomach-emptiness index of 7.5%. Prey items were characterized using the relative importance index (IRI). A total of four prey types were observed in the stomach contents: insects, arachnids, annelids, and molluscs. Insects constituted the main component of the diet, accounting for 92.11% and 94.83% of the IRI in juveniles and adults, respectively, and 95.15% and 93.21% in males and females, respectively. Principal component analysis (PCA) revealed an overlap in dietary profiles across sites. Statistically, comparisons of IRI values showed no significant differences based on age class, sex, or site ($p > 0.05$). Thus, this species has a primarily insectivorous and relatively diverse diet, with variations in the relative importance of prey items but no significant overall trophic differentiation among the groups studied. This dietary flexibility would facilitate the use of available resources in habitats with different ecological characteristics.

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INTRODUCTION

Amphibians are important for the balance of terrestrial and aquatic ecosystems. They consume a wide variety of invertebrates and play a role in energy transfer between different trophic levels (Wells, 2007). Knowledge of their diet is essential for understanding their ecology (Toft, 1985; Wells, 2007). Recent studies on the feeding ecology of anuran amphibians highlight that prey composition and categories can vary considerably among species and populations (Pedroso-Santos *et al.*, 2024; Moser *et al.*, 2025).

The natural diet of anuran amphibians is influenced by numerous intrinsic and extrinsic factors, including body size, sex, developmental stage, foraging strategy, prey availability, and habitat characteristics (Toft, 1985; Wells, 2007). This variability is particularly significant in human-altered landscapes, especially agroecosystems, where changes in habitat structure can influence the diversity and abundance of available invertebrates. In these environments, the consumption of a wide variety of arthropods by certain frog species also highlights their potential contribution to the regulation of invertebrate populations, including certain organisms associated with crops (García-Padrón, 2021).

Afrixalus dorsalis (Peters, 1875) is a small arboreal anuran belonging to the family Hyperoliidae. It is found in the West African forest belt as well as in vegetation types associated with humid savannas (Channing and Rödel, 2019).

Despite its ability to occupy a variety of habitats, research on its feeding ecology remains limited. In general, recent studies show that, despite an increase in the number of studies on the natural diets of amphibians, gaps in knowledge persist for many tropical species (Moser *et al.,* 2025).

The vegetation cover of the Etuessika area (southern Côte d'Ivoire) consists of a mosaic of natural and anthropogenic wetland habitats that are likely to provide diverse food resources for amphibians. Understanding the diet of *Afrixalus dorsalis* in these wetlands would not only help to better document the still poorly understood ecology of this species in Côte d'Ivoire but also assess the potential influence of local habitat characteristics on the utilisation of food resources.

This study aims to characterize the natural diet of *Afrixalus dorsalis* in two habitats in the village of Etuessika, in southeastern Côte d'Ivoire. These results contribute to improving our understanding of the feeding ecology of A. dorsalis and, more broadly, of the functional role of amphibians in the wetland and agricultural landscapes of West Africa.

MATERIALS AND METHODS

Study Area

Sampling was conducted in the village of Etuessika, located in the Adiaké Department in southeastern Côte d'Ivoire, near the Éhotilé Islands National Park and the Aby lagoon complex. The region has a humid sub-equatorial climate characterized by four distinct seasons: two rainy seasons and two dry seasons. The average annual temperature is approximately 26 °C, and annual precipitation generally ranges from 1,800 to 2,000 mm. The landscape surrounding the Éhotilé Islands consists of a mosaic of wetlands, forest formations, and anthropogenic environments (Djah, 2009; UNESCO, 2006).

Characteristics of the sampling sites

Specimens of *Afrixalus dorsalis* were collected at two selected sites. Site A (S-A) (05°11.0115′ N; 003°19.1483′ W; elevation 12 m) is an open, humid habitat characterized by small streams and shrubby vegetation. Bamboo stands, palm trees, and coconut palms are also present there. Site B (S-B) (05°10.7905′ N; 003°19.5251′ W; elevation 12 m) is an open, humid environment comprising a marshy area heavily influenced by agricultural activities. The vegetation consists mainly of vegetable crops, including tomatoes (*Solanum lycopersicum*), okra (*Abelmoschus esculentus*), eggplant (*Solanum melongena*), and cabbage (*Brassica oleracea*), along with cassava (*Manihot esculenta*) and corn (*Zea mays*).

