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Current state of the art in anuran dietary studies in Brazil

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Abstract

Amphibians are key players in ecosystem dynamics, and their diets offer critical insights into trophic interactions, community structure, and ecological functioning. However, there is a lack of understanding the role of anurans in the trophic ecosystem dynamics. Here, we gathered available information from the literature to outline current knowledge of the diet of Brazilian post-metamorphic anurans. We retrieved 221 studies spanning from 1971 to June 2025, resulting in dietary data for 233 species, around 19% of Brazilian frog species. Most studies focused on the family Hylidae (84 spp.; 36.1%), followed by Leptodactylidae (55 spp.; 26.6%), Bufonidae (23 spp.; 9.9%), and Microhylidae (15 spp.; 6.4%). Only 12 (1.05%) species classified as threatened to some degree had their diet described. Among Brazilian ecoregions, the Atlantic Forest had the highest number of dietary studies published (110; 49.8%), followed by Amazon (47; 21.3%), Cerrado (32; 14.5%), Caatinga (23; 10.4%), Pampa (10; 4.5%) and Pantanal (8; 3.6%). Despite the increase in diet studies in recent decades, more than 80% of Brazilian anuran species lack dietary data, a trend potentially stemming from the current undervaluation of natural history studies. This scenario is concerning, since anurans are the most threatened vertebrates globally, and information about the natural history of species is fundamental in all phases of research (e.g. development of hypotheses, interpretation, and discussion of data). Our findings underscore a significant information gap in the trophic ecology of Brazilian anurans.

Keywords Ecoregion, Feeding ecology, Food resources, Natural history, Trophic ecology

1 Introduction

Understanding the natural history of species such as diet, behavior, and geographic distribution is essential for experimental design, and for the development and testing of ecological hypotheses [1]. Among them, diet is a core component that provides fundamental information about community dynamics, ecological interactions and ecosystem functioning [2–5]. Dietary analysis can reveal foraging strategies [6, 7] and gain insights into the trophic organization of ecosystems by examining species interactions, including predator-prey dynamics and intra- and interspecific competition [8–10]. Moreover,

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combining diet studies with potential prey data from the studied environments can unveil specialized feeding habits and food preferences [3, 6, 7, 11]. When available for sympatric species within the same temporal window, this information enables the inference of trophic niche overlap and resource partitioning strategies [2, 12].

Despite the paramount importance of interactions between species, the Eltonian shortfall persists as a prominent knowledge gap in biodiversity research, particularly in tropical regions [13], which boast unparalleled biodiversity. Brazil, for instance, harbors the world's richest anuran fauna, representing 14.9% of Anura global [14], the lack of comprehensive literature reviews on anuran diets is noticeable. This gap of knowledge presents a paradoxical scenario where a region abounding with biodiversity have few crucial information on species interactions. Hence, elucidating the extent of our knowledge regarding anuran diets is imperative for addressing this deficiency and gaining a deeper understanding of tropical ecosystem dynamics.

Currently, Brazil harbors 1,144 species of anuran amphibians, about 77% of which are endemic to their respective ecoregions (i.e. Amazon, Atlantic Forest, Caatinga, Cerrado, Pampa, and Pantanal) [15, 16]. Furthermore, anuran amphibians are the most endangered group of vertebrates worldwide [17, 18], and specifically in Brazil, they face a great increase in the percentage of threatened species from 3% (35 spp.) in 2004 to 16% (184 spp.) in 2022 [17]. However, for species classified as data-deficient or not assessed, the percentage dropped significantly from 48.7% (557 spp.) to 6.7% (77 spp.) [17]. Despite it, a substantial information gap persists regarding the natural history of these amphibians, resulting in a lack of information for decision-making on the conservation of these species. In 2006, McCallum and McCallum [19] suggested a lack of documentation in natural history in general in Brazilian amphibians. More than a decade later, we see that this gap remains, as documented in the review by Guerra et al. [18], which shows, for example, that almost half of the Brazilian species lack documented vocalizations. Considering that the reproductive behavior of amphibians is one of the most documented across literature [16, 20–22], other areas of their natural history might have even larger gaps.

Beyond taxonomic coverage, it is also essential to consider geographic representativeness in natural history studies. Ecological traits such as diet are strongly influenced by local resource availability, which can vary widely across geographic and environmental gradients [9, 10]. Another important factor to take into consideration is the scientific journals where these studies are published. The identification of journals publishing dietary studies serves as a proxy for evaluating how widely such knowledge is being disseminated across scientific audiences. Thus, identifying spatial gaps in dietary research is key to understanding how anurans interact with their environments across Brazil's heterogeneous landscapes.

