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Ex Situ Dietary Behavior of *Dendrobates Truncatus* (Cope 1861) (Anura: Dendrobatidae)

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Abstract

Objective: food preference in captivity was determined with a free choice of ants, fly larvae, and termites as a viable alternative for the suitable, easily-executed *ex situ* management of *Dendrobates truncatus*. **Methods/Statistical Analysis**: 6 dietary offerings were tested: larval fruit flies, 4 species of ants and 1 termite species, on a group of ten *D. truncatus* individuals held in captivity. The diet was calculated with an average animal weight of 1.75 g (1.3-2.0) and an offer of 12% body weight, which is equivalent to 2.1g/day in total. For the comparison between the diets, Friedman's ANOVA was applied; to compare the body weights, a t-test was used; and for size, ANOVA and Tukey test were used. **Findings**: The diet with significant acceptance was termites, with greater preference than the fly larvae and ants. There was trophic plasticity and the concept of extreme specialization of diet in captivity was confirmed. **Application:** the results suggest that this species can be maintained *ex situ* with low cost and a wide availability of food resources, which is an important alternative for conservation programs especially since this species is endemic to Colombia.

Keywords: *Dendrobates Truncatus*, Feeding, Captivity, Management, Trophic Plasticity

1. Introduction

In the Dendrobatidae family, there are five genera in Colombia of the nine known worldwide: *Colostethus*, *Dendrobates*, *Epipedobates*, *Minyobates* and *Phyllobates*[1]; this amphibian family is exclusive to South and Central America[2].

Dendrobates truncatus is the smallest species of the *Dendrobates* genus with a length between 20 and 30 mm[3,4] and a body weight ranging between 0.85 and 2.0 g. Males are somewhat smaller than females, but it is difficult to distinguish the sexes. The base color is black with yellow stripes on the back and fringes or stippling on the back that are white or cream colored; the abdominal area usually has white spots. This species is linked to soil with leaf litter and nearby bodies of water[3,5]. *D. truncatus* is endemic to Colombia, distributed in regions ranging from 0 to 1,200 meters above sea level[6,7] in humid tropical forest ecosystems, sub-Andean forests and lowland dry forests in the Magdalena Valley and Caribbean region[8,9]. Its distribution extends from Chaparral in the Department of Tolima to the Caribbean coast and the northern lowlands of the Central and Western Cordilleras, west of the Gulf of Urabá[6]. Regionally, it is located in dry forest areas of the Department of Sucre, such as Montes de María[10].

It feeds primarily on ants and other small insects, with venom and skin exudate acquired through the diet thanks to the large number of ingested ants[11]. These frogs are insectivorous, especially myrmecophages; their diet also includes termites, small flies, spiders, centipedes, mosquitoes and other small invertebrates[6]. It is postulated that toxins may be related to diet[12].

D. truncatus is considered a threatened species, found in Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora - CITES. It is in a low risk category, almost threatened, according to the global categories of the International Union for the Conservation of Nature - IUCN[13].

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The objective of this work was to determine food preference in captivity with an open offering ants, fly larvae and termites as a viable alternative for *ex situ* management that is adequate and easy to execute.

2. Materials and Methods

Study area: El Perico Farm, Universidad de Sucre (9°12'45"N and 75°24'02"W), located on the Sincelejo road leading to the municipality of Sampués, at Km 8 and 202 msnm. This area belongs to a tropical dry forest[14], with an average temperature of 27°C (32-21 °C), 1,200 mm/year of precipitation and average/annual relative humidity of 75%.

Experiment phase: Between October 1 and 27, 2015, ten non-sexed individuals from a previous study carried out at the same site[15] were kept in a terrarium, 50 cm long x 30 cm wide and 50 cm high, with plants, hollow trunks, water tank, soil with sand and small rocks[15], and an average temperature of 27°C, relative humidity of 85% and artificial luminosity of 12 hours with external fluorescent lamps.

The diet was calculated with an average weight of 1.75 g (1.3-2.0) and based on 12% of the body weight, which amounted to a total of 2.1g/day. The experiment diet consisted of fruit fly larvae (*Drosophila melanogaster*), ants (*Crematogaster* sp., *Cephalotes* sp., *Pheidole* sp. and *Solenopsis* sp.), and termites (*Nasutitermes* sp.) and was given between 10:00 and 12:00, distributed daily as shown in Table 1.

The ants *Crematogaster* sp and *Cephalotes* sp. were collected from yarumo tree (*Cecropia peltata*) and campano tree (*Pithecellobium saman)*; *Pheidole* sp. and *Solenopsis* sp. were extracted from its nests in the soil[16]; the *Nasutitermes* sp. larvae were collected manually from arboreal termite mounds in open areas of grazing areas in the marsh of Caimanera, Gulf of Morrosquillo, Sucre, Colombia; *Drosophila melanogaster* larvae were cultured *in situ*[17]; the food was offered at a temperature of between 10° and 15°C for reduced mobility of the prey. A sample of 20 individuals of each feeding item was randomly chosen, and the body length was measured.