Specimen collection

Specimens were captured from 7:45 p.m. to 11:45 p.m., for a total of 5 hours of sampling per day, by a team of 4 people. The time-limited visual search method proposed by Crump and Scott (1994) was used. All observed individuals were captured by hand and identified.

Identification of prey

After dissection, all gastric contents were removed and spread out in Petri dishes containing alcohol. The prey were then sorted based on their similarities before being examined under a binocular magnifying glass. The identification keys by Roth (1974) and Tachet *et al.* (2010) were used to identify the prey.

Determination of indices

Vacuity coefficient: The vacuity index (VI) is the percentage of empty stomachs relative to the total number of stomachs examined (Sorbe, 1980). This index provides information on periods of low or intense feeding activity in frogs.

VI(%)=(Total number of stomachs examined/Number of empty stomachs)×100

Relative importance index (% IRI)

The Relative Importance Index (IRI) provides a better understanding of the diet. It was chosen for this study to assess the diet of *Afrixalus dorsalis* off the coast of the Éhotilé Islands. According to Pinkas *et al.* (1971), the formula is as follows:

$\% \text{ IRI} = (\% \text{ N} + \% \text{ P}) \times \% \text{ F}$

where:

%N = numerical percentage of each prey category in the diet,

%P = weight percentage of each prey category,

%F = frequency of occurrence of each prey category in the diet

The consumed prey items were classified using the method proposed by Rosecchi and Nouazé (1987). A proportion of 50% or more of the total index is obtained by summing the index percentages.

Thus, these foods are referred to as preferred prey. The various food categories whose index, when added to that of the preferred prey, reaches at least 75% are considered secondary prey. All other foods are referred to as incidental prey.

Numerical percentage (%N)

Numerical percentage (%N) is used to count the number of individuals in a prey category "i" for a given sample (Hureau, 1970).

% N = (Total number of individuals of prey species i / Total number of prey species recorded)*100

Numerical percentage (%N)

Assesses the relative importance of each prey type based on its weight. It is expressed as the percentage of the weight of a particular prey category relative to the total weight of all identified prey.

P= (Weight of a prey category) / (Total weight of all prey) × 100

Occurrence frequency (%F)

Estimates the frequency of occurrence of a particular prey item in the stomachs examined. It is expressed as the percentage of stomachs containing that prey item relative to the total number of stomachs containing food (Hyslop, 1980; Young *et al.*, 1997).

%F = (Number of stomachs containing prey i/number of stomachs containing food)* 100

Statistical analysis

The nonparametric Mann-Whitney and Kruskal-Wallis tests were used to compare the dietary patterns of the participants. The Kruskal-Wallis test was used when $P > 0.05$. However, when $P < 0.05$, the Mann-Whitney test was used to identify these differences by comparing pairs of groups. These tests were performed using STATISTICA 7.1 software (Statsoft, 2005). Principal Component Analysis (PCA) was performed using R software version 4.4.3 to assess the distribution of consumed items according to habitat

RESULTS

General diet

Of the 80 *Afrixalus dorsalis* stomachs examined, 74 contained food, and 6 were empty, representing an emptiness rate of 7.5%.

The diet of this species consists of four types of prey that were observed and identified (Table 1). These include insects, arachnids, annelids, and molluscs. In addition to these prey items, macrophytes were also present.

Table 1. Composition of the general diet of *Afrixalus dorsalis*

Prey items consumed	F (%)	N (%)	P (%)	IRI (%)
Insects				
Coleoptera	11.38	12.13	6.45	12.61
Hemiptera	8.13	7.11	3.22	5.01
Trichoptera	5.69	6.69	13.07	6.70
Heteroptera	9.76	9.62	9.25	10.97
Lepidoptera	13.82	11.72	9.76	17.69
Isoptera	8.94	11.30	15.19	14.12
Diptera	5.69	7.95	4.20	4.12
Orthoptera	5.69	7.53	4.75	4.17
Dermaptera	8.94	8.37	11.37	10.52
Odonata	9.76	7.95	7.81	9.16
∑ Insects	87.80	90.38	85.07	95.08
Arachnids	2.44	1.67	6.87	1.24
Annelids	5.69	3.77	3.90	2.60
Molluscs	2.44	2.09	3.48	0.81
Macrophytes	1.63	2.09	0.68	0.27
Total	100	100	100	100