Given the importance of understanding anuran diets and the lack of studies on this topic in Brazil, this work aimed to gather and synthesize the information available in literature on the diet of Brazilian anuran amphibians. More specifically, this study aimed to: (i) review the history of dietary research on Brazilian post-metamorphic anurans; (ii) catalog studied species; (iii) analyze publishing journals; (iv) evaluate dietary data for threatened species, and (v) identify the ecoregions with the largest number of studies. Thus, our goal was to pinpoint critical knowledge gaps in this field.

2 Methodology

To ensure a systematic and comprehensive review of the literature on the diet of Brazilian anurans, we followed the PRISMA framework for Systematic Reviews and Meta-Analyses [23]. We searched for studies on the diet of anurans in Brazil in four databases: the Web of Science database (www.webofscience.com), Scientific Electronic Library online (Scielo; www.scielo.org), Google Scholar (www.scholar.google.com) and Scopus (www.scopus.com). For the bibliographic review, we used the following keywords: "Anura" and "diet" or "trophic ecology" or "feeding ecology" or "food habits" or "autoecology" or "trophic overlap" or "trophic composition" and "Brazil". We also used the same set of words in Portuguese: "Anura" and "diet*" or "ecologia trófica" or "ecologia alimentar" or "hábito alimentar" or "autoecologia" or "sobreposição trófica" or "composição trófica" and "Brasil". The identified studies were evaluated based on predefined inclusion and exclusion criteria, ensuring the selection of relevant and methodologically sound articles. Studies with taxa identified only at the genus level or those lacking clear species identification (e.g. aff., cf., and gr.) were excluded from consideration, as well as studies on tadpole diet and gray literature (i.e. abstracts presented at conferences, theses, dissertations and other works not published in scientific journals). Furthermore, notes of a single predation or observation of predation were not considered, because they are fortuitous records. The screening process included the removal of duplicates, title and abstract screening, and full-text assessment of the selected articles [23]. This approach allowed us to rigorously and transparently synthesize the available knowledge on the diet of post-metamorphic anurans in Brazil, identifying gaps and trends in the literature. We considered only studies published until June 30th, 2025 and included anuran species occurring within the territory of the Brazilian federation, based on the list of amphibians in Brazil [15], which compiled 1,144 valid species. Additionally, as this list was outdated at the time of our search, we incorporated taxonomic updates from Frost [14], including newly described species for Brazil and recent taxonomic rearrangements, which increased the number of Brazilian species to 1,232 spp. To ascertain the ecoregion distribution of each species, we referenced the ICMBio database [24] and studies on the distribution of species.

From each study, the following variables were extracted: (i) taxonomic classification (species, genus, family), (ii) method used to obtain the diet (dissection, stomach flush, field observation), (iii) assessment of prey availability, (iv) origin of sampled individuals (whether they were collected in the field or were from museum specimens) and, (v) source scientific journal and its 2022 Clarivate impact factor. In addition, for each species, we obtained (vi) the ecoregion of occurrence [24], (vii) IUCN Red List conservation status [17], and (viii) national conservation status (Ordinance No. 300 of the Ministry of the Environment, dated December 13, 2022). The species names and the year of description were recorded according to Frost [14]. The classification of species distribution by Brazilian ecoregion was carried out by consulting the specialized bibliography and Frost [14].

3 Results

We retrieved 221 scientific studies describing the diet of anurans species in Brazil, published between 1971 and June 30th 2025 (Fig. 1). The first diet study was published by the journal *Ciência e Cultura*, describing the diet of *Thoropa miliaris* (Spix, 1824) [25].

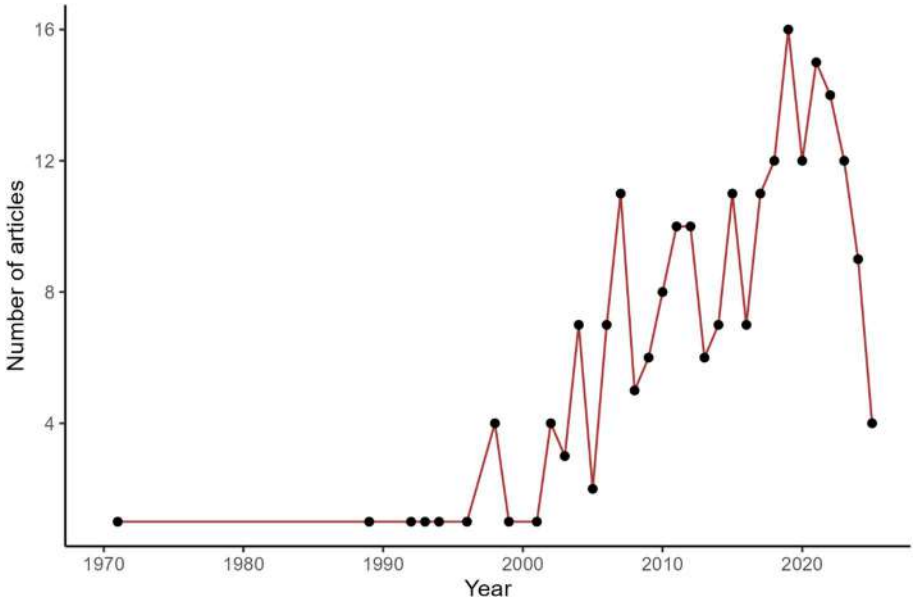

Fig. 1 Evolution in the descriptions of the diet of Brazilian anurans between 1971 and 2025

Notably, only nine additional studies on anuran diets were identified throughout the entire 20th century. However, with the dawn of the 21 st century, we observed a growth in the number of studies (Fig. 1). We observed an increase in the anuran diet publication of articles between 2019 and 2023 (69 studies published; 31.2%).