Statistical analysis: The data were grouped in a Table 1 for an analysis of more than 2 samples and completely randomized blocks, which did not comply with the requirements of adjustment of normality and homogeneity of the variances; Friedman's ANOVA was applied to evaluate the diets. To compare the initial and final weight of the group of experiment animals, student's t-test was applied; for preference, ANOVA and Tukey test were applied taking into account the size of the animals[18].

3. Results

For the evaluated diets, the consumption percentage was: termites 57%, fly larvae 32%, and ants, on average, 5%: *Crematogaster* sp. 5%, *Cephalotes* sp. 4.5%, *Pheidole* sp. 5.5% and *Solenopsis* sp. 5%.

Friedman's ANOVA (N = 4, df = 1) = 4.00 p = 0.045 showed that there is a significant difference when comparing the consumption of termites with that of fruit fly larvae; there were no significant differences when comparing the different species of the offered ants (N = 4, df = 3) = 5.363 p = 0.147. Figure 1 shows the graphic differences.

In the type of food, the average body length was: *Crematogaster* sp. 2.55 mm (1.8-3.0) SD = 0.51, *Cephalotes* sp. 6.48 mm (5.0-8.0) SD = 1.08, *Pheidole* sp. 1.80 (1.6-2.0) SD = 0.16, *Solenopsis* sp. 2.87 mm (2.0-4.0) SD = 0.58, *Nasutitermes* sp. 4.91 mm (3.0-7.0) SD = 0.85, and *D. melonogaster* larvae 1.20 mm (1.0-1.5) SD = 0.17.

There was a significant difference in the size of the prey (F = 200.65, gL = 5 p> 0.0001). Table 2 shows the results of the Tukey test.

Table 1. Dates corresponding to each feeding per species, supplied from October 1 to 27, 2015.

Family	Species	Days			
Formicidae (Myrmicinae)	*Crematogaster* sp.	1	8	15	22
Formicidae (Myrmicinae)	*Cephalotes* sp.	2	9	16	23
Drosophilidae	*Drosophila melanogaster*	3	10	17	24
Formicidae (Myrmicinae)	*Pheidole* sp.	4	11	18	25
Formicidae (Myrmicinae)	*Solenopsis* sp.	5	12	19	26
Termitidae	*Nasutitermes* sp.	6	13	20	27

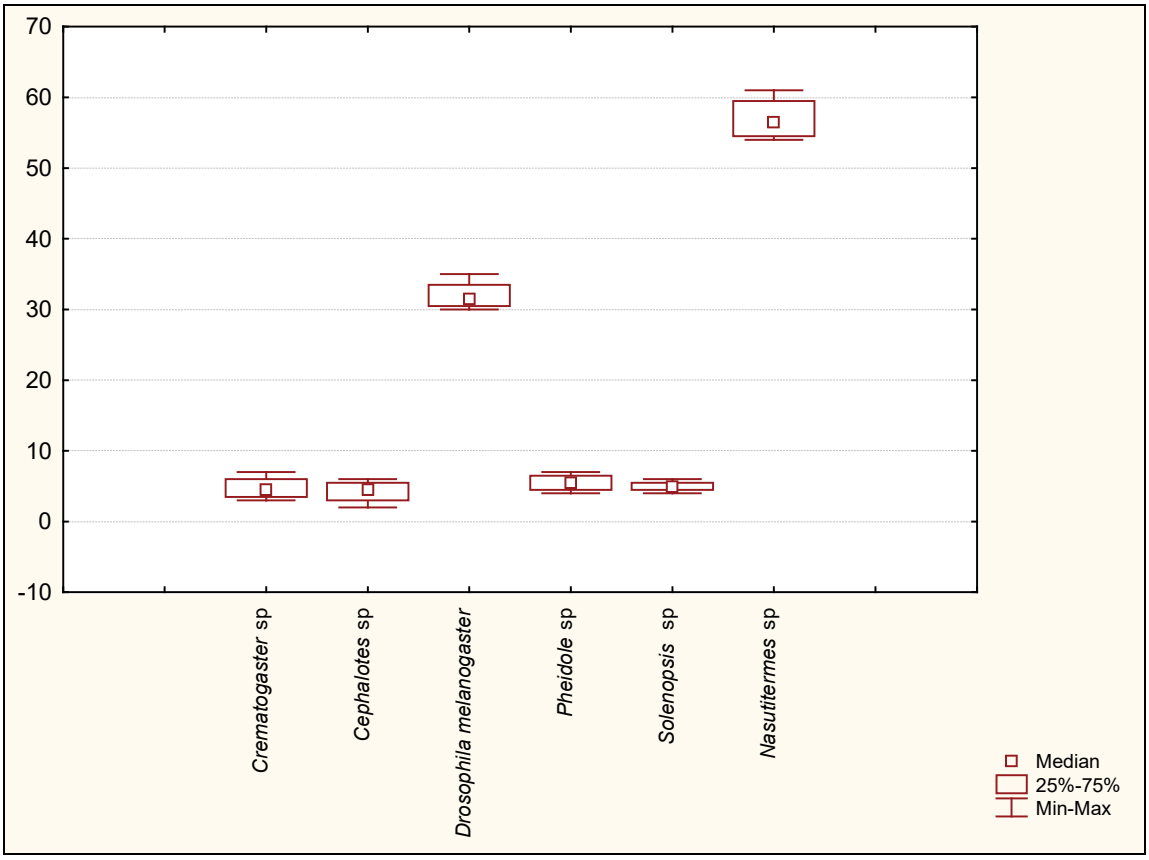

Figure 1. The differences between each of the offered food items.