F (%) = Frequency of occurrence; N (%) = Numerical percentage; P (%) = Weight percentage; IRI (%) = Relative importance index

Table 2. Dietary composition of Afrixalus dorsalis by sex (male and female)

Prey items consumed	Males (n = 37)				Females (n = 25)			
	F (%)	N (%)	P (%)	IRI (%)	F (%)	N (%)	P (%)	IRI (%)
Insects								
Coleoptera	12.07	10.94	5.90	11.14	10.26	15.87	10.26	14.25
Hemiptera	8.62	7.81	3.61	5.40	7.69	7.94	7.69	6.39
Trichoptera	5.17	3.91	7.87	3.34	2.56	3.17	2.56	0.78
Heteroptera	13.79	11.72	11.64	17.66	5.13	7.94	5.13	3.56
Lepidoptera	17.24	15.63	13.45	27.48	10.26	6.35	10.26	9.06
Isoptera	8.62	13.28	18.53	15.03	10.26	9.52	10.26	10.79
Diptera	5.17	7.03	0.33	2.09	5.13	6.35	5.13	3.13
Orthoptera	5.17	6.25	3.77	2.84	5.13	4.76	5.13	2.70
Dermaptera	5.17	7.03	9.84	4.78	12.82	15.87	12.82	19.56
Odonata	6.90	7.03	7.22	5.39	15.38	12.70	15.38	22.98
∑ Insects	87.93	90.63	82.16	95.15	84.62	90.48	84.62	93.21
Arachnids	3.45	2.34	10.00	2.33	2.56	1.59	2.56	0.57
Annelids	3.45	1.56	1.64	0.61	7.69	4.76	7.69	5.09
Molluscs	3.45	3.13	5.41	1.61	2.56	1.59	2.56	0.57
Macrophytes	1.72	2.34	0.79	0.30	2.56	1.59	2.56	0.57
Total	100	100	100	100	100	100	100	100

n= total number of stomachs; F (%)= frequency of occurrence; N (%)= numerical percentage; P (%)= weight percentage; IRI (%)= relative importance index.

Insects, with a relative importance index (IRI) of 95.08%, constitute the primary prey of this species. All other prey items are considered secondary food sources. Concerning insects, ten orders were identified. Among these orders, the Heteroptera (IRI = 17.69) are the most consumed, while the least consumed are the Diptera and Orthoptera, with relative importance indices of 4.12% and 4.17%, respectively.

Table 3. Diet by sampling site

Prey items consumed	Site A				Site B			
	F (%)	N (%)	P (%)	IRI (%)	F (%)	N (%)	P (%)	IRI (%)
Insects								
Coleoptera	11.86	13.18	5.77	13.12	10.94	10.91	7.87	11.60
Hemiptera	8.47	6.20	4.26	5.18	7.81	8.18	1.05	4.07
Trichoptera	6.78	7.75	18.18	10.27	4.69	5.45	2.36	2.07
Heteroptera	8.47	10.08	11.29	10.57	10.94	9.09	4.99	8.70
Lepidoptera	13.56	12.40	7.27	15.58	14.06	10.91	14.96	20.54
Isoptera	10.17	13.95	20.94	20.72	7.81	8.18	3.15	5.00
Diptera	5.08	4.65	0.19	1.44	6.25	11.82	12.60	8.62
Orthoptera	3.39	5.43	3.89	1.84	7.81	10.00	6.56	7.31
Dermaptera	6.78	6.98	9.03	6.34	10.94	10.00	16.27	16.23
Odonata	8.47	6.98	5.89	6.37	10.94	9.09	11.81	12.91
∑ Insects	83.05	87.60	86.71	91.42	92.19	93.64	81.63	97.04
Arachnids	3.39	2.33	6.39	1.73	1.56	0.91	7.87	0.77
Annelids	10.17	6.20	4.26	6.21	1.56	0.91	3.15	0.36
Molluscs	1.69	1.55	2.26	0.38	3.13	2.73	6.04	1.55
Macrophytes	1.69	2.33	0.38	0.27	1.56	1.82	1.31	0.28
Total	100	100	100	100	100	100	100	100

F (%)= Frequency of occurrence; N (%)= Numerical percentage; P (%)= Weight percentage; IRI (%)= Relative Importance Index.