3.1 Species with described diet

We documented dietary information for a total of 233 species of anurans, representing approximately 19% of Brazilian species. The family with the highest number of species with a described diet was Hylidae (84, 36.1%), followed by Leptodactylidae (55; 26.6%), Bufonidae (23; 9.9%), and Microhylidae (15; 6.4%). For the families Alsodidae and Centrolenidae, no studies on the diet of their species were found (Fig. 2).

The species with the highest number of diet studies were *Leptodactylus fuscus* ($N = 14$) and *Physalaemus cuvieri* ($N = 14$), followed by *Boana raniceps* ($N = 12$), *L. macrosternum* ($N = 11$), *Dendropsophus minutus* ($N = 9$), *L. luctator* ($N = 7$), *L. podicipinus* ($N = 7$), *Rhinella diptycha* ($N = 7$), *Adenomera hylaedactyla* ($N = 6$), *P. cicada* ($N = 6$), *A. andreae* ($N = 5$), *Allobates femoralis* ($N = 5$), *B. albopunctata* ($N = 5$), *L. pentadactylus* ($N = 5$), *L. troglodytes* ($N = 5$), *R. granulosa* ($N = 5$), *Scinax fuscomarginatus* ($N = 5$), *S. x-signatus* ($N = 5$), *P. albifrons* ($N = 5$), and *Pleurodema diplolister* ($N = 5$).

Among the 233 species with documented diets, 133 (57.1%) species are represented by a single dietary description, 43 (18.4%) have two dietary studies and 57 (24.5%) have more than two studies. Among the 221 retrieved studies, 180 used the dissection method to examine amphibian diets (81.4%), 40 (18.1%) used stomach flushing, and two (1%) used the observation method. Nine (4.1%) studies used specimens deposited in scientific collections, 176 (79.6%) killed individuals to assess the diet, 35 (15.8%) captured and released individuals after stomach flushing and only 34 (15.4%) studies provided data on the availability of prey in the environment.

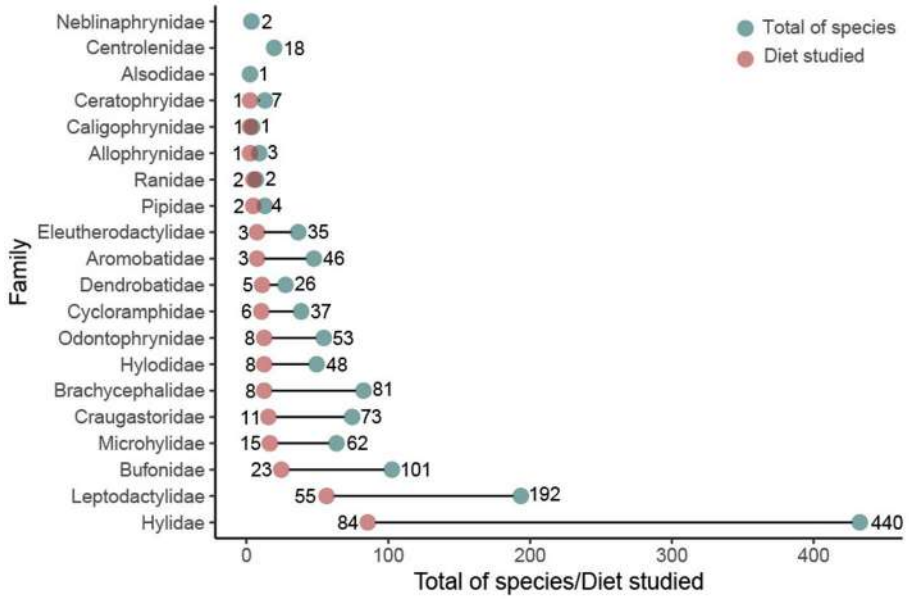

Fig. 2 Total number of species with described diet from each of the Brazilian anuran families