Table 2. Tukey test for differentiation of size by species

Species	Mean	N	
D. melanogastser	1.20	20	A
Pheidole sp.	1.80	20	B
Crematogaster sp.	2.55	20	C
Solenopsis sp.	2.87	20	C
Nasutitermes sp.	4.91	20	D
Cephalotes sp.	6.48	20	E
Means with a common letter are not significantly different (p> 0.05)			

The initial and final weight of the group was 17.5 g and 17.2 g, respectively; the student's t test showed that there were no significant differences (Ds = 0.082, t = 1.152, df = 9, p = 0.278).

4. Discussion

The results reconfirmed that *D. truncatus* has a diet based on invertebrates, which includes ants, termites and flies[12]. In a natural environment, the Dendrobatidae family has a diet preferentially composed of ants and mites[19,20]; the genera *Colostethus*, *Epipedobates* and *Phyllobates* have a more general diet, while the genera *Dendrobates* and *Minyobates* tend to have specialized diets[20].

For food preference, according to the present study, the highest consumption was seen with *Nasutitermes* sp. (Termitidae), followed by *D. melanogaster* larvae (Drosophilidae), which had already been verified using larvae of the same fly, individuals of an indeterminate species of Termitidae and *Crematogaster* sp. Individuals (Formicidae)[21].

The results are contrary to findings reported for natural environments, where it is generally stated that different Dendrobatidae species mainly consume ants and mites[12,19,20]; in *Andinobates minutus* (Dendrobatidae), for example, analyzes of the stomach content of individuals from a natural environment indicated a higher consumption of mites, followed by ants and insect larvae[22]. For natural environments, it has been reported that *D. truncatus* manifests a greater preference for ants and mites[6,23-25]. In

this study, the ants, independent of size, were of less interest. It has been reported that many Neotropical anuran species present myrmecophagy and acariphagy behavior in natural environments, a favorable feeding strategy that takes into account the abundance of prey and a comparative lower foraging cost[26].

The formicivorous diet of Dendrobates frogs is a strategy to produce cutaneous alkaloids that are related to defense mechanisms[27-28] and exogenous in nature or obtained from another organism through ingestion[28-34]. The alkaloids secreted by the skin in Dendrobatidae frogs are related to the consumption of ants and other small arthropods, making them specialists[11].

In dendrobatids that have cutaneous poisons, it is estimated that the diet is composed of between 50 and 73% ants, whereas, in non-toxic ones, such as the *Colostethus* species, this number drops to between 12 and 16%[12]. In previous studies, captive Dendrobates frogs fed cricket and fruit fly larvae did not present alkaloids, while others fed termites and fruit flies presented alkaloids[35]. In this case, the consumption of two species was notable as being significant: termites and *D. melanogaster* larvae, leading to the conclusion that they are a viable alternative for functional feeding in captivity even though they are not reported as being part of the diet in natural environments.

Intrinsic and extrinsic factors such as ontogeny change in resource availability, spatial distribution of resources and plasticity of diet and condition the trophic niche of a species[36]. Under captivity conditions, this concept is restricted to the availability offered by the handlers. A good indicator of the acceptance and functionality of the diet is body condition, which did not present significant differences when comparing the initial weight and the final weight of the experiment group. On the other hand, the trophic adaptability, described as an expression that relates the feeding behavior with the flexibility to change between types of food depending on the situation[37], would in part explain the preferential consumption of termites and fruit fly larvae, which are not usually consumed in natural environments.

Additionally, many anuran species increase the amplitude of their trophic niche when time is restrictive, as seen in seasonal changes, including new diet restrictions, leading to the conclusion that a species cannot be classified as an extreme specialist since species do not generally occupy continuous trophic niches[38], a concept that would explain adaptation to diets offered in captivity based on trophic plasticity.

5. Conclusions

Trophic plasticity was established for *D. truncatus* kept in captivity, which has significant importance for *ex situ* conservation programs, especially since it is an endemic species.

Furthermore, the costs involved in the supply of food that is acceptable and has good yield for maintaining *D. truncatus* in captivity are minimal for the studied food items.

The captive breeding of *D. truncatus* is a valuable option for exploring the fundamental aspects of its biology, which would support efforts to safeguard it from the danger of extinction because aspects such as habitat loss, over-exploitation, climate change, introduction of exotic species and pollution have resulted in a strong decline of natural populations of amphibians and this species is no exception.

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