Diet by sex

The diet of male and female Afrixalus dorsalis individuals was determined and presented in Table 2.

Overall, regardless of sex, insects constitute the majority of the prey consumed by A. dorsalis in our study area. The relative importance index for males is 95.15%, compared to 93.21% for females. All other types of prey are consumed incidentally. Among males, Lepidoptera (IRI = 27.48%) are the most commonly consumed, while Diptera (IRI = 2.09%) are the least commonly consumed. In contrast, among females, dermapterans (IRI = 19.56%) are the most commonly consumed, and the least commonly consumed are caddisflies (IRI = 0.78%).

Statistical analysis reveals that there is no significant difference in diet between males and females (Mann-Whitney test: n1 = 14; n2 = 14; U = 98, Z = 0, p = 1.00).

Diet by site

The diet of Afrixalus dorsalis was studied by sampling site (Table 3). In total, four food types were identified at the two sampling sites. Regardless of the sampling site, insects constitute the primary food source for A. dorsalis, with an index percentage of 91.42% for Site A and 97.04% for Site B. Other prey items constitute the secondary food source. Regarding the insects found in the stomach contents of specimens from Site A, Isoptera were the most commonly consumed, with an index percentage of 20.72%, while Diptera were the least commonly consumed (IRI = 1.44%). In contrast, in the stomach contents of specimens collected at Site B, the most commonly consumed insects were Lepidoptera (IRI = 20.54%), and the least commonly consumed were Trichoptera (IRI = 2.07%). However, the prey consumed did not differ significantly between habitats (Kruskal-Wallis test, n1 = 14; n2 = 14; p-value = 0.3).

Diet by age class

The dietary composition of adult and juvenile specimens of *Afrixalus dorsalis* was determined in this study (Table 4). The stomach contents of adult individuals consisted of four types of prey (insects, arachnids, annelids, and molluscs), compared to two (insects and annelids) in juveniles. However, in individuals of both age groups, insects constitute the primary component of the A. dorsalis diet, with a relative importance index of 92.11% for juveniles and 94.83% for adults. Among insects, caddisflies (IRI = 34.76%) are the most commonly consumed by juveniles. In contrast, among adults, Lepidoptera (IRI = 19.42%) are the most commonly consumed. However, the diet of adults does not differ statistically from that of juveniles (Mann-Whitney test, n1= 12; n2= 14; U= 86, Z= −0.55, p= 0.58).

Table 4. Diet composition by juveniles and adults

Prey items consumed	Juveniles (n= 18)				Adults (n= 62)			
	F	N	P	IRI	F	N	P	IRI
Insects								
Coleoptera	10.71	10.42	5.89	10.24	11.34	12.57	6.88	12.66
Hemiptera	7.14	4.17	2.11	2.62	8.25	7.85	3.66	5.45
Trichoptera	10.71	18.75	36.63	34.76	4.12	3.66	7.43	2.63
Heteroptera	7.14	6.25	5.89	5.08	10.31	10.47	10.54	12.43
Lepidoptera	10.71	8.33	7.16	9.72	14.43	12.57	10.87	19.42
Isoptera	7.14	8.33	10.95	8.07	9.28	12.04	16.98	15.45
Diptera	7.14	12.50	1.47	5.85	5.15	6.81	0.41	2.14
Orthoptera	7.14	14.58	12.63	11.39	5.15	5.76	2.89	2.56
Dermaptera	3.57	2.08	2.95	1.05	8.25	9.95	14.09	11.38
Odonata	7.14	4.17	3.79	3.33	10.31	8.90	9.21	10.72
∑ Insects	78.57	89.58	89.47	92.11	86.60	90.58	82.97	94.83
Arachnids	0.00	0.00	0.00	0.00	3.09	2.09	8.99	1.97
Annelids	7.14	8.33	8.42	7.01	5.15	2.62	2.77	1.60
Molluscs	10.71	0.00	0.00	0.00	3.09	2.62	4.55	1.27
Macrophytes	3.57	2.08	2.11	0.88	2.06	2.09	0.72	0.33
Total	100	100	100	100	100	100	100	100

n= total number of stomachs; F (%)= frequency of occurrence; N (%)= numerical percentage; P (%)= weight percentage; IRI (%) = relative importance index.