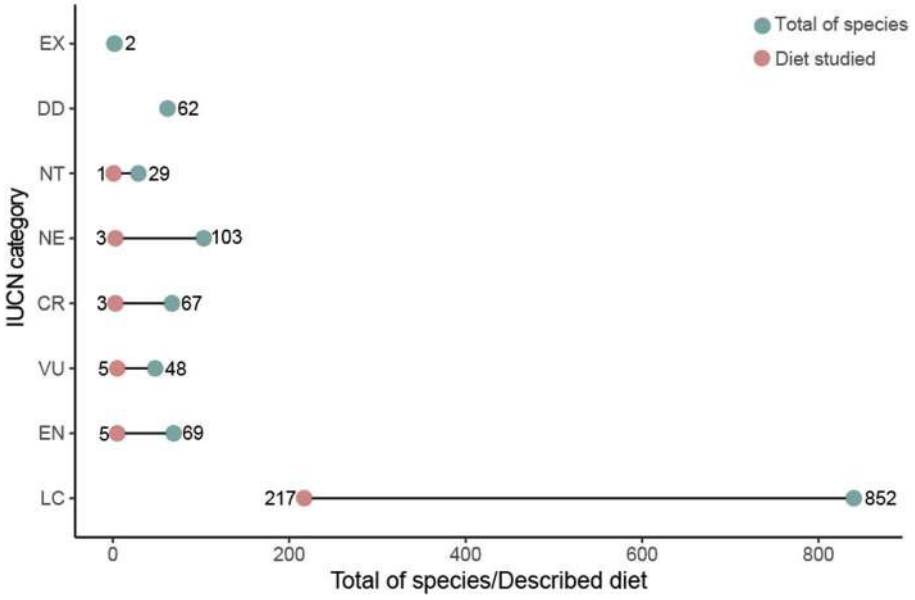

Fig. 3 Number of Brazilian anuran species in each of the categories of threat of the IUCN red list. Where: LC = Least Concern, NE = Not Evaluated, DD = Data Deficient, NT = Near Threatened, VU = Vulnerable, EN = Endangered, CR = Critically Endangered

3.2 Threatened species

We recorded dietary information for 12 globally threatened species, encompassing two Critically Endangered (CR) species [*Adelophryne maranguapensis* and *Proceratophrys ararype*], five Endangered (EN) [*Brachycephalus garbeanus*, *Crossodactylus timbuhy*, *Cycloramphus brasiliensis*, *Hylodes nasus*, and *H. perere*], and five Vulnerable (VU) [*Brachycephalus brunneus*, *Chiasmocleis alagoana*, *Phyllodytes tuberculosus*, *Pseudopaludicola restinga*, and *Xenohyla truncata*] (Fig. 3). Regarding threatened species at national level, there is information on the diet only for *A. maranguapensis*, *C. alagoana*,

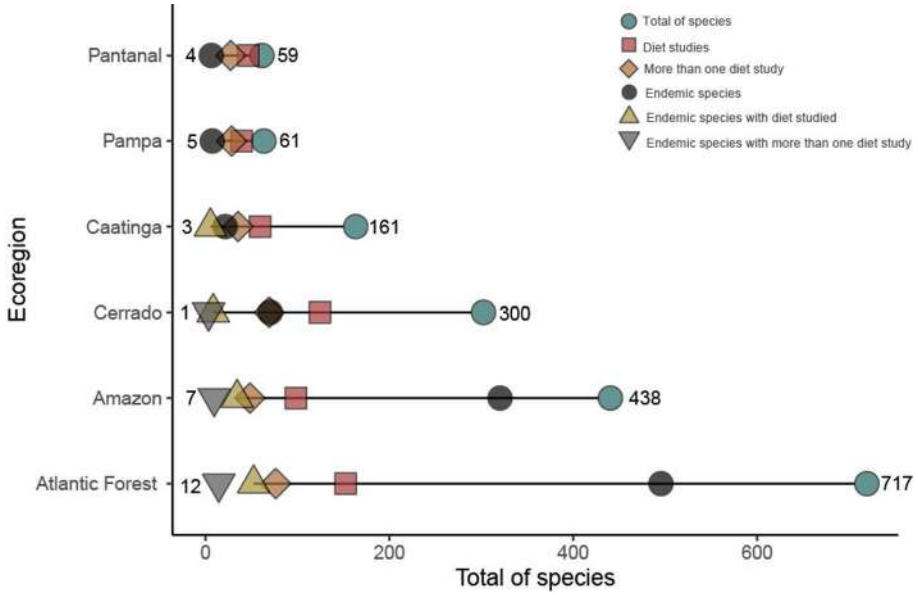

Fig. 4 Number of anuran species (overall and endemic) in each Brazilian ecoregion with one or more published diet descriptions

P. ararype, and *X. truncata* (Fig. 3). Except for *P. tuberculosus* (stomach-flushing method) and one population of *X. truncata* (observation method), all other threatened species were collected, killed, and dissected to obtain food contents.