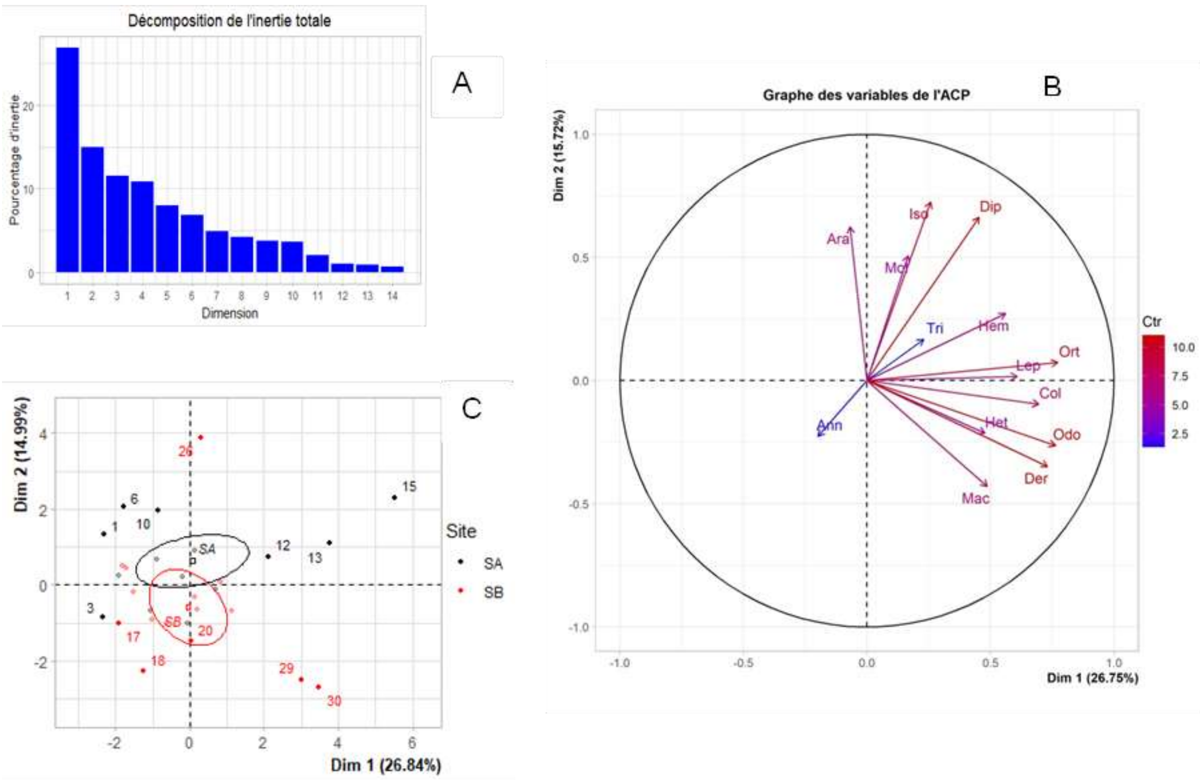

Fig. 1. Principal component analysis (PCA) of the spatial distribution of prey consumed

Ara = Arachnids, Ann = Annelids; Mol = Molluscs; Mac = Macrophytes; Col= Coleoptera; Hem = Hemiptera; Tri= Trichoptera; Het = Heteroptera; Lep = Lepidoptera; Iso = Isoptera, Dip= Diptera; Ort = Orthoptera; Der = Dermaptera; Odo = Odonata

Spatial distribution of diet

Principal component analysis (PCA) performed on the food categories consumed by *Afrixalus dorsalis* shows that axes 1 and 2 account for 26.75% and 15.22%, respectively, or 41.97% of the total inertia. The first axis is positively correlated with Orthoptera, Coleoptera, Lepidoptera, Odonata, Heteroptera, Dermaptera, and macrophytes, and negatively correlated with Annelida and Arachnida. Meanwhile, axis 2 is positively correlated with Isoptera, Mollusca, and Diptera, and negatively correlated with macrophytes, Annelida, Dermaptera, Odonata, and Heteroptera. The projection of individuals by site shows an overlap between the groups from sites S-A and S-B, suggesting a similarity in their natural diet. However, a slight differentiation is observable: individuals from site S-A are correlated with positive values on Axis 2, whereas several individuals from site S-B are projected onto its negative portion.