None of the 62 species classified as Data Deficient (DD) at the international level have a described diet, and only one of the 29 species classified as Near Threatened (NT) has information about its diet (*Crossodactylus trachystomus*) (Fig. 3). Among the 103 Non-Evaluated (NE) species, only three species have available information on their diet (*Dendropsophus tapacurensis*, *Odontophrynus asper*, and *Pristimantis crepitaculus*), and, regarding the 852 non-threatened species, classified as Least Concern (LC), 217 (25.5%) have a described diet (Fig. 3). At the national level, of the 85 species classified as DD, there is information on the diet only for *Phyllodytes tuberculosus*, while there is no information on the diet of any of the 27 species classified as NT (Fig. 3).

3.3 Diet analysis by ecoregion

The ecoregion with the highest number of dietary studies was the Atlantic Forest (110 publications; 49.8%), followed by the Amazon (47; 21.3%), Cerrado (32; 14.5%), Caatinga (23; 10.4%), Pampa (10; 4.5%) and Pantanal (8; 3.6%) (Fig. 4). We registered 91 endemic species considering all six Brazilian ecoregions with the described diet (10.1%) of a total of 907 endemic species (Table S1, Fig. 4). Of these species, 50 species are endemic to the Atlantic Forest (54.9%), 32 to the Amazon (35.2%), six to the Cerrado (6.6%), and three to the Caatinga (3.3%) (Table S1, Fig. 4).

3.4 Scientific journals

We identified 56 scientific journals that have published studies describing the diet of Brazilian post-metamorphic anurans. Of these, 19 (33.9%) do not have an Impact Factor (IF). Among the remaining journals, the average IF was 1.4 (± 1.1). *Iheringia (Zoology)* and *Phyllomedusa – Journal of Herpetology* had the lowest IF (0.4), while *Ecology* and *Journal of Animal Ecology* had the highest (4.8).

More specifically, 32.2% ($N = 75$) of the 233 studies were published in journals without IF. Furthermore, the journal with the highest number of dietary studies published was *Herpetology Notes* ($N = 26$; 11.2%), which also does not have IF. In contrast, the second journal with the highest number of publications was *North-Western Journal of Zoology* ($N = 21$; 9%), which has an IF of 0.7. Regarding the other journals with the highest number of published studies, the *Brazilian Journal of Biology* ($N = 16$; 6.9%) also does not have an IF value, while the *Journal of Herpetology* (13; 5.6%), *South American Journal of Herpetology* (13; 5.6%) and *Phyllomedusa – Journal of Herpetology* (10; 4.3%) have an IF value below one. The journals with the highest IF values that published studies on the diet of anurans were *Ecology* (IF = 4.8; $N = 1$ study), *Journal of Animal Ecology* (IF = 4.8; $N = 1$), *OIKOS* (IF = 3.4; $N = 1$), *Oecologia* (IF = 2.7; $N = 2$), *Copeia* (IF = 2.6; $N = 3$), *Hydrobiologia* (IF = 2.6; $N = 1$), *Herpetologica* (IF = 2.4; $N = 1$) and *Journal of Zoology* (IF = 2; $N = 1$), representing only 3.6% of published studies.

4 Discussion

Our review reveals striking gaps and biases in the current knowledge of the trophic ecology of Brazilian anurans. Diet data are still unavailable for the vast majority of species (> 80%), including species with wide geographic distributions and several that are threatened. This scarcity of basic ecological information as the feeding behavior, impose limits to our ability to understand species' functional roles in ecosystems, hinders the identification of key prey interactions, and constrains conservation planning. On the other hand, our findings underscore a broader pattern: while generalist species with large distributions are relatively well-studied, rare and range-restricted taxa—particularly those in under-sampled ecoregions such as the Caatinga, Pantanal, and Pampa—remain critically understudied. The recent increase in dietary studies is likely associated with the scientific funding crisis that affected Brazil in the late 2010 s, rather than with increased academic incentives [26, 27]. Given their relatively low cost and logistical simplicity, dietary studies may have become a more accessible research alternative during periods of financial constraint. These knowledge gaps raise concerns not only for ecological research but also for evidence-based conservation strategies, especially as environmental changes accelerate across Brazil's diverse ecoregions.

4.1 Dietary research on Brazilian post-metamorphic anurans

Among the 1,232 known Brazilian anuran species, we identified 20 that have been more extensively studied, each with five or more published articles focusing on their trophic ecology: *Adenomera andreae* [28–32], *A. hylaedactyla* [28, 33–37], *Allobates femoralis* [28, 29, 32, 35, 38], *Boana albopunctata* [9, 32, 39–41], *B. raniceps* [9, 33, 34, 37, 42–48], *Dendropsophus minutus* [9, 29, 33, 34, 49–53], *Leptodactylus fuscus* [9, 30, 34, 37, 39, 43, 44, 54–60], *L. luctator* [9, 57, 61–65], *L. macrosternum* [9, 33, 34, 37, 43, 44, 59, 66–69], *L. pentadactylus* [30, 37, 70–72], *L. podicipinus* [9, 32, 37, 66, 73–75], *L. troglodytes* [33, 34, 43, 44, 76], *Physalaemus albifrons* [34, 43, 44, 77, 78], *P. cicada* [34, 43, 44, 77–79], *P. cuvieri* [9, 33, 34, 50, 56, 57, 74, 78, 80–85], *Rhinella diptycha* [9, 34, 43, 44, 56, 80, 86], *R. granulosa* [32, 34, 43, 44, 79], *Scinax fuscomarginatus* [9, 32, 34, 87, 88], and *S. x-signatus* [33, 34, 37, 43, 44]. These species are all classified as Least Concern (LC) and have broad geographic distributions. For example, *D. minutus* and *L. fuscus* are found

in all six Brazilian ecoregions [14, 17]. The wide distribution and high abundance likely explains the higher number of studies on these species.

Most of these species are generalists, with opportunistic feeding behavior [33, 34, 43–45, 56, 74]. However, this is not a rule, as *A. hylaedactyla*, *P. albifrons*, and *P. cuvieri* consume more ants than other insects— although studies on prey availability for these species were not evaluated—while *B. raniceps* has a preference for Coleoptera, and *P. cicada* is a termite specialist [79, 88]. Diet preference is a point in the natural history of species that must be known and understood in order to preserve the species. Another point of the diet that must be evaluated is ontogenetic differentiation. In fact, ontogenetic effects were noted, particularly in *D. minutus* and *L. podicipinus*, where juveniles consume smaller prey compared to adults [29, 73, 74]. The assessment of ontogenetic differences and food preferences is important when making conservation decisions, such as when evaluating endangered species.

Additionally, nearly 50% of studies on these species also analyzed community-level dietary patterns, examining niche differentiation, food resource partitioning, and intraspecific dietary variation [29, 33, 34, 43, 44, 81]. These studies typically demand substantial time and resources but provide insights into evolutionary, ecological, and historical influences on dietary patterns [e.g., 9, 10]. Such integrative approaches not only advance our understanding of trophic ecology but also tend to result in publications in higher-impact ecological journals, underscoring the scientific value of community-level dietary analyses.

Most anuran species with available dietary studies are considered generalists with opportunistic feeding behavior; however, a few exceptions have been documented. Three species exhibit specialist diets: *Amazophrynella minuta* appears to specialize in mites (Acari) [89], *Rhinella granulosa* in termites (Isoptera) [79], and *Phyllodytes edelmoi* in ants (Formicidae) [90]. In addition, several other species demonstrate clear dietary preferences. For instance, *Aplastodiscus albosignatus* and *Boana semiguttata* preferentially consume Coleoptera [91], *B. raniceps* favors Coleoptera and Hemiptera [47], *Leptodactylus notoaktites* feeds mainly on Hemiptera and Pseudoscorpionida [91], *Pseudis minuta* on Hemiptera, Coleoptera, Orthoptera, and Araneae [92], *Scinax acuminatus* on Hemiptera [47], *Physalaemus ephippifer* on Formicidae [60], *Proceratophrys boiei* on Orthoptera [91], and *Trachycephalus typhonius* on Araneae, Coleoptera and Hemiptera [47]. Moreover, *Physalaemus carrizorum* tends to consume primarily Formicidae [93], while *Scythrophrys sawayae* and *Brachycephalus brunneus* show a marked preference for Acari [91, 94]. Additionally, *Allobates marchesianus* and *Anomaloglossus stepheni* appear to have a preference for ants and Collembola [95]. These findings highlight that, although generalist feeding is predominant among Brazilian anurans, dietary specialization and preferences do occur and may reflect ecological adaptations, habitat use, or evolutionary history—underscoring the importance of expanding dietary studies to a broader range of species and ecological contexts.

4.2 Threatened species

Despite the large number of threatened species, both internationally (184 spp.; 14.9%) [17] and nationally (56 spp.; 4.5%; Ordinance No. 300, of December 13, 2022), only 15 (6.8%) studies describe the diet of 12 globally threatened species. Seven of the 12 threatened species with known diets were generalists, typical of amphibians, exhibiting

opportunistic feeding behaviors [78, 96–101]. In contrast, *B. brunneus* [94] and *B. garbeanus* [102] had a more specialized diet, primarily feeding on mites, suggesting active foraging behavior. Regarding foraging strategies, *A. maranguapensis* was identified as an active forager [80], while *C. timbuhy* exhibited both active and "sit-and-wait" foraging behaviors, feeding on both mobile insects (e.g. ants, flies) and stationary prey (e.g. insect larvae) [96]. *Crossodactylus brasiliensis* consumes both terrestrial and aquatic prey, feeding in and out of the water [99]. An exception to the general trend of invertebrate-based diets is *X. truncata*, which feeds actively on fruits, nectar, and plant parts [103–105]. Recently, *X. truncata* was observed feeding on nectar from *Iris x germanica* and *Cordia taguahyensis* flowers, with plant pollen adhering to its body, suggesting its role as a potential pollinator [105].