DISCUSSION

The diet of *Afrixalus dorsalis*, as determined at the Etuessika sites, is largely dominated by insects and characterized by a notably high diversity of prey categories. The estimated stomach-emptiness index of 7.5% reflects significant feeding activity during the sampling period, which could be explained by the availability of food resources in the studied ecosystems. These observations corroborate those of Toft (1985) and Wells (2007), who report that feeding activity in anuran amphibians depends on food availability and environmental conditions.

Overall, *Afrixalus dorsalis* has an exclusively insectivorous diet (IRI = 95.08%). Analysis of the relative importance indices (IRI > 90%) across the categories studied (males: 95.15%; females: 93.21%; Site A: 91.42%; Site B: 97.04%; juveniles: 92.11%; adults: 94.83%) confirms the insectivorous nature of this species. The importance of insects, despite the qualitative differences observed in the items consumed, is consistent with the behavior of so-called generalist insectivorous species observed among West African hyperoliids, whose diet reflects prey availability rather than strict selection (Godwin, 2023).

Regarding diet by sex, despite a significant overlap between males and females, it is noteworthy that in the diet of male individuals, the most commonly consumed insects are Lepidoptera (27.48%), Heteroptera (17.66%), and Isoptera (15.03%), whereas the insects consumed by females show a different hierarchy, with Odonata (22.98%), Dermaptera (19.56%), and Lepidoptera (9.06%). This distribution is similar to the intersexual diets examined in Amolops shihaitaoi, where sex differences were attributed to variations in energy expenditure and behavior rather than to marked differences in prey size (Siliyavong *et al.*, 2023). Furthermore, the high proportion of Odonata (IRI = 22.98%) among females could be explained by sexual size dimorphism, which facilitates the capture of larger, more mobile prey. This mechanism would promote intersexual trophic overlap, as observed in Odorrana schmackeri (Wu *et al.*, 2022).

About diet by habitat, although insects dominate both sites, an even more pronounced variation in the hierarchy of consumed foods (insects) is observed. Isoptera, with an estimated relative importance index of 20.72%, dominate in Habitat A. In contrast, Lepidoptera, Dermaptera, and Odonata predominate in Habitat B, where Isoptera drop to 5.00%. This reversal in the hierarchy of prey consumed between the two habitats suggests a strong effect of microhabitat on diet composition. This type of influence has already been observed in Pristimantis species in the Amazon (Kaefer *et al.*, 2024) and in Proceratophrys ararype, whose diet depends on the presence of arthropods (Mascarenhas *et al.,* 2023).

Regarding the insects consumed by juveniles and adults, Caddisflies dominate the juveniles' diet (IRI = 34.76%), while adults have a more diverse diet (Lepidoptera, Isoptera, Coleoptera, etc.). This finding is likely related to the ontogenetic change observed in gape-limited anurans, where the size of prey items increases with the size of the predator (García-Padrón, 2022; Luría-Manzano and Ramírez-Bautista, 2019). The small size of juveniles' mouths may explain their specialization in small prey such as Caddisflies, whereas adults broaden their diet to include larger, more mobile prey such as Dragonflies and Beetles. These same observations were made by Konate *et al.* (2022) in *Amnirana albolabris* in Banco National Park.

CONCLUSION

The results of the dietary study of *Afrixalus dorsalis* on the outskirts of the Ehotilé Islands confirmed that this species is both predatory and opportunistic, with a diet centered on insects. This diet varies depending on biological and ecological factors. When foraging, juveniles specialize in small prey due to morphological constraints. In contrast, adults, in addition to small prey, exploit a more varied trophic spectrum. The sampling area influences diet composition, reflecting prey availability and habitat structure, while dietary differences by sex show a more subtle trophic segregation. These results highlight the importance of considering age, sex, and microhabitat when studying the trophic ecology of anuran amphibians.

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