Regarding threat assessment, it is noteworthy that no dietary data are available for the 62 species (5.1%) currently classified as Data Deficient (DD) [17]. This is particularly concerning given that, with the exception of *Physalaemus claptoni*, all other DD species listed by the IUCN are endemic to Brazilian ecoregions—40 species (64%) are endemic to the Atlantic Forest, 16 (26%) to the Amazon, and five (8%) to the Cerrado [17; Ordinance No. 300, December 13, 2022]. Among them, the lack of dietary information for *Cycloramphus asper* is especially notable. In addition to being endemic to the Atlantic Forest, this species is listed as Near Threatened (NT) at the national level (Ordinance No. 300, December 13, 2022). These gaps underscore the urgent need for more research not only on the trophic ecology of these species, but also on their broader natural history, to better assess their actual conservation status.

This research highlights a significant knowledge gap regarding the feeding ecology of Brazil's most threatened anuran species. The scarcity of studies in this area is likely due to the fact that many of these species have small, isolated populations and are often endemic [17], as is the case with DD species. We emphasize that dietary studies on threatened species are essential for understanding ecological interactions, identifying factors that influence survival and reproductive success, and evaluating species' resilience to environmental changes [2–5]. Therefore, new approaches and increased sampling efforts are urgently needed to obtain reliable dietary data for the remaining threatened species. Furthermore, we propose that trophic information can serve as an early indicator of ecosystem changes or anthropogenic impacts, thereby informing habitat management strategies [106]. Integrating dietary analyses into conservation research is crucial for the development of effective management plans aimed at safeguarding threatened amphibian species.

4.3 Ecoregions and endemic species

Brazil harbors a high number of anuran species endemic to one of its six major ecoregions (i.e., Amazon, Atlantic Forest, Caatinga, Cerrado, Pampa, and Pantanal), totaling 907 species, and representing 73.6% of the country's anuran fauna [24]. Despite this, only 91 of these species (10.1%) have dietary information available in the literature, highlighting a significant research gap and suggesting that endemic species remain disproportionately understudied compared to their non-endemic counterparts.

The Atlantic Forest (493 spp.; 54.3%) and the Amazon (318 spp.; 35.1%) are the ecoregions with the highest number of endemics. However, only 50 and 32 of them, respectively, have available dietary data. A similar pattern is observed in the Cerrado, which

hosts 68 endemic species (7.5%), yet only six have documented dietary information. In contrast, the Caatinga (19 spp.), Pampa (five spp.), and Pantanal (one spp.) are the ecoregions with the lowest numbers of endemic anurans, together accounting for approximately 3% of Brazil's endemic species. Among these, only three species endemic to the Caatinga have their diet described [96, 97].

This pronounced disparity between the number of endemic anuran species and the availability of dietary information reveals a critical gap in our understanding of Brazil's amphibian trophic ecology [107]. Endemic species, by definition, have restricted geographic distributions and are often more vulnerable to habitat loss, climate change, and other anthropogenic pressures [108, 109]. The lack of basic ecological data—such as dietary composition—not only hampers conservation planning but also limits our ability to understand functional roles and ecological interactions within their native ecosystems [107, 110, 111]. Addressing this knowledge gap is essential for developing effective conservation strategies and for advancing ecological theory in biodiverse and threatened ecoregions [110, 111].

4.4 Scientific journals

Among the 56 scientific journals publishing studies on the trophic ecology of Brazilian anurans, about 1/3 of the articles (33.9%) were published in journals without an impact factor. Meanwhile, most articles on the diet of Brazilian amphibians (44.8%) were published in scientific journals with an impact factor of less than one. This suggests that studies on trophic ecology tend to be published in journals with lower impact factors, which is concerning, as studies on the natural history of species may lack scientific prestige [112], with high-impact journals often avoiding publishing these studies [19]. This pattern is worrying because trophic ecology is vital for understanding habitat use and dietary preferences, which are key for experimental design and testing ecological hypotheses [1–5].

In contrast, only 11 studies (5%) were published in journals with an Impact Factor (IF) greater than two. Among them, two studies were published in *Ecology* and the *Journal of Animal Ecology* (IF = 4.8), addressing niche variation in dietary patterns [81] and spatiotemporal variation in predator-prey interactions [10]. Other studies in higher-impact journals typically combine trophic ecology with additional ecological factors and more robust analyses [29, 30, 33, 34, 113–115], or focus on endangered species, such as *Xenohyla truncata* [105]. Therefore, while studies solely describing species' diets are important, including other approaches and detailed statistical analyses increases the likelihood of publication in high-impact journals.

4.5 Methods in diet studies of Brazilian Anuran amphibians

Different methods can be used to assess the anurans diet. In the present study, we detected the use of stomach and intestine dissection, stomach flush, observation method and isotope analysis. The most of studies on the diet of Brazilian anuran amphibians (180 publications; 81.4%) used stomach and intestine dissection. Only nine studies (4.1%) analyzed museum specimens, thereby avoiding the need to collect and kill new animals.

In recent decades, there has been a notable increase in the use of stomach flushing—a non-lethal technique proposed by Solé et al. [116], which force individuals to regurgitate stomach contents without harm. Despite its ethical and conservation advantages,

the use of this method remains limited, appearing in only 40 publications (18.1%), with just one study applying it to a threatened species, *Phyllodytes tuberculosus* [117]. Given the growing number of threatened and data-deficient species, we strongly encourage the broader adoption of stomach flushing, particularly when working with populations that are small, declining, or difficult to access. Its implementation can significantly reduce the impact of fieldwork on vulnerable species and promote more sustainable research practices.

Additionally, two studies used the observation method to describe the trophic ecology of *Phantasmarana apuana* [118] and *Xenohyla truncata* [105], a method that, while logistically challenging, provides valuable data without harming individuals.

Some studies have also employed stable isotope analysis to understand anuran diets [64, 81, 93, 113, 114], offering insights into nutritional sources and dietary variation. Stable isotopes help identify whether a species' diet consists of terrestrial or aquatic prey [113, 114], whether isotopic niche breadth varies by season [96], and determine the origin of forest species [93]. While this technique is invaluable for understanding species' diets and their environmental adaptations, the costs of such analyses can be prohibitive for mid-income countries with limited science funding. Nonetheless, stable isotope analysis remains crucial for unraveling the complexities of trophic ecology and aiding in biodiversity conservation.

Furthermore, information on prey availability is crucial for detecting dietary selection [3, 6, 7, 11], and can show preferences and help us understand the requirements for species conservation. In this sense, only 34 studies (15.4%) included data on prey availability in the environment. Over half of these studies were published in the last decade [64, 75, 76, 91, 93, 119–122], indicating a growing trend. Assessing prey availability for arboreal species remains challenging, as most tree frogs forage in the canopy during non-reproductive periods, complicating prey assessments outside of their breeding sites (ponds, streams).

More recently, DNA-based techniques have been increasingly applied in trophic ecology studies [123]. Methods such as multiplex PCR and next-generation sequencing (NGS) have become powerful tools, enabling the identification of prey items with high sensitivity and taxonomic resolution, even when morphological identification is hindered by digestion. Despite their advantages —including the ability to analyze complex diets from minimal or highly degraded samples— these techniques are still rarely employed in Brazilian herpetology. This represents a promising opportunity to advance dietary research and improve our understanding of anuran trophic ecology in the region.

4.6 Information gaps and future directions

Despite the increasing number of studies on the trophic ecology of Brazilian anurans, significant gaps remain. Currently, we know the feeding ecology of fewer than 20% of species, with most species only studied in a single location, underscoring the need for further research in this area.

As new technologies and research tools, such as those in genetics and molecular biology, evolve, fewer researchers are pursuing studies on natural history [19, 112]. Research in natural history often involves labor-intensive, costly, and time-consuming fieldwork. Moreover, journals that publish natural history studies generally have a low scientific impact, which discourages researchers from investing in this type of research. This gap

is concerning as natural history knowledge contributes to all stages of scientific research, from hypothesis development to data interpretation and discussion [16, 19, 112]. While natural history studies do not typically require costly technologies, integrating such methods can improve publication chances [19]. For example, Huckembeck et al. [64, 113, 114], Araújo et al. [81], and De Oliveira et al. [93] used stable isotopes to infer the nutritional contributions of primary producers in studying anuran diets, leading to publications in high-impact journals compared to most diet-focused studies.

We particularly emphasize the need for more research in the Atlantic Forest, Amazon and Cerrado. Despite being the biomes with the most publications, the biodiversity in these regions still requires substantial efforts to evaluate species' diets. This information gap extends to the Caatinga, Pampa, and Pantanal, the least-studied biomes regarding amphibian trophic ecology. Notably, only three endemic species from the Caatinga, *Adelophryne maranguapensis*, *Adelophryne baturitensis*, and *Proceratophrys ararype*, have their diets studied.

While some species have been identified as conservation priorities, the current lack of knowledge about the trophic ecology of Brazilian anurans signals the need for more studies across practically all species. This review emphasizes the critical need for more research on the diets of anurans, as such data are essential for understanding predator-prey interactions, hypothesis testing, and assessing conservation status. We recommend fieldwork using non-lethal methods that include as many species as possible. Studies on specimens in scientific collections are also vital to address this information gap.

Supplementary Information

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Supplementary Material 1.

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Author contributions
C.F.M. collected the data. C.F.M. e K.C. wrote the main manuscript text. K.C. prepared figures. C.F.M., K.C., L.K.S., D.J.S., S.I., and A.M.T. reviewed the manuscript.